isise

Institute for Sustainability and Innovation in Structural Engineering

Technical & Scientific Activities Report 2014 - 2016

U C

Universidade do Minho
Escola de Engenharia

TECHNICAL & SCIENTIFIC ACTIVITIES

REPORT | 2014-2016

Institute for Sustainability and Innovation in Structural Engineering

Luís Simões da Silva

Paulo Lourenço

ISISE is a Research, Development and Innovation (RD&I) Unit created in 2007 that involves researchers with different expertise mostly from the Departments of Civil Engineering from the universities of Coimbra and Minho. ISISE currently comprises about 160 researchers, including a large number of PhD students.

ISISE possesses full expertise to address the seven basic requirements needed to bring building products to the market (Mechanical resistance and stability; Safety in the case of fire; Hygiene, health and the environment; Safety in use; Protection against noise; Energy economy and heat retention). It is well known that assessment of the environmental performance of building products can only be provided considering the building concept and use. ISISE can contribute to this vision by high-level research and development, which fosters innovation, in aspects such as the planning and design of the built environment, the structural and technical concept, and the quality achieved with the construction works.

In the previous reporting period, ISISE secured important funding (about 10 M€) for the construction and equipment of additional laboratory facilities in its two major campi (Coimbra and Minho). The new facilities have been completed and include a state-of-the-art Fire Safety Experimental Laboratory (FireLAB), in Coimbra, and the Institute for Bio-Sustainability (IBS), in Minho, joining engineering and biological sciences to address integrative and complex problems in the natural and built environment.

The Institute continued to be involved in several Advanced Educational Programs, including two Erasmus Mundus International Masters, funded by the European Commission, four PhD programs, as well as 5 advanced MSc programs.

The scientific results and outputs are illustrated throughout the report. A global ratio of 2.0 papers in peer-reviewed journals listed in SCI per PhD member per year constitutes an excellent result in the field of Civil Engineering. Earning competitive funding in the scope of international Research projects and cooperation with industry are additional strong points of ISISE.

Extracted from the many exciting news that can be found in the biannual ISISE Newsletter (https://isise.net >>newsmedia), the following list only gives a few highlights for the period 2014-2016:

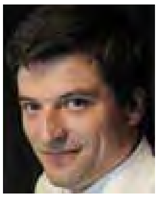
- By October 2014 ISISE received the visit of the External Evaluation Panel, by the Portuguese Science and Technology Foundation, who awarded ISISE with the label of "Excellent" (attributed to the top 20% RD&I units in Portugal).
- The Fire Engineering Laboratory of the University of Coimbra (Firelab) has started operating; this is a unique facility in Portugal and provides services in all areas of engineering and fire safety.
- The starting of operations in the building of IB-S (http://ib-s.uminho.pt/) took place in December 2015 with a meeting of the board of IB-S, its scientific council and the Rector of the University of Minho.
- An industry sponsored chair in "Construction of the future: Automation and modularization" was secured for IB-S, with the support of the dst group.
- The new Master in Acoustic and Energy Efficiency for a Sustainable Construction and the new Master on Building Rehabilitation have started in October 2015, at the University of Coimbra.
- The international master in Structural Analysis of Monuments and Historical Constructions (SAHC) of the University of Minho received the most prestigious European award in the area of cultural heritage. Europa Nostra 2017 Award Granted to the Advanced Master in Structural Analysis of Monuments and Historical Constructions, Turku, Finland, June 2017.
- The number of PhD members continued increasing mainly due to increase of postdoctoral collaborators and new faculty members.
- The organization of the ISISE Day-Out and associated PhD Workshop took place every year alternating between Minho region and Coimbra region, always with the presence of the majority of the members, in average more than 120 participants.
- The usage of electronic communication platforms was extended from the biannual newsletters and triennial report to a Facebook page with over 13,000 friends (www.facebook.com/isise.net), and a video channel (https://www.youtube.com/isisechannel).

ISISE faces many challenges for its future, including the integration of the recent new members. In the period 2014-2016, new strategic fields were addressed, such as Geotechnics, Bioengineering, Offshore Construction and Functional Performance, although the core of the Institute remained based on building materials such as composites, masonry, steel or timber. Aspects related to experimental characterization, advanced simulation, on site testing and life cycle analysis, with a modern perspective of building and structural engineering are also in the scope of the ISISE activities. The completion of the many projects and PhD theses shown in this report, and the attraction of new students and new financed projects, will allow continuing our quest for excellence, with real impact in science, technology and the economy. The Directors are privileged to lead such an enthusiastic staff of researchers and technicians and will be very happy to further extend cooperation to all interested international and national colleagues.

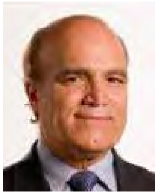
MEMBERS

PhD


Aldina Santiago


Alfredo Dias


Andreia Pereira


António Correia


António Ventura Gouveia


Ashkan Shahbazian


Bahman Ghiassi


Carlos Rebelo


Constança Rigueiro


Cristina Calmeiro


Daniel D. Costa

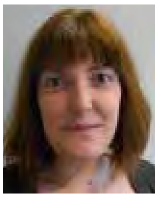

Daniel Oliveira


Diogo Mateus


Dulce Rodrigues

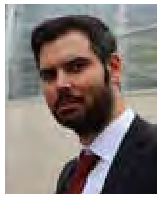

Eduarda Luso


Eduardo Pereira

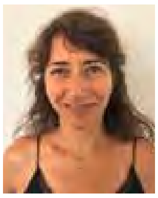

Elisa Poletti


Fatemeh Soltanzadeh


Graça Vasconcelos


Hélder Craveiro

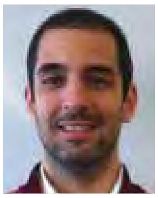

Hélder Sousa


Helena Gervásio

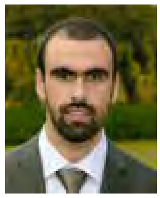

Isabel Valente


João Miguel Pereira


João Paulo Rodrigues


João Pedro Martins

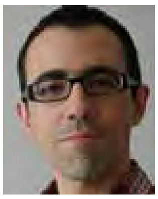

Joaquim Barros

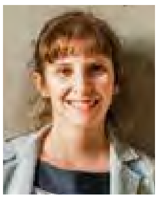

Joaquim Tinoco

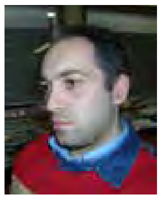

Jorge Branco


José Granja


José Matos


José Sena-Cruz


Liliana Marques


Luís Godinho


Luís Laím


Luís Mesquita


Luís Ramos


Luís Simões da Silva


Maria Giovanna


Miguel Azenha

Nuno Mendes

Paulo Lourenço

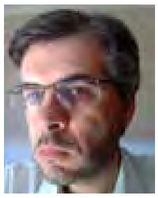

Paulo Mendes

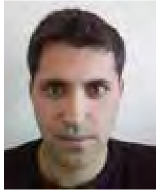

Paulo Oliveira


Paulo Santos


Pedro Fernandes


Ricardo Costa


Rui Marques


Rui Silva


Rui Simões


Salvador Dias


Sandra Jordão


Sandra Monteiro


Telmo Morgado


Tiago Miranda


Tiago Ferreira


Vitor Cunha

Researchers

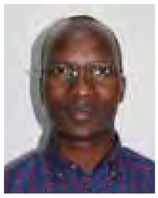

Adriana Baio Dias

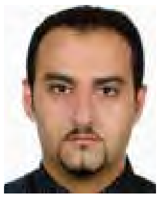

Alberto Barontini


Alberto Simões


Ali Edalat


Ali Esfahani


Amarildo Benzane

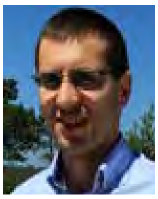

Amin Abrishambaf


Ana Francisca Santos


Ana Margarida Gonçalves


Ana Patrícia Gaspar

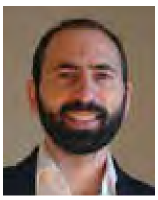

Ana Sofia Araújo

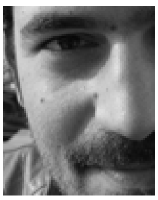

André Marques


André Silva


Andreia Martins


Andri Rifai


Angelo Gaetani


António Correia


António Letras


Antonio Romanazzi


Behnam Mobaraki


Bruno Gonçalves

Bruno Pedrosa	Carlos Albino	Carlos Barroso	Carlos Martins	Catarina Vilaça	Cécile Haremza	Cecília Barra

César Chácara	Chandan Gowda	Christoph Sousa	Chrysl Aranha	Cláudio Martins	Cláudio Pereira	Cristiana Bonifácio

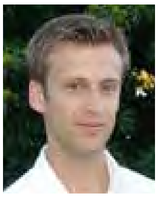
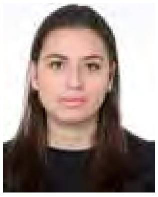
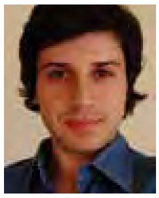
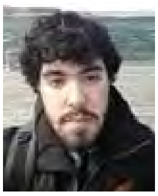
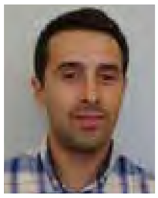
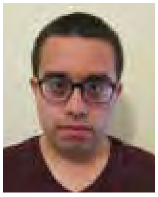
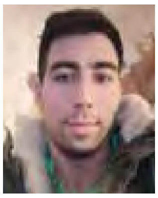
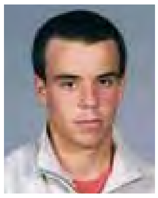
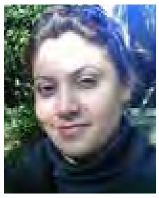
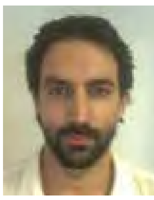
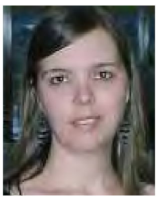
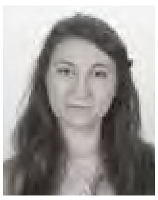
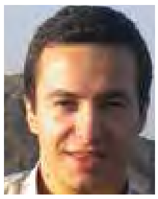
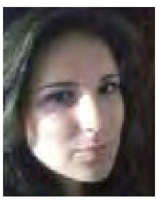
Cristina Frazão	Damjan Cekerevac	Daniel Oliveira	David Andrade	David Cassiano	Dirceu Santos	Edgar Soares

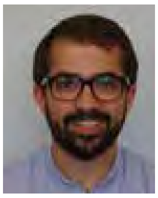
Eduardo Rodrigues	Eduardo Roque	Elizabeth Manning	Esmaeel Esmaeeli	Fábio Rocha	Farhad Akhoundi	Fernanda Lopes

Filip Ljubinkovic	Filipe Matos	Gabriela Lins	Galileu Santos	Georgios Karanikoloudis	Giovanni Ferrante	Guiomar Vicente

Hadi Baghi	Hadi Mazaheripour	Halene Moraes	Hamdi	Hamed Azizi	Hamid Maljaee	Hamidreza Salehian

Hassan Abdolpour	Hélder Ferreira	Hugo Augusto	Hugo Caetano	Hugo Guimarães	Inês Costa	Isis Rodríguez Pérez

						
Jacinto Silva	Javier Ortega	Jéssica Cartacho	João Almeida	João Costa	João Fernandes	João Leite
						
João Maximino	João Ribeiro	Jocelyn Reyes	Joel Cunha	Jorge Fernandes	Jorge Teixeira	José Carlos Lino
						
Jose Valdez	José Pedro Lopes	José Ricardo da Cruz	Juan Fonfria	Karel Šobra	Laanaya Ahmed	Leonardo Avila
						
Leonardo Rodrigues	Leslie Alejo	Luís Carlos Silva	Luís Correia	Luís Magalhães	Luís Silva	Mahsa Taheri
						
Manuel Parente	Maria de Lurdes Martins	Maria Inês Costa	Maria Pia Ciocci	Marialuigia Sangirardi	Mário Coelho	Mário Fernandes
						
Mário Martins	Marisa Pinheiro	Mateus Oliveira	Matheus Pereira	Matteo Breveglieri	Maxime Verbist	Meera Ramesh


Miguel Pereira


Mirian Velay Lizancos

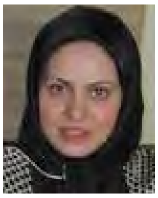

Mohammad Hosseini


Mohammad Kheradmand

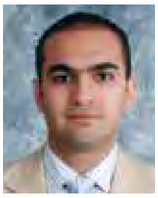

Mohammad Mastali


Mohammad Mohammadi


Monica Ona

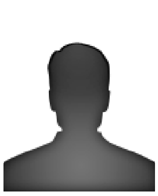

Neda Hajisadeghi


Nuno Rosa

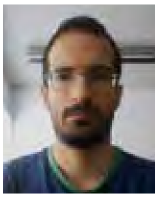

Onur Onat


Patrícia Silva


Paula Lamego

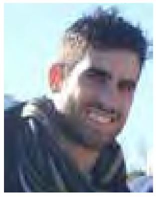

Paulo Albuquerque


Paulo Saraiva


Pedro Gil

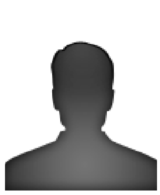

Pichandi Subramani


Ricardo Barros


Ricardo Breda


Ricardo Patraquim

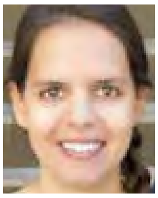

Rodrigo Lameiras


Rosamaria Codispoti


Rui Matos


Rui Oliveira


Sanam Moghimi


Sara Gomes


Sara Oliveira

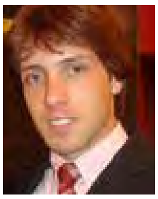

Seyed Rafsanjani


Slobodanka Jovasevic


Subramani Pichandi


Susana Moreira


Telma Ribeiro


Thiago Carlos

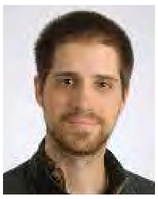

Thomas Sturm Moreira


Tiago Manco


Tiago Oliveira


Tiago Valente


Trayana Tankova


Vicente Moreira

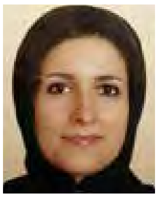

Worajak Janwaen


Ziaaddin Zamanzadeh

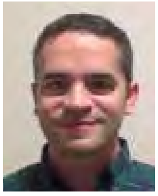
Collaborators

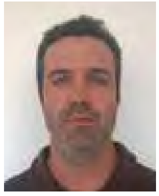

Francisco Fernandes

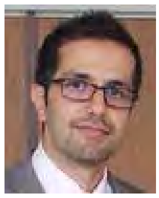

Francisco Martins


Honeyhe Ramezansefat


José Alexandre Henriques


Luís Borges


Luís Jorge


Mohammadali Rezazadeh

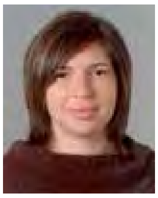

Nelson Soares


Nuno Araújo

Secretariat & Technicians


Ana Fonseca

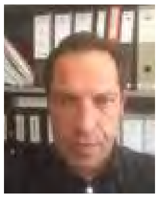

António Matos


Carla Ribeiro


Cristina Carolino


Ilídio Santos

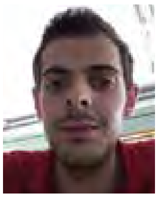

Lara Leite


Luís Gaspar

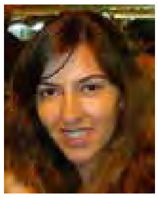

Manuela Rodrigues


Marco Jorge


Marta Mateus


Miguel Queirós Santos


Paula Teixeira


Sónia Esteves


Tiago Cardoso

Advisory Board


Bozidar Stojadinovic


Olivier Vassart


Thanasis Triantafillou

TABLE OF CONTENTS

TABLE OF CONTENTS

I - ISISE TODAY	
PhD Programs and Advanced MSc's	xxiii
Infrastructures and experimental capacity	xxxi
Events and Awards	xlv
ISISE in Numbers	liii
ISISE online	lvii
ISISE Newsletter	lxi
ISISE Day Out	lxix
Friday@ISISE	lxxvii
Connect@ISISE	lxxxi
II - PROJECTS & NETWORK ACTIONS	
Efficient harvesting of the wind energy | AEOLUS4FUTURE	3
Safety evaluation and retrofitting of infill masonry enclosure walls for seismic demands| ASPASSI	5
Behaviour charwacterization and rehabilitation of earthen construction | BE+EARTH	7
Reducing the vulnerability of cultural heritage buildings to blast loading | CH-SECURE	9
Development of a prefabricated emergency house prototype made of composite materials | CLICKHOUSE	11
Towards the next generation of standards for service life of cement-based materials and structures | COST Action TU1404	13
Quality Specifications for Roadway Bridges, Standardization at a European Level (BridgeSpec) | COST Action TU1406	15
Long-term structural and durability performance of concrete elements strengthened with the NSM technique | CutInDur	19
Innovative carbon fibre reinforced polymer laminates with capacity for a simultaneous flexural and shear/punching strengthening of reinforced concrete elements | CutInov	21
Development innovative sandwich panels made of fiber reinforced polymer (FRP) for the rehabilitation of degraded wooden floors of old buildings | EASYFLOOR	23
Acoustic and Thermal Comfort | EcoSteelPanel	25
Sustainable solutions for high performance prefabricated decks | Eco-Tabuleiro	27
Euro Latin America partnership in natural Risk mitigation and protection of the Cultural Heritage | ELARCH	29
Environmentally-friendly solutions for Concrete with Recycled and natural components | EnCoRe	31
European network for durable reinforcement and rehabilitation solutions | Endure	33
European pre-QUALified steel JOINTS | EQUALJOINTS	35

ERASMUS MUNDUS: European master on Sustainable Construction under natural Hazards and Catastrofic Events| Suscos	37
Development of Sustainable Fibercement Building Elements Containing Vegetable Fibers and Urban Residues | CAPES	39
Experimental and Numerical Analysis of Cold-Formed Steel Elements Subjected to Fire | FIRE_COLDFSTEEL	41
Fire Behaviour of Reinforced Concrete Structures Incorporating FRP Composites | FIRECOMPOSITE	43
Optimization of frames for effective assembling | FRAMEUP	45
Free from Damage Steel Connections | FREEDAM	47
Fire Resistance of Innovative and Slender Concrete Filled Tubular Composite Columns | FRISCC	49
Long-term structural and durability performances of reinforced concrete elements strengthened in flexure with CFRP | FRPLongDur	51
Short and long-term structural behavior of concrete elements flexurally strengthened with prestressed CFRP laminates | FRPreDur	53
Artefacts for hotel industry and urban furniture incorporating wastes | GEO-DESIGN	55
Monitoring and preventive conservation of historical and cultural heritage | HeritageCARE	57
High Strength Long Span Structures | HILONG	59
High Strength Steel for Wind Turbines | HISTWIN+	61
Innovative structural system based on advanced materials for lightweight and durable Offshore Wind Towers | InOlicTower	63
Innovative material of ultra-high ductility for the rehabilitation of the built patrimony | INOTEC	65
Development of a new reinforcing system and evaluation of the existing models for composite slabs | INOV-LAMI	67
Innovative systems for earthquake resistant masonry enclosures in RC buildings | INSYSME	69
A comprehensive multi-physics and multi-scale approach to the combined effects of applied loads and thermal/shrinkage deformations in reinforced concrete structures | IntegraCrete	71
A dendrochronological survey of the structural woods of historic city centres in Portugal | INVISIBLE WOODS	73
Large Valorisation on Sustainability of Steel Structures | LVS^3	75
Concrete Behaviour at Meso-Scale | MesoCrete	77
Next Generation Monitoring of Coastal Systems in a Scenario of Global Change | NEXT-SEA	79
Optimal Use of High Strength Steel Grade Within Bridges | OPTIBRI	81
Optimization of forest resources in construction | OptimizedWood	83
Optimization of Steel Plated Bridges in Shape and Strength | OUTBURST	85
Systems with PCM-filled rectangular cavities for the storage of solar thermal energy for buildings | PCMs4Buildings	87

Performance of reinforced concrete structures strengthened in flexural with an innovative system using prestressed NSM CFRP laminates | PRELAMI	89
Pre-fabricated thin panels using advanced materials for structural rehabilitation | PREPAM	91
Prolonging Life Time of old Steel-Concrete Bridges | PROLIFE	93
Probabilistic Assessment of Existing Timber Structures | ProTimber	95
Promotion of new Eurocode rules for structural stainless steel | PUREST	97
Rehabilitation of Building Floors with Lightweight High Performance GFRP Sandwich Panels | REHABGFRP	99
Developing Innovative Solutions for Seismic Retrofitting of Masonry Infill Walls| RetroInf	101
Seismic Protection of Earthen Construction Heritage | SafEarth	103
Standardization of Safety Assessment Procedures across Brittle to Ductile Failure Modes | SafeBrictile	105
European Masters in Structural Analysis of Monuments and Historical Constructions | SAHC	107
Valorisation of Knowledge for Sustainable Steel-Composite Bridges in Built Environment | SBRI+	109
Vernacular Seismic Culture in Portugal | Seismic V	111
Steel Hybrid Onshore Wind Towers Installed with Minimal Effort | SHOWTIME	113
Seismic Design of Multi-storey CLT buildings | SISMO 2.0	115
Flat slabs for multi-storey buildings using hybrid reinforced self-compacting concrete: an innovative structural system | SlabSys-HFRC	117
South Mediterranian Welding Center for Education, Training and Quality Control | SM Weld	119
SUstainability-driven international/intersectoral Partnership for Education and Research on modelling next generation CONCRETE | SUPERCONCRETE	121
Sustainable Infrastruture Management System| SUSTIMS	123
Stability design of non-uniform steel members | TaperSteel	125
Curved thin panels for structural application| UltimatePanel	127
Fibre reinforced concrete of enhanced properties of durability for urban furniture and infra-structures | UrbanCrete	129
Innovative method for continuous monitoring of concrete viscoelastic properties since early | VisCoDyn	131
III - PHD THESES	
Alberto Barontini: Bio-inspired structural health monitoring systems for civil engineering structures	135
Alberto Belarmino: Innovative system for metal cladding of buildings	136
Ali Edalat Behbahani: Constitutive models to simlate failure of structures made by cement based materials	137
Ali Dalalbashi Esfahani: Multi-scale investigation of the durability perfromance of TRM-strengthened masonry	138
Amarildo Benzane: Fire risk and evacuation modelling in hospitals - the case of the Hospital Sousa Martins in Guarda	139

Amin Abrishambaf: An integral approach to simulate the creep behaviour of steel fibre reinforced self-compacting concrete laminar structures	140
Ana Araújo: Modelling of the seismic performance of connections and walls in ancient masonry buildings	141
Ana Gaspar: Constribution to control uncertainties in numerical modelling of dam performances. An application to a RCC SAM	142
Ana Santos: Behaviour of friction joints under impact loads	143
Andreia Martins: Seismic Behaviour of Masonry veener walls	144
Angelo Gaetani: Seismic performance of masonry cross vaults: learning from historical developments and experimental testing	145
Antonio Romanazzi: Seismic performance of rammed earth constructions considering an innovative strengthening technique	146
Bruno Gonçalves: The use of advanced technologies on lifecycle assessment of infrastructures	147
Carlos Barroso: The rural vernacular construction from the Entre-Douro-e-Minho	148
Carlos Martins: Health assessment of structural glued laminated timber members	149
Catarina Silva: Tall building using CLT. An integrated design considering moisture induced effects	150
Cécile Haremza: Robustness of steel composite open car parks under localised fire	151
César Espinoza: Macro-elements nonlinear dynamic analysis for the assessment of teh seismic vulnerability of masonry structures	152
Chandan Gowda: Use of NSM FRP for torsional strengthening of thin walled tubular RC structures	153
Christoph de Sousa: Development of a multifunctional composite sandwich panel for the rehabilitation of building facades	154
Chrysl Aranha: Experimental and numerical assessment of the seismic behaviour of log and cross-laminated timber systems	155
Cristiana Bonifácio: A cutting-edge asset management framework for railway tracks	156
Cristina Santos: Residual mechanical properties of ordinary concretes after fire	157
Cristina Frazão: New construction systems in concrete reinforced with recycled fibers	158
David Andrade: Analysis of the thermo-mechanical conditions in friction stir based technologies	159
David Cassiano: Post seismic structural robustness in moment resisting frame steel buildings	160
Eduardo Roque: Energy performance of lightweight steel-framed buildings in warm climates under the Passive House umbrella	161
Elizabeth Manning: Enhancement of the tube-jack non-destructive test method for historical structural masonry diagnosis	162
Esmaeel Esmaeeli: Development of hybrid composite plate (HCP) of strengthening and repair of RC structures	163
Fatemeh Soltanzadeh: High performence fibre reinforced concrete for the replacement of shear stirrups	164
Fernanda Lopes: Composite joints for improved fire robustness	165

Filip Ljubinkovic: Cylindrically curved steel panels in bridge design	166
Filipe Matos: Seismic behaviour assessment of timber buildings applying the new regulation	167
Georgios Karanikoloudis: Risk management applied to cultural heritage buildings. The effect of soil settlements and vibrations induced by underground structures	168
Giovanni Cavallaro: Seismic response of beam-to-column connections equipped with friction pads	169
Guiomar Vicente: Moment resisting bolted joints connecting steel tubular section members	170
Hadi Baghi: The effectiveness of SHCC-FRP panels for the shear resistance of RC beams	171
Hadi Mazaheripour: Structural behaviour of hybrid GFRP and steel reinforced FRC prestressed beams	172
Hamed Azizi-Bondarabadi: Seismic assessment of unreinforced masonry structures	173
Hamidreza Salehian: Evaluation of the performance of steel fibre reinforced self-compacting concrete in elevated slab systems; from the material to the structure	174
Hassan Abdolpour: Development of prefabricated modular houses in pure composite sandwich panels	175
Hélder Craveiro: Fire resistance of cold-formed steel columns	176
Hugo Augusto: Characterization of the behaviour of partial-strength joints under cyclic and seismic loading conditions	177
Hugo Caetano: Fibrous concretes with improved fire behaviour	178
Inês Costa: Prestressed carbon fibre laminates applied according to near surface mounted technique to increase the flexural resistance of reinforced concrete beams	179
Jacinto Silva: Continuous monitoring of deformability of stabilized soils based on modal identification	180
Javier Ortega: Reduction of the seismic vulnerability of vernacular architecture with traditional strengthening solutions	181
João Almeida: High ductility strengthening system for masonry structural rehabilitation	182
João Fernandes: Risk-based railway infrastructure management systems	183
João Leite: Seismic behaviour of masonry infill walls: test and design	184
João Martins: Behaviour of cylindrically curved steel panels under in-plane stresses	185
João Pereira: Security evaluation and design of structures subjected to blast loading	186
João Ribeiro: Influence of joint ductility in the robusteness of steel structures	187
Jocelyn Reyes: Development of sustainable solutions for urban rehabilitation	188
José Granja: Continuous characterization of stiffness of cement-based materials: experimental analysis and micro-mechanics modeling	189
José Henriques: Behaviour of joints: simple and efficient steel-to-concrete joints	190
Juan Fonfría: Behaviour of assymetric T-stub components	191
Leonardo Avila: Seismic behaviour of concrete blocks masonry buildings	192
Leslie Guerra: Effect of the masonry morphology on the seismic behaviour of existing masonry buildings	193
Luís Silva: Homogeneized dynamic analysis of out-of-plane loaded masonry walls and evaluation of fragility curves	194

Luís Correia: Durability and long-term behaviour of RC slabs flexurally strenghtened with prestressed CFRP laminates	195
Luís Magalhães: Behaviour of steel joints between I profile beams to hollow columns with welded reverse chanel	196
Luís Miguel Silva: Innovative systems for earthquake resistant masonry enclosures in RC buildings	197
Mahsa Taheri: A model to predict the crack width of FRC members reinforced with longitudinal bars	198
Manuel Parente: Development of an intelligent earthworks optimization system	199
Maria Ciocci: Effect of timber floor diaphragms on the seismic behaviour and analysis of existing masonry buildings	200
Maria Masciotta: Damage identification of structures based on spectral output signals	201
Marialuigia Sangirardi: Seimic assessment of mixed masonry - reinforced concrete buildings. An insight into modelling approaches	202
Mário Coelho: Bond behaviour of FRP NSM systems in concrete	203
Marisa Pinheiro: Numerical methodology to model heteegoeneous rock masses	204
Mateus Oliveira: A multi-physics approach applied to masonry structures with non-hydraulic lime mortars	205
Matteo Breveglieri: Shear strengthening of RC neams using the embedded through-section technique	206
Maxime Verbist: Mechanical behaviour of traditional timber carpentry connections	207
Meera Ramesh: A multi-scale approach to the study of the effects of adding lime to cement in masonry mortars:from the micro-scale to the structural level	208
Miguel Pereira: Development of a new reinforcing system and evaluation of the existing models for composite slabs	209
Mahammad Kheradmand: Incorporation of hybrid phase change materials in plastering mortars for increased energy efficiency in buildings	210
Mohammadali Rezazadeh: Innovative methodologies for the enhancement of the flexural strenghtening performance of NSM CFRP technique for RC beams	211
Mohammad Mohammadi: Hybrid high-rise wind turbine tower: aeroelastic load, dynamic response and fatigue assessment	212
Mohammadreza Hosseini: Behaviour of RC slabs flexurally strengthened with prestressed NSM CFRP laminates	213
Neda Sadegui: Conservation and safety assessment of adobe vaulted architecture in Yazd, Iran	214
Nelson Soares: Thermal energy storage with phase change materials (PCMs) towards buildings' enegry efficiency	215
Nuno Rosa: Structural and thermal performance of LSF modular constructuion	216
Onur Onat: Investigation of seismic behaviour of infill wallsurrounded by reinforced concrete frame	217
Patrícia Moreira: Time-dependent behaviour and durability of RC slabs strenghtened with NSM CFRP strips	218
Paula Lamego: Seismic strengthening of residential buildings. Risk analysis and mitigation	219

Pedro Fernandes: Bond behaviour of NSM CFRP-concrete systems: durability and quality control	220
Pedro Santos: Hybrid performance-based wood panels for a smart construction	221
Ricardo Barros: Material and structural behavior assessment of schist masonry constructions	222
Ricardo Patraquim: 3D acoustic diffusers with organic shape: numerical study and optimization	223
Rodrigo Lameiras: Sandwich structural panels comprising thin-walled SFRSCC and GFRP connectors: from material features to structural behaviour	224
Rosamaria Codispoti: Mechanical performance of natual fiber-reinforced composite for the strengthening of ancient masonry	225
Rui Matos: Steel towers for wind turbines	226
Sanam Moghimi: Seismic risk mitigation stretgy; Cost effective analysis	227
Sandra Monteiro: Load distribution on timber-concrete composite floors	228
Sara Gomes: Reliability analysis of FRP strengthened prestressed concrete girders	229
Seyed Rafsanjani: High strain rate constitutive modeling for historical structures subjected to blast loading	230
Seyed Maljaee: Long-term durability of bond in FRP-masonry components	231
Slobodanka Jovasevic: In situ bolted connections in lattice towers for wind energy converters	232
Subramani Pichandi: Development of composite auxetic structures for civil engineering applications	233
Telma Ribeiro: Conservation of earth heritage: an approach for a new methodology	234
Thiago Carlos: Fire behavior of RC beams strengthened with CFRP laminate strips	235
Thomas Moreira: Experimental characterization of dry-stack interlocking compressed earth block masonry	236
Tiago Manco: Behaviour of steel members subjected to hazardous loading in support offshore structures	237
Tiago Valente: Advanced numerical models for the analysis of the behavior of structures strenghtened with an innovative technique	238
Trayana Tankova: Consisten safety assessment among Eurocode 3 stability design rules for steel members	239
Vicente Moreira: A cutting-edge resilience-based risk assessment framework for existing bridge networks	240
Worajak Janwaen:Behavior of CFRP-confined rectangular RC columns unsing a new strengthening technique	241
Ziaaddin Zamanzadeh: Cement based materials reinforced with recycled steel fibres: mechanical durability and structural performance	242
IV - BOOKS	
X Congresso Construção Metálica e Mista	245
1st International Meeting of the Young Transportations Geotechnics Engineers of the ISSMGE	246
9th International Masonry Conference	247
Advances in Transportation Geotechnics III	248

BIM no Departamento de Engenharia Civil: Rumo às necessidades do tecido empresarial	249
IFireSS 2015	250
Construir em Madeira	251
Defects in Masonry Walls. Guidance on Cracking: Identification, Prevention and Repair	252
Design of Steel Structures - 2nd Edition	253
Design of Steel Structures - UK Edition	254
Design procedures for the use of composites in strengthening of reinforced concrete structures	255
Dimensionamento de Estruturas de Aço	256
Eco-efficient Masonry Bricks and Blocks: Design, Properties and Durability	257
fib Commission 5: Seminar on Durability of Concrete Structures	258
Intervir em Construções Existentes de Madeira	259
1º Congresso Português de Building Information Modelling	260
LVS^3 Background Document	261
LVS^3 Design Guide	262
Manual de Dimensionamento de Estruturas Metálicas	263
New uses for old railways	264
Paredes de Alvenaria	265
RILEM TC-CMS Workshop: Cracking of massive concrete structures	266
IFireSS 2015	267
Reabilitação de Fachadas	268
Seismic Retrofitting: Learning from Vernacular Architecture	269
Supplement to the Proceedings of 3rd International Conference on Transportation Geotechnics	270
COST Action TU1406: eBook of the 1st Workshop Meeting	271
COST Action TU1406: eBook of the 2nd Workshop Meeting	272
COST Action TU1406: eBook for the 3rd Workshop Meeting	273
Training School COST Action TU1406	274
WG1 Technical Report – Performance Indicators for Roadway Bridges of COST Action TU1406	275
V - TECHNOLOGY TRANSFER	
CONTRACTS WITH INDUSTRY AND GOVERNMENT	279
Development of a new omega configuration in cold-formed steel	281
Seismic retrofit project Getty Conservation Institute, USA	282
PATENTS	283
Laminado de fibra de carbono e respetiva técnica de reforço de estruturas de betão	285
Sistema para medição de deslocamentos em estruturas com recurso a transdutores de deslocamento	286
Tampa em betão reforçado com fibras e grelha em material compósito para aplicação em infraestruturas	287

PhD PROGRAMS AND ADVANCED MSc's

The Institute provides several Advanced Educational Programs, including two Erasmus Mundus International Masters, funded by the European Commission, four PhD programs, as well as 5 advanced MSc programs.

SAHC - Advanced Masters in Structural Analysis of Monuments and Historical Constructions

The building industry and tourism represents about 15-20% of the GNP in Europe. As the built environment ages, conservation of existing buildings and infrastructure is receiving more and more attention, reaching an average value of 1/3 of the market in Europe. The SAHC - Structural Analysis of Monuments and Historical Constructions programme will address the issue of existing buildings, but with a focus on buildings with cultural value. Being monuments and historical centres main attractors for tourism, their conservation is not only a societal demand but also an economical one.

Europe is a world leader in the generation of knowledge, methodology and technology applicable to the conservation and restoration of the architectural heritage. The large investment made during the last years lead to significant advances in experimental and numerical techniques applied to the conservation of architectural heritage structures.

The objective of SAHC is to offer an advanced education programme on the engineering of conservation of structures, with a focus on architectural heritage. The Master combines the diversity of expertise at leading European universities in the field, offering education oriented to a multidisciplinary understanding of structural conservation through the involvement of experts from complementary fields (engineers, architects, materials scientists and others). Students face top level structural analysis knowledge in a research oriented environment, with close cooperation with the industry and a focus on problem solving.

The Master course will provide a cross-disciplinary education comprising engineering oriented issues (experimental techniques, computer modelling, structural analysis, seismic behaviour and structural dynamics, repairing and strengthening techniques, surveying, monitoring, etc.) with more general methodological or philosophical concepts (history of construction and restoration, principles and methodology of conservation, building rehabilitation, etc.).

The main focus of this training is the application of scientific principles in analysis, innovation and practice of conservation of monuments and historical constructions worldwide. The course will combine the very recent advances in research and development with activities oriented to practical applications. In turn, the course will pay significant attention to the regional differences shown by the architectural heritage and historical construction techniques within Europe or at World scale.

More information can be found @ **http://www.msc-sahc.org/**

SUSCOS - Advanced Masters in Sustainable Constructions under Natural Hazards and Catastrophic Events

The focus of SUSCOS Sustainable Constructions under Natural Hazards and Catastrophic Events European master course is to provide attendees the engineering ability and know-how to design and construct steel and timber structures in a balanced approach between economic, environmental and social aspects, enhancing the sustainability and competitiveness of the steel and timber industry.

The courses are lectured in English by academics from all partner institutions (Czech Technical University in Prague, University of Coimbra, University of Liège, University of Naples Federico II, University Politehnica of Timisoara and Technical University of Lulea) and invited teachers from associated members. The first edition (2012-2014) took place at the University of Coimbra and the Czech Technical University in Prague.

The course is organized in three modules covering buildings, bridges and energy-related infra- structures and equipments with a practice oriented approach. The degree awarded is a Master Degree, provided as a multiple diploma. The programme is structured in 3 semesters for one and a half year of study.

Doctoral Programme in Civil Engineering

The main objective of the Doctoral Programme in Civil Engineering is to train highly qualified experts and researchers capable of undertaking autonomous research, development and innovation work within academic or business contexts in the field of Civil Engineering. The set of skills acquired by PhD students over their academic life will enhance the interaction between the University and the entrepreneurial fabric and will contribute towards the competitiveness and sustainability of the Civil Engineering sector at national and international levels.

The guiding principles of the Doctoral Programme in Civil Engineering are the following:

- to complement the training received by holders of master degrees and 5-year undergraduate degrees in the field of Science and Engineering, particularly Civil Engineering, by providing advanced training in fast-growing areas such as Construction, Structures and Geotechnics, Hydraulics and Environment, as well as Planning and Transport Infrastructures, with particular emphasis on innovation and development of technologies and processes in these areas and on the source materials/products for construction technologies;
- to provide students with solid training in research methodology and experimentation, which may allow them to conceive and promote the elaboration of research and development projects in academic and/or professional contexts, thus contributing to increase their abilities in terms of research, technological development and, consequently, their ability to innovate in order to achieve further knowledge in the field;

– to boost Civil Engineering-related research and technological development, promoting their consolidation as an important element of the industrial sector.

More information can be found @ **http://www.pdec.civil.uminho.pt/site/**

PDcmm - Doctoral Programme in Steel and Composite Construction

The Doctoral course in Steel and Composite Construction aims to give a solid institutional framework, methodology and advanced training in the specialized field of steel and composite construction, developing skills related to construction sub-sector with the design, production, execution, supervision and the management of construction works with steel or composite structure.
The cross-cutting nature of the content taught in the course allows obtaining specific concepts in a variety of structural applications such as bridges, buildings, offshore structures, wind towers, etc.

In this context, the Doctoral course of Steel and Composite Construction provides a solid scientific training, to enable the development of knowledge and skills in the context of research and train people capable of becoming a self-learning throughout life and a self-guided mode thus being technological innovator

More information can be found @ **https://apps.uc.pt/courses/en/course/601**

Doctoral Programme in Fire Safety Engineeering

More information can be found
@ **http://www.uc.pt/fctuc/dec/ensino/doutoramentos/doutengsegincendio**

International Doctorate in Sustainable Built Environment

University of Minho (Portugal), together with the Czech Technical University in Prague (Czech Republic), the Polytechnic University of Madrid (Spain), the International Initiative for a Sustainable Built Environment (iiSBE) and several other universities and other non- commercial organisations, is launching a high quality International Doctoral Programme in Sustainable Built Environment - iDiSBE.

The relationship of the partners with iiSBE ascertains the possibility of benefiting from the contact and collaboration of experts from over the world, taking into consideration their experience on world-regional sustainable building problems and practices. The partnership includes the leaders of several national delegations of iiSBE and some of the organizers of the series of SB conferences on Sustainable Building (1998-2014). The partners are also involved in relevant technical committees and enjoy a proven record of R&D&I external funding and top professional experience on aspects such as Energy Efficiency, Life-cycle Analysis, Integrated Design Processes, Materials, Products and Systems for Sustainable Building and Sustainable Urban Regeneration.

The built environment has evolved to frame and facilitate nearly all human activities. Simultaneously, its constant expansion has become more and more harmful to the natural environment.

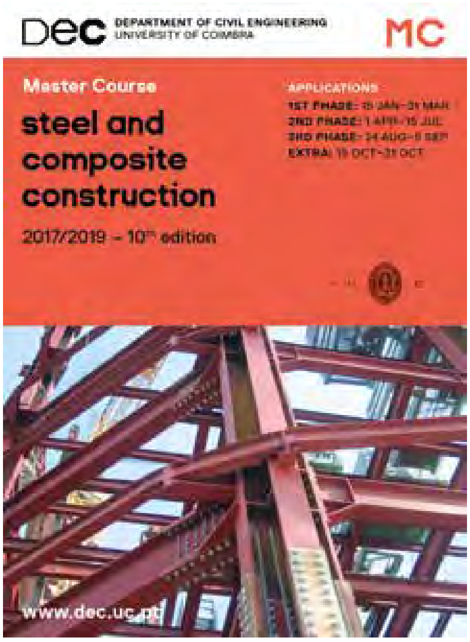
The construction sector accounts for an estimated 40% of earth resources consumption and, therefore, has a crucial role to play in achieving sustainability. Urban development has special importance within the broader context of sustainability as well, while current trends predict that the number of urban dwellers will keep rising, reaching almost 5 billion by 2030 out of a world total of 8.1 billion.

The main objective of the doctoral programme is to create an integrated approach to this subject, covering phases of: design, construction materials and technologies, service life evaluation and durability, rehabilitation, building comfort and use of energy, construction economics and management, sustainable urban development and regeneration.

iDiSBE aims at providing a high level specialized advanced education in order to develop in the doctoral candidates the ability to contribute to the advancement of knowledge in the field of sustainable built environment, through creative and autonomous investigation.

More information can be found @ **http://civil.uminho.pt/idisbe/**

Master Course in Steel and Composite Construction



The Master course in Steel and Composite Construction aims to give advanced training in the specialized field of steel and composite construction, developing skills related construction sub-sector with the design, production, execution, supervision and the management of construction works with steel or composite structure.

The cross-cutting nature of the content taught in the course allows obtaining specific concepts in a variety of structural applications such as bridges, buildings, offshore structures, wind towers, etc. In addition, the course provides the theoretical basis for entry potential graduate training (PhD).

In this context, the Master of Steel and Composite Construction provides a solid scientific training, to enable the development of knowledge and skills in the context of research and train people capable of becoming a self-learning throughout life and a self-guided mode thus being technological innovators.

More information can be found @ **https://apps.uc.pt/courses/en/course/333**

Master Course in Acoustic and Energy Efficiency for a Sustainable Construction

The Master course in Steel and Composite Construction aims to give advanced training in the specialized field of steel and composite construction, developing skills related construction sub-sector with the design, production, execution, supervision and the management of construction works with steel or composite structure.

The cross-cutting nature of the content taught in the course allows obtaining specific concepts in a variety of structural applications such as bridges, buildings, offshore structures, wind towers, etc. In addition, the course provides the theoretical basis for entry potential graduate training (PhD).

In this context, the Master of Steel and Composite Construction provides a solid scientific training, to enable the development of knowledge and skills in the context of research and train people capable of becoming a self-learning throughout life and a self-guided mode thus being technological innovators.

More information can be found @ **https://apps.uc.pt/courses/en/course/333**

Master Course in Rehabilitation of Buildings

The Master Course in Rehabilitation of Buildings is aimed at Engineers, Architects and other professionals dealing with construction that look at specializing in this field as well as graduate students.

The course covers the two following main thematic areas: "Structural Rehabilitation" and "Non-Structural Rehabilitation" – but it's intrinsically multidisciplinary, allowing a comprehensive but in-depth study of all professional chain. Therefore, includes among a strong component in engineering sciences, architecture contents, economics, law, environment and sustainable development, counting on a highly specialized academic staff of the different areas of knowledge and deeply motivated for a continued integration of the theoretical and scientific approach with the project experience, of work and the answers of a market in strong development

More information can be found @ **http://www.uc.pt/fctuc/dec/ensino/mestrados/mre**

Master Course in Urban Fire Safety

More information can be found
@ **http://www.uc.pt/fctuc/dec/ensino/mestrados/mestradosegincurbanos**

INFRASTRUCTURES AND EXPERIMENTAL CAPACITY

The Institute have several facilities, some of which brand new, as are the Fire Safety Ex- perimental Laboratory (FireLab), in Coimbra, and the Institute for Bio-Sustainability (I-BS), in Minho, joining engineering and biological sciences to address integrative and com- plex problems in the natural and built environment. These were investments that more than doubled the experimental capabilities of the ISISE.

The laboratory in the Department of Civil Engineering, at the University of Coimbra, is equipped in order to prepare test specimens, in some cases of large dimensions, and to perform different types of tests, in the context of research work with experimental component, laboratory classes and the provision of services abroad. It has a set of qualified technicians who provide support to the activities of the classes, research work, namely master's and doctoral theses, and tests and services abroad.

Equipment such as universal (tension and compression) machines, compression presses, gantry, loading equipment (actuators and hydraulic jacks), furnaces and smoke extraction devices, and several other equipment for preparing and assembling test pieces assure the performance of experimental research work (theoretical and applied), static, dynamic, fire resistance and non-destructive tests, and quality control tests of materials and construction systems. From the point of view of data acquisition, it is possible to combine different measurement and reading systems, using various devices and computer systems.

There is also a space for hygrothermal tests, where a set of hygrothermal characterization of materials, products and construction systems can be carried out under controlled ambient and humidity conditions. It is a pedagogical area, where some research work is also carried out in the area of evaluation of hygrothermal behaviour.

The laboratory also has two reverberant acoustic chambers where the acoustic insulation to aerial sounds of vertical separation elements (eg. walls) can be analysed or determine the sound absorption of coatings. The test equipment is operated from an adjacent control room. In this room is also available a small acoustic chamber, designed for experimental works in insulation to percussion sounds, as well as an ultrasonic equipment, for non-destructive tests.

The Firelab is a laboratory in the area of reaction to fire and fire resistance, which provides services in all areas of engineering and fire safety, also in Coimbra. It is a centre of excellence targeted towards providing services to companies, advanced technical training, consulting, research and development in fire safety, supported by the expertise of the ISISE research centre (rated EXCELLENT in the latest review of the FCT in 2014). This was a project co-financed by QREN, under the Programa Mais Centro and the European Union through the European Regional Development Fund.

This laboratory performs certification of materials and construction solutions, in accordance with the relevant standards. It is equipped with the most modern equipment to address multiple aspects, such as detection systems, fire extinguishing systems, smoke control, fire hazard, organization and safety management, design of steel structures subjected to fire, etc.

The laboratories in Coimbra have about 3118 sqm, with a strong floor and two reaction walls and the main equipment listed on Table 1.

TABLE 1	
A.1 - Reaction frames	E.5.5 – Accelerometers
B.2 - Furnaces	F.6 - Thermal
B.2.1 – Gas furnaces	F.6.1 - High temperature extensometer
B.2.2 - Electric furnaces	F.6.2 – Thermal conductivity measurements (Hot Disk TPS2500S)
C.3 - Mechanical testing machines	F.6.3 – Thermographic cameras
C.3.1 - Compression testing	F.6.4 – Hot-Box
C.3.2 - Dynamic testing	G – Acoustics
C.3.3 – Fatigue testing	H – Fire reaction
D.4 - Mechanical actuators	H.1 – Flooring Radiant Panel
D.4.1 - Servo-hydraulic actuators	H.2 – Small ignition
D.4.2 - Electric-mechanical actuators	H.3 – Non-combustibility
D.4.3 - High pressure hydraulic closed load control units for actuators	H.4 – Bomb calorimeter
D.4.3 - Hydraulic central units	H.5 - Single burning item
E.5 – Data acquisition equipment	I – General equipment
E.5.1 - Data loggers	I.1 – Forklifts
E.5.2 - Load cells	I.2 – Air compressors
E.5.3 - Displacements transducers	J - Vehicles
E.5.4 – High speed cameras	

The FIRELAB comprises the following list of equipment:

Fire resistance equipment	
Gas furnaces	
Vertical furnace – Internal dimensions: 3 100 (width) x 3 100 (height) x 1 500 (length) [mm]; – Installed thermal power: 2 064 000 kcal/h; – Maximum service temperature: 1 200ºC.	
Horizontal furnace – Internal dimensions: 3 050 (width) x 1 500 (height) x 4 050 (length) [mm]; – Installed thermal power: 2 408 000 kcal/h; – Maximum service temperature: 1 350ºC.	
Electrical furnaces	
Vertical furnace To measure mechanical and thermal properties of materials at high temperature, on steady and transient sate.	
Vertical tubular furnace - split type To measure mechanical and thermal properties of materials at high temperature.	

Fire reaction equipment

Flooring Radiant Panel

For measure the spread of flame of the product under thermal exposure. It is relevant to classification of the flooring material into classes A2fl, Bfl, Ffl and Dfl.
Main tests:

- Observed distance of flame spread v. Time, used to determine the critical flux at extinguishment;
- Chamber, Stack and radiant panel surface temperature;
- Heat flux profile curve;
- Smoke density v. time.

Small Ignition

This equipment is used to conduct the Euroclass test that measures the ignitability of a product when it is subjected to direct impingement of a small flame. It is relevant to the classification of a product into classes B, Bfl, C, Cfl, E and Efl for all building materials.

Non-combustibility

This test specifies the procedure for determining whether or not a product will contribute directly to the fire development. It is relevant to classification of all building products (including floorings) into classes A1, A2 and A1fl and A2fl.

Bomb Calorimeter

This equipment gives the reaction to fire for building products and measures the gross calorific value of a sample. It is relevant to material classes A and B.

Single Burning Item

The Single Burning Item (SBI), is a method of test for determining the reaction to fire behaviour of building products (excluding floorings) when exposed to the thermal attack by a single burning item.

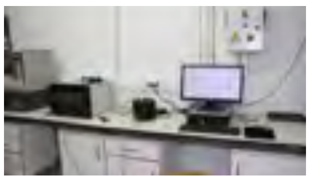
Thermal equipment

Hot Box

The guarded hot box apparatus is used for determining the steady-state thermal transmittance and thermal conductance of construction elements.

Thermal Conductivity Measurements

This equipment allows to simultaneously determine thermal conductivity, thermal diffusivity and specific heat capacity from a single measurement.



Thermographic Cameras

Two thermal imaging cameras with a temperature range of -40 ºC to +2000 ºC.

<table>
<tr><th colspan="2">Mechanical testing machines</th></tr>
<tr><td>Compression Testing Machine

Technical Data:
– Test force 3000 KN;
– Ram travel 100 mm;
– Test chamber height 1000 mm.
Main tests:
– Concrete According NP EN 12390; NP EN 12504;
– Elastic modulus calculation;
– Bending tests</td><td></td></tr>
<tr><td>Servo-hydraulic Dynamic Testing Machine

Technical Data:
– Max. test load ± 600 KN;
– Accuracy class 0.02;
– Reproducibility error ±0.003%.</td><td></td></tr>
<tr><td>Actuator System - Double Acting

For static and dynamic testing of components and structures.
Technical Data:
– Compression capacity: 2000 KN (at 250 bar);
– Tension capacity: 1000 KN (at 250 bar).</td><td></td></tr>
<tr><th colspan="2">Data acquisition equipment</th></tr>
<tr><td>High Speed Camera

Provide 1,280 by 1,024 pixel resolution to 4,000 frames per second (fps) and reduced resolution operation all the way to 800,000 fps, with 1,280(H) by 720 (V), equivalent to 720 HD video resolution, to 6,400 fps.</td><td></td></tr>
<tr><td>Data Acquisition Systems

– 8-channel universal data logger;
– K thermocouples data logger, with 16-channels;
– Strain gauge bridge amplifier;
– Inductive displacement transducer;
– Precise load cell for tensile and compressive forces with high and dynamic oscillation width, 500 kN;
– Load cell with high nominal rated forces, for the measurement of static and dynamic pressure forces, 2MN.</td><td></td></tr>
<tr><th colspan="2">Vehicles</th></tr>
<tr><td>Forklift

Technical Data:
– Lift Capacity: 3000 kg
– Max lift height: 6 000 mm
– Energy: Electric
– Engine Power: 11 KW</td><td></td></tr>
</table>

FireFurnace building	
To place the furnaces	

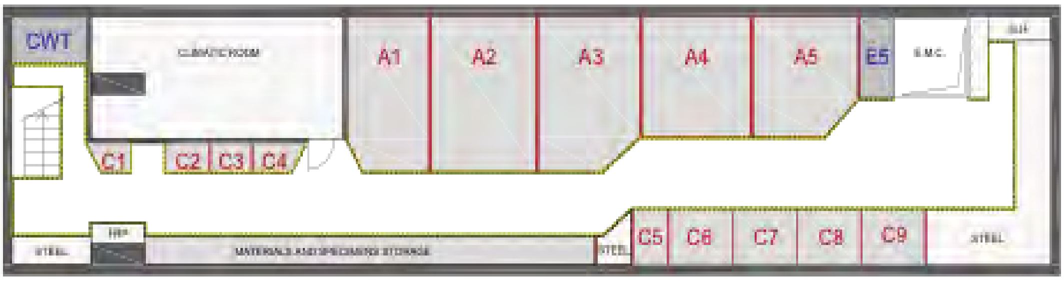
The laboratories in Guimarães have about 1600 sqm, with two areas each one with a strong floor and a reaction wall. Some of these facilities are in the new Institute on Bio-Sustainability (IB-S). The facilities at UMinho support the following activies:

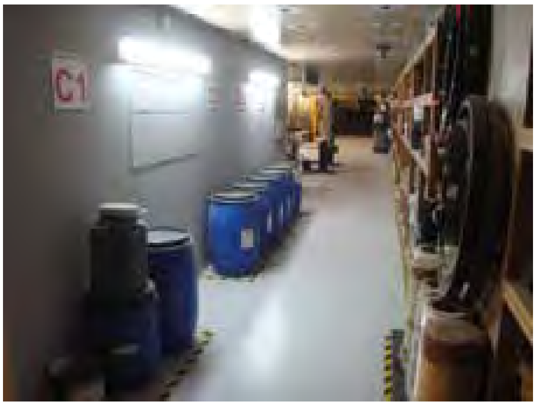
- Testing and consultancy work in civil engineering for public and private companies or institutions;
- Tests and works applied to research and development (R&D) and transfer of know-how for markets and industrial activities;
- Development of new products or solving problems for industry;
- Pedagogical tests and support in the scope of different curricular units.

Facilities

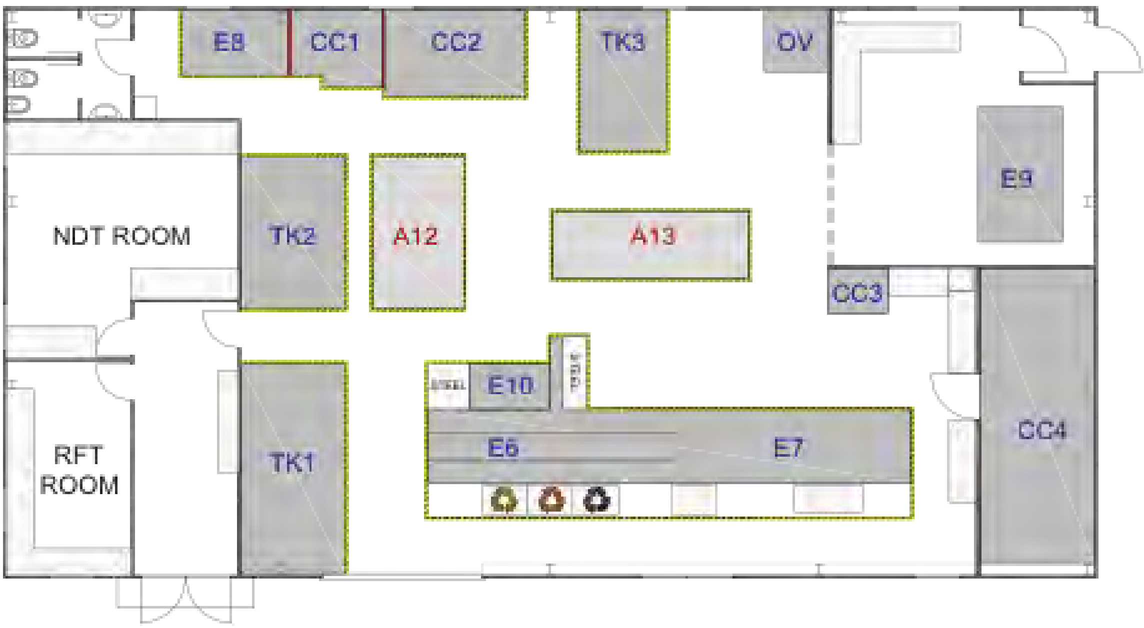
PAV1 is made by a heavily reinforced concrete slab of 450 mm thickness with a grid of holes of 90 mm diameter to clamp steel profiles and other devices, in order to serve as a reaction slab. Thick reinforced concrete walls at the contour of PAV1 give partial clamped support conditions to this RC slab, resulting a very stiff structure. PAV1 also includes a RC reaction wall, where specimens can be submitted to multiaxial load configurations. A room for the technical staff is also part of PAV1.

PAV2 is the basement of the laboratory PAV1 where we have the climatic room, some test areas and is dedicated, mainly, to the accommodation of materials and test specimens.





PAV3 includes the most recent equipments and is planned to have an area where students can carry out tests within the ambit of the lessons. PAV3 also includes rooms for the technical staff, researchers and to accommodate equipment of high precision (None Destructive Test room).



PAV4 is the area affected to Geotechnical equipment and classes, also includes rooms for the technical staff, researchers and to accommodate equipment of high precision.

IB-S is made by a heavily reinforced concrete slab with a grid of holes of 90 mm diameter to clamp steel profiles and other devices, in order to serve as a reaction slab. This pavilion also includes a RC reaction wall, where specimens can be submitted to multiaxial load configurations.

Equipments

The laboratory is equipped with several servo-controlled equipments for tests that need to be executed under force or deflection control:

- A servo-controlled biaxial machine (2000 kN in compression and 200 kN in tension).
- A load frame for servo-controlled compression tests (2500 kN).
- A modern fatigue machine (+/-1000 kN).
- Adaptive five steel reaction frames, allowing to carry out all types of test configurations under force or deflection control including materials characterization standard tests (Modulus of elasticity, Compressive strength, Tensile strength, Flexural strength, Shear strength, Friction angles).
- A Pre-stress system.
- Four climatic chambers, and one climatic room with controlled humidity and temperature for conducting durability tests and time-dependent behavior of materials and structural systems;

- It is equipped with several data acquisition (analogue and digital) systems, Lvdt´s, accelerometers load cells, allowing a wide range of field tests.
- It has advanced non-destructive test equipment for structural inspection and diagnosis such as the Ground-Penetrating Radar, Pylodin (hardness timber test), Tico (ultrasound test), Hygrometer, Registograph, Digital camera, Laser range meter, Rebar detector, Boroscopy camera, Ultrasonic test equipment, Temperature humidity data logger, Flatjack tests, Pull-out and pull-off tests.
- It is prepared to define, install and analyze the data from structural health monitoring systems.
- It has geotechnical equipment to perform general geotechnical characterization: particle size distribution (shakers and sieves – American and European series); sedimentation tests (heating plate, electric stirrer, glass beakers, digital thermometer and hydrometer); equivalent sand test, determination of Atterberg limits (motorized Casagrande shell, plotter, glass plate, glass and cone penetrometer); density in soils and rocks (weighters), determination of particle density (pycnometers, digital thermometer, oven); rock strength index (point load test apparatus); compaction test (Proctor and CBR compactor, molds).
- It is equipped with testing equipment for the mechanical characterization of soil and rocks, such as: consolidation tests (front loading oedometers and hydraulic cell (Rowe), linear displacement transducers and calibrated); Direct/residual shear strength apparatus; triaxial test (load frame, Bishop-Wesley cells, load cells, transducers, volume change apparatus, Hoek triaxial chamber for rock testing) and advanced measuring devices for shear modulus quantification (bender elements and accelerometers).
- It carries out in situ structural testing: bearing capacity of soils (plate loading tests), dynamic modal identification tests; vibrations tests; dynamic penetration tests (from light and heavy); in-place density and moisture content (nuclear density gauge test); dilatometer soil testing for stiffness and shear strength (Marchetti flat dilatometer probe); pore water pressure, shear and bearing capacity of soils (electronic piezocone penetration test probe).

Climatic test equipments

Climatic Chamber - Fitoclima

Main Characteristics:
- Temperature range [ºC] 22
- Humidity range [%] 55
- Dimensions [cm] 700x250x200

Climatic Chamber – Fitoclima 6400

Main Characteristics:
- Temperature range [ºC] -25 to +80
- Humidity range [%] 30 to 98 (±2)
- Dimensions [cm] 240x160x200

Climatic Chamber – Fitoclima 1500

Main Characteristics:
- Temperature range [ºC] -45 to +180
- Humidity range [%] 30 to 98 (±2)
- Dimensions [cm] 205x129x225

Climatic Chamber – Fitoclima 1000

Main Characteristics:
- Temperature range [ºC] -45 to +180
- Humidity range [%] 30 to 98 (±2)
- Dimensions [cm] 204x130x183

Mechanical tests equipment

Adaptive steel reaction frame - E7

Main Characteristics:
- Allow to carry out all types of test configurations under force or deflection control.
- Pre-stress system included.
- 1000kN maximum capacity (different actuators and load cells can be used)
- Allow to carry out fatigue an biaxial tests.


Fatigue machine – E9

Main Characteristics:
- Allow to carry out all types of test configurations under force or deflection control including materials characterization standard tests (Modulus of elasticity, Compressive strength, Tensile strength, Flexural strength, Shear strength, Friction angles and Fatigue tests).
- 1000kN maximum capacity (2000, 200, 50kN Load cells)
- Clamps (1000kN and 200kN).
- DAQ System to record several strain-gauges and LVDT´s.


Vehicles

Van

Forklift

Technical Data:
- Lift Capacity: 1500 kg
- Max lift height: 3 000 mm
- Energy: gas (Diesel)

Testing systems	
Testing system E1 Test zone with a steel frame of 50 kN load capacity, to which a servo-actuator of 25 kN is connected. This servo-actuator is commanded by SENTUR II	
Testing system E2 Test zone with a steel frame of 600 kN load capacity, to which a servo-actuator of 550 kN is connected. This servo-actuator is commanded by SENTUR II	
Testing system E3 Test zone for continuous (two or more spans) structures. Two steel frames are available, each one of 100 kN capacity. Servo-actuators can be installed in these steel frames. These servo-actuators are commanded by SENTUR IV.	
Testing system E4 Test zone with a steel frame of 1000 kN load capacity, to which servo-actuators can be connected. These servo-actuator are commanded by SENTUR V. The geometry of the reaction frame is included in the figure.	
Testing system E5 Test zone for biaxial tests using the reaction frame. The servo-actuators are commanded by SENTUR III.	

Testing system E6 Test zone for biaxial tests using the reaction frame. The servo-actuators are commanded by SENTUR III.	
Testing system E8 Load frame for compression tests (2500 kN in close-loop control; 5000 kN in pressure control).	

EVENTS AND AWARDS

ISISE is an active institute that promotes investigation and the transmission of knowledge. Therefore, between 2014 and 2016 there were twenty-one Workshops, eleven Courses and several Seminars, Conferences, Training Schools, Meetings, Ceremonies, Congresses, Symposiums, Lectures and Expositions.

Following there are some of thoses:

2014		
Events	Designation	Date
Workshop	Impact on Steel Connections	Jan-14
Ceremony	Graduation ceremony for master students of the SUSCOS program	Feb-14
Workshop	INFASO + "Valorization of Knowledge for Innovative Fastening Solution between Steel and Concrete"	Mar-14
Workshop	Railway 2014-S06, Special Session: Geotechnical Aspects in Rail-Track Performance	Apr-14
Meeting	ECCS TC10, CONNECTIONS	Apr-14
Course	Building Information Modelling	Feb to Apr-14
Seminar	fib Commission 5 Seminar on Durability of Concrete Structures	May-14
Conference	9th International Masonry Conference	Jul-14
Lecture	Lectures from Prof. Fumio Tatsuoka, International Specialist in Geotechnics	Sep-14
Seminar	2nd Seminar on the Project of Reinforced Concrete Structures with FRP's (SPREB-FRP 2014)	Sep-14
Conference	9th International Conference on Structural Analysis of Monuments and Historical Constructions	Oct-14
Course	Building Information Modelling - 2nd Edition	Oct to Dec-14
Course	International intensive course focuses on steel structures and sustainable development	Oct-14
Workshop	2nd Workshop on the Industrial Application of Friction Stir Welding Technologies	Oct-14
Course	Offshore Structures	May-14
Workshop	Design of dissipative joints for seismic resistant steel frames	Jun-14
Workshop	3rd PhD Students Workshop Sweden-Portugal	Oct-14
Workshop	Workshop LVS3	Dec-14

2015		
Events	Designation	Date
Course	Advanced Course in "Reliability and Risk Analysis"	Feb-15
Workshop	Workshop on Trends and Challenges for Wind Energy Harvesting ISISE Day-Out and 6th PhD Workshop 2015	Mar-15 Apr-15
Workshop	1st Workshop of COST Action TU1404	Apr-15
Course	Offshore Structures Course	May-15
Training School	FP1101 and RILEM TC 245 RTE Training School - Assessment and Reinforcement of timber elements and structures	May-15
Workshop	HISTWIN+ Workshop: Dissemination of results from HISTWIN+ project and introduction in Design according to Eurocodes	Sep-15
Workshop	Steelprost DEMO project	Sep-15
Meeting	Joint TMB/PMB & Networking Meeting	Sep-15
Conference	8th International Conference on Advances in Steel Structures	Jul-15
Seminar	Paredes de Alvenaria: Reabilitação e Inovação	Jun-15
Workshop	III Workshop of the PhD Students in Civil	Oct-15
Seminar	3.º Seminário sobre o Projeto de Reforço de Estruturas de Betão com FRP's (SPREB-FRP 2015)	Sep-15
Course	3rd Edition of the Building Information Modeling Course	Sep to Dec-15
Seminar	Safeguarding earthen cultural heritage in Peru	Jun to Jul-15
Exposition	Guimarães Noc Noc: Casa Guimarães + Verde	Oct-15
Workshop	1st Workshop of COST Action TU 1406	Sep-15
Symposium	Engineered skins 2015 – Recent developments in Glass and Façade Engineering research at the University of Cambridge - Annual Symposium hosted by the Glass and Façade Technology Research Group at Cambridge University	Sep-15
Workshop	Workshop on Traffic noise: measurements, simulation and mitigation	Oct-15
Meeting	COST TU 1403 Adaptive Façade Network	Sep-15
Workshop	HISTWIN+ International Workshop	Nov-15 & Dec-15
Conference	CM14 - National Conference on Steel Structures	Nov-15
Congress	X Congresso de Construção Metálica e Mista	Nov-15

2015		
Events	Designation	Date
Ceremony	European Commissioner for Research, Science and Innovation as part of the celebrations of 40 years of the first graduates of DEC-UC.	Nov-15
Workshop	2nd Workshop of COST Action TU 1406 - An overview of Key Performance Indicators across Europe and Overseas	Mar-16 & Apr-16
Course	Training Course on Design of Offshore Structures	May-16
Workshop	SAFEBRICTILE workshop	May-16
Course	Advanced Course in Materials, Techniques and Design Approaches for the Structural Strengthening	Jun-16
Workshop	EQUALJOINTS workshop	Jun-16
Training School	COST TU1404 – Service life of cement-based Materials and Structures Materials, Systems and Structures in Civil Engineering – MSSCE 2016. Segment of COST Action	Aug-16
Conference	TU1404 “Service Life of Cement-Based Materials and Structures”	Aug-16
Conference	3rd International conference on Transportation Geotechnics (3rd ICTG 2016)	Sep-16
Training School	COST TU1406 – Performance-based assessment of existing road bridges	Sep-16
Seminar	Seminário Reabilitação de Fachadas	Sep-16
Course	Building Information Modeling (BIM)	Sep to Nov-16
Workshop	AEOLUS4FUTURE WORKSHOP: Sustainability and life cycle assessment	Oct-16
Workshop	WG 2 and WG 3 Workshop of COST TU 1406	Oct-16
Course	Erasmus Mundus ELARCH Master Course	Oct-16

2016		
Events	Designation	Date
Workshop	2nd Workshop of COST Action TU 1406 - An overview of Key Performance Indicators across Europe and Overseas	Mar-16 & Apr-16
Course	Training Course on Design of Offshore Structures	May-16

2016		
Events	Designation	Date
Workshop	SAFEBRICTILE workshop	May-16
Course	Advanced Course in Materials, Techniques and Design Approaches for the Structural Strengthening	Jun-16
Workshop	EQUALJOINTS workshop	Jun-16
Training School	COST TU1404 – Service life of cement-based Materials and Structures Materials, Systems and Structures in Civil Engineering – MSSCE 2016. Segment of COST Action	Aug-16
Conference	TU1404 "Service Life of Cement-Based Materials and Structures"	Aug-16
Conference	3rd International conference on Transportation Geotechnics (3rd ICTG 2016)	Sep-16
Training School	COST TU1406 – Performance-based assessment of existing road bridges	Sep-16
Seminar	Seminário Reabilitação de Fachadas	Sep-16
Course	Building Information Modeling (BIM)	Sep to Nov-16
Workshop	AEOLUS4FUTURE WORKSHOP: Sustainability and life cycle assessment	Oct-16
Workshop	WG 2 and WG 3 Workshop of COST TU 1406	Oct-16
Course	Erasmus Mundus ELARCH Master Course	Oct-16

Between 2014 and 2016 there were also time for recognition among the members of the Institute and by external entities recognizing the high level of the research developed by the ISISE members, namely:

- *Vasconcelos, G., Fernandes, F.M., Alves, C., Ramos, L.F. (2014). "Assessment of the stability conditions of an ancient stone masonry tower." REHAB 2014 – International Conference on Preservation, Maintenance and Rehabilitation of Historic Buildings and Structures (REHAB 2014), 19th – 21th March, Tomar, Portugal*. doi 10.14575glrehab2014104. received the best paper award.

- The Best Presentation Award, in the scope of the II Workshop of the PhD Students in Civil Engineering, University of Minho, September 2014 was awarded to Chrysl Aranha.

- *J. Sena-Cruz, P. Silva, P. Fernandes, M. Coelho, M. Azenha, A. Benedetti, J. Granja: - Next Generation Design Guidelines for Composites in Construction with the poster entitled "CutInDur – Longterm structural and durability performance of concrete elements strengthened with the NSM technique"*. won 1st place on the poster competition held in the scope of the COST Action TU1207, Kaiserslautern, Germany, October 2014.

- *Granja, J., Azenha M., Sousa, C., Faria, R. and Barros, J. (2014) "Hygrometric Assessment of Internal Relative Humidity in Concrete: Practical Application Issues" (http://dx.doi.org/10.3151/jact.12.250)*. was awarded by the Japanese Concrete Institute 2015, in recognition for their contribution to the Journal of Advanced Concrete Technology.

- The Director of ISISE, Luís Simões da Silva, was elected Member of the Portuguese Academy of Engineering. The ceremony took place during the commemorative session of the Engineering Academy Day, December 2014.

- Chrysl Aranha was awarded with the Best Presentation Award in the ISISE Day-Out and 6th PhD Workshop, April 2015.

- *Lourenço, P. B., Abrams, D. P. Mendes, N., Costa, A. A., Costa, A. C. (2015) "Challenges in modeling out-of-plane seismic response of existing masonry buildings", May 2015.* won the Best Paper Award in the Fifteenth North American Masonry Conference.

- The Institution of Structural Engineers (UK) in Annual People awarded Ashkan Shahbazian and Yong Wang and Papers Awards Luncheon 2015 with the Henry Adams Award for the best research and development paper entitled "*Performance-based fire resistance design method for wall panel assemblies using thin-walled steel sections", June 2015*.

- António Gomes Correia delivered the 33rd Manuel Rocha Lecture in October 2016, at the Calouste Gulbenkian Foundation, in Lisbon, entitled: "*Development and Innovation in Transportation Geotechnics*". Manuel Rocha Memorial Lectures are given annually, by academics and researchers judged to be the leaders in their chosen field. The Portuguese Geotechnical Society and the Geotechnical Association of Alumni of the New University of Lisbon organize this lecture series each year, since 1984. This lecture series commemorates the distinguished professional career of Manuel Rocha, firstly by its own contributions as a scholar and as consultant engineer, and secondly through the impact of the National Laboratory of Civil Engineer, which he created. He was one of the founders of the International Society for Rock Mechanics (ISMR), its second president (1966-1970) and the chairman of the first congress of the ISRM (Lisbon, 1966).

- Japanese Concrete Institute Award of 2015 was attributed to the paper: J. Granja, M. Azenha, C. Sousa, R. Faria, J. Barros (2014) "*Hygrometric Assessment of Internal Relative Humidity in Concrete: Practical Application Issues". Journal of Advanced Concrete Technology, vol. 12 (8), pp. 250-265*. http://dx.doi.org/10.3151/jact.12.250.

- Former SAHC student and former PhD student at University of Minho, Susana Moreira, received the 2016 Best Doctoral Dissertation Award from The Masonry Society, USA.

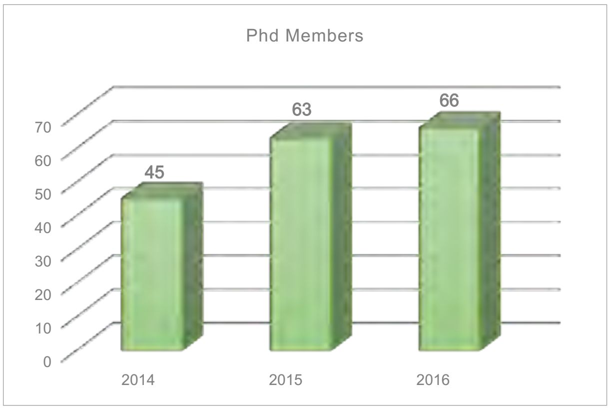
- Luís Simões da Silva awarded an honorable mention resulting from the activities and initiatives of entrepreneurship related to new research projects and other research and development initiatives and activities (R & D activities).

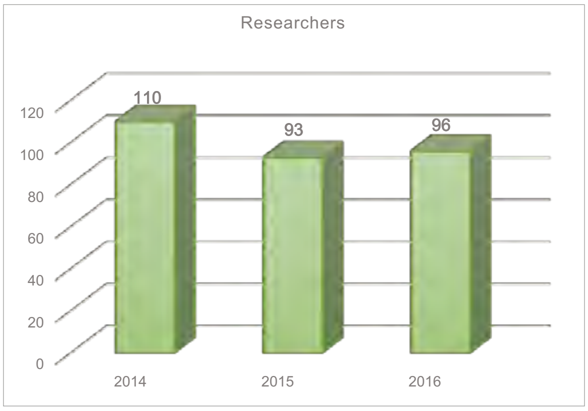
isise

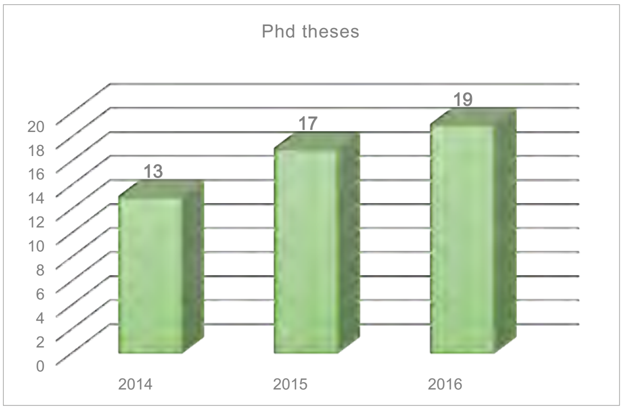
IN NUMBERS

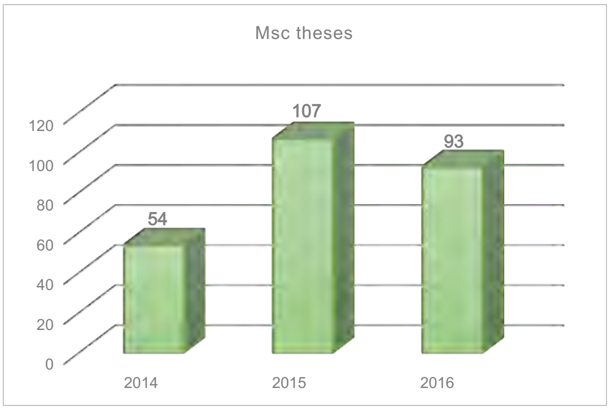
The scientific results and outputs are illustrated in the following graphics. From 2014 to 2016 the number of members increased. Although among PhD members and researchers the difference is seven, there are twenty-one more PhD members, which corresponds to a growth of about 50% compared to 2014. In addition, the number of papers in ISI journals rose from 92, in 2014, to 122, in 2016. A global ratio of 1.85 papers in peer-reviewed journals listed in SCI per PhD member per year was attained in 2016, which is an excellent result in the field of Civil Engineering.

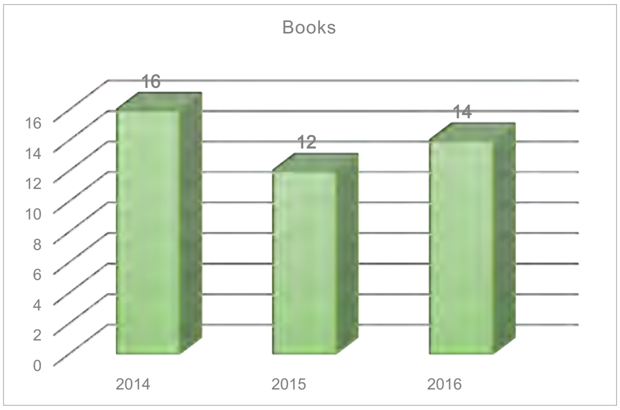
The number of PhD and Master Theses concluded each year is also quite expressive, making a total of 49 and 254 theses between 2014 and 2016, respectively. As for published books, there is an average of fourteen per year. The cooperation with industry is another strong point of ISISE, proved by the number of patents in the last three years, eight between 2014 and 2016.

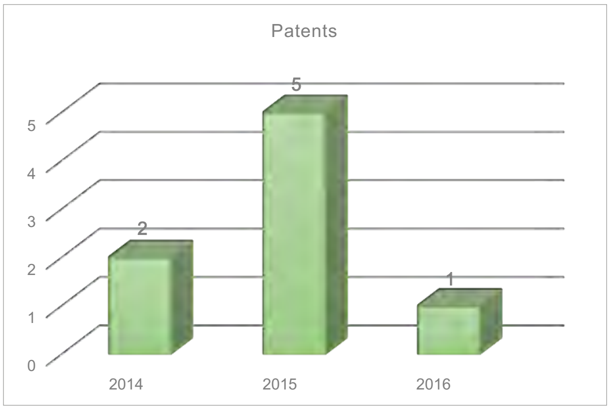








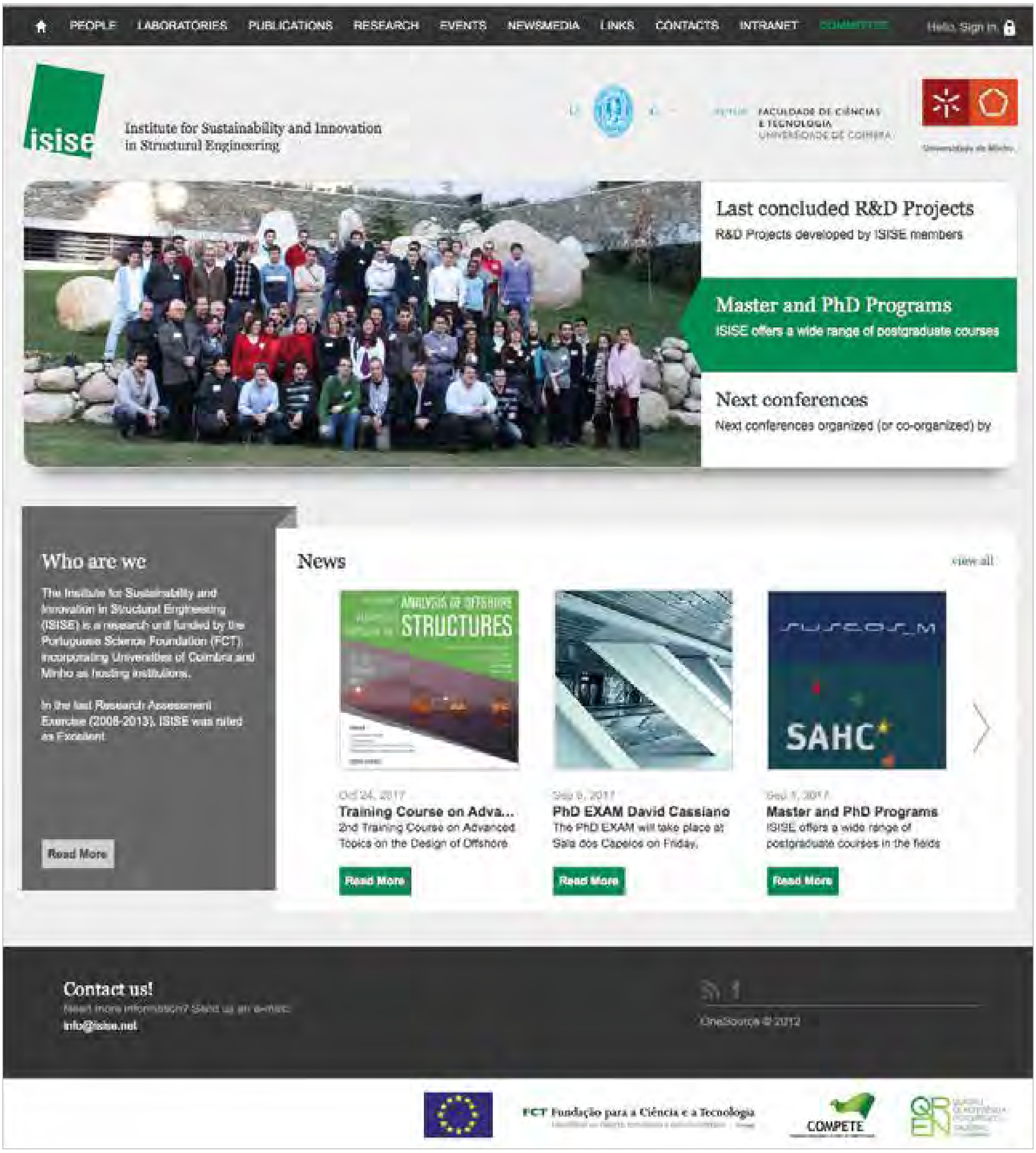

Books
16
12
14
16
14
12
10
8
6
4
2
0
2014
2015
2016


Patents
5
2
1
5
4
3
2
1
0
2014
2015
2016

ONLINE

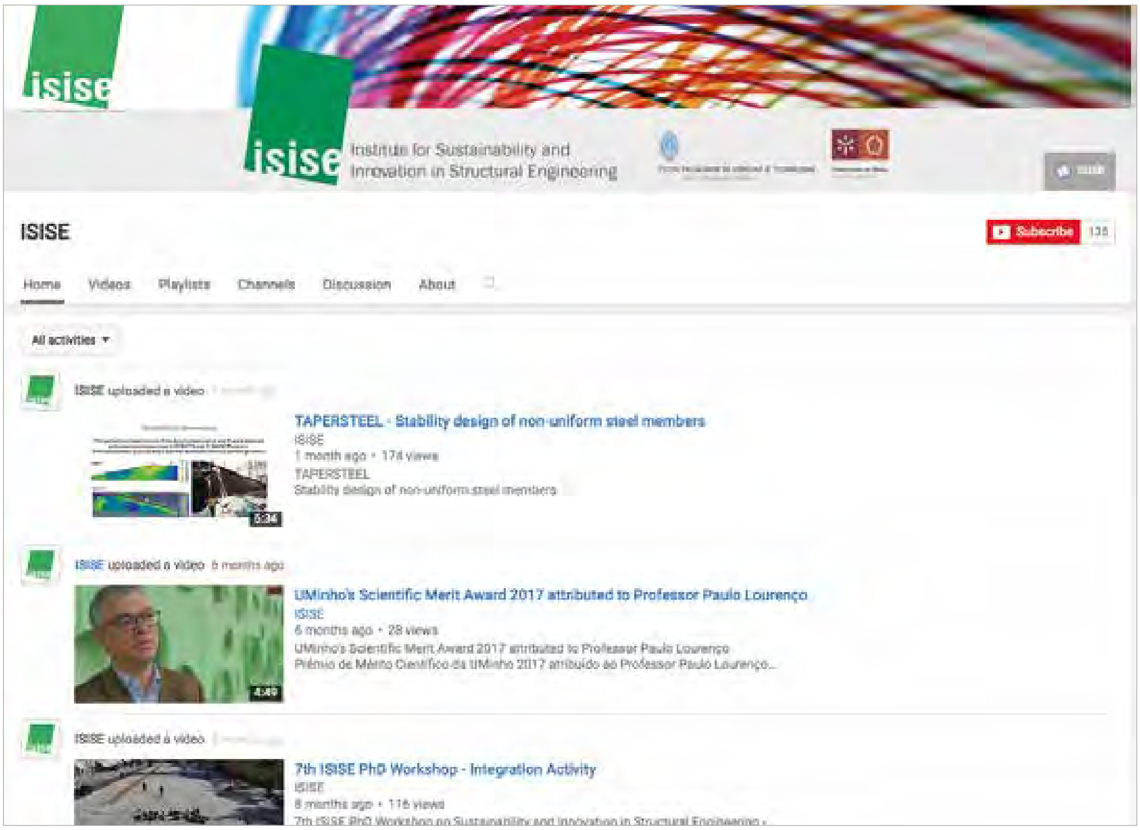
The usage of electronic communication platforms was extended from the biannual newsletters and triennial report to a Facebook page with over 13,000 friends and a Youtube channel subscribed by more the 120 users. Thus, you can find ISISE online @

www.isise.net



https://www.facebook.com/isise.net

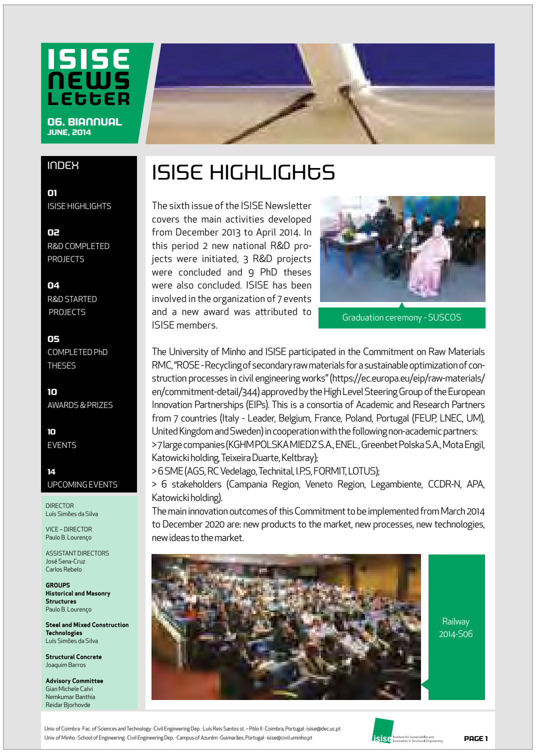
https://www.youtube.com/isisechannel



NEWSLETTER

The **ISISE Newsletter** is a biannual publication where the activities, events, projects and relevant achievements of the ISISE group and members are given to known. During the period to which this report relates six newsletters were published. From those, the following highlights were extracted.

06. June 2014


ISISE NEWS LETTER
06. BIANNUAL
JUNE, 2014

INDEX

01 ISISE HIGHLIGHTS
02 R&D COMPLETED PROJECTS
04 R&D STARTED PROJECTS
05 COMPLETED PhD THESES
10 AWARDS & PRIZES
10 EVENTS
14 UPCOMING EVENTS

DIRECTOR
Luís Simões da Silva

VICE - DIRECTOR
Paulo B. Lourenço

ASSISTANT DIRECTORS
José Sena-Cruz
Carlos Rebelo

GROUPS
Historical and Masonry Structures
Paulo B. Lourenço

Steel and Mixed Construction Technologies
Luís Simões da Silva

Structural Concrete
Joaquim Barros

Advisory Committee
Gian Michele Calvi
Nemkumar Banthia
Reidar Bjorhovde

ISISE HIGHLIGHTS

The sixth issue of the ISISE Newsletter covers the main activities developed from December 2013 to April 2014. In this period 2 new national R&D projects were initiated, 3 R&D projects were concluded and 9 PhD theses were also concluded. ISISE has been involved in the organization of 7 events and a new award was attributed to ISISE members.

Graduation ceremony - SUSCOS

The University of Minho and ISISE participated in the Commitment on Raw Materials RMC, "ROSE - Recycling of secondary raw materials for a sustainable optimization of construction processes in civil engineering works" (https://ec.europa.eu/eip/raw-materials/en/commitment-detail/344) approved by the High Level Steering Group of the European Innovation Partnerships (EIPs). This is a consortia of Academic and Research Partners from 7 countries (Italy - Leader, Belgium, France, Poland, Portugal (FEUP, LNEC, UM), United Kingdom and Sweden) in cooperation with the following non-academic partners:
>7 large companies (KGHM POLSKA MIEDZ S.A., ENEL , Greenbet Polska S.A., Mota Engil, Katowicki holding, Teixeira Duarte, Keltbray);
>6 SME (AGS, RC Vedelago, Technital, I.P.S, FORMIT, LOTUS);
> 6 stakeholders (Campania Region, Veneto Region, Legambiente, CCDR-N, APA, Katowicki holding).
The main innovation outcomes of this Commitment to be implemented from March 2014 to December 2020 are: new products to the market, new processes, new technologies, new ideas to the market.

Railway 2014-S06

Univ. of Coimbra · Fac. of Sciences and Technology · Civil Engineering Dep. · Luís Reis Santos st. – Pólo II · Coimbra, Portugal · isise@dec.uc.pt
Univ. of Minho · School of Engineering · Civil Engineering Dep. · Campus of Azurém · Guimarães, Portugal · isise@civil.uminho.pt
isise Institute for Sustainability and Innovation in Structural Engineering
PAGE 1

The sixth issue of the ISISE Newsletter covers the main activities developed from December 2013 to April 2014. In this period 2 new national R&D projects were initiated, 3 R&D projects were concluded and 9 PhD theses were also concluded. ISISE has been involved in the organization of 7 events and a new award was attributed to ISISE members.

The University of Minho and ISISE participated in the Commitment on Raw Materials RMC, "ROSE - Recycling of secondary raw materials for a sustainable optimization of construction processes in civil engineering works" (https://ec.europa.eu/eip/raw-materials/en/commitment-detail/344) approved by the High Level Steering Group of the European Innovation Partnerships (EIPs).This is a consortia of Academic and Research Partners from 7 countries (Italy - Leader, Belgium, France, Poland, Portugal (FEUP, LNEC, UM), United Kingdom and Sweden) in cooperation with the following non-academic partners:

- 7 large companies (KGHM POLSKA MIEDZ S.A., ENEL , Greenbet Polska S.A., Mota Engil, Katowicki holding, Teixeira Duarte, Keltbray);
- 6 SME (AGS, RC Vedelago, Technital, I.P.S, FORMIT, LOTUS);
- 6 stakeholders (Campania Region, Veneto Region, Legambiente, CCDR-N, APA, Katowicki holding).

The main innovation outcomes of this Commitment to be implemented from March 2014 to December 2020 are: new products to the market, new processes, new technologies, new ideas to the market.

07. November 2014

COST Action TU1404 – "Towards the next generation of standards for service life of cement-based materials and structures".

A new COST Action, whose application has been led by ISISE member Miguel Azenha, has been recently approved. The Action is named TU1404 - "Towards the next generation of standards for service life of cement-based materials and structures", and currently involves 22 EU countries. The official kick-start of the Action occurs in November 21st at the first meeting of its Management Committee. Additional information in: http://www.cost.eu/domains_actions/tud/Actions/TU1404


ISISE NEWS LETTER
07. BIANNUAL
NOVEMBER, 2014

INDEX
01 ISISE HIGHLIGHTS
02 R&D COMPLETED PROJECTS
06 R&D STARTED PROJECTS
06 COMPLETED PhD THESES
09 ISISE TECHNOLOGIES
10 AWARDS & PRIZES EVENTS
15 UPCOMING EVENTS

DIRECTOR
Luís Simões da Silva
VICE - DIRECTOR
Paulo B. Lourenço
ASSISTANT DIRECTORS
José Sena-Cruz
Carlos Rebelo
GROUPS
Historical and Masonry Structures
Paulo B. Lourenço
Steel and Mixed Construction Technologies
Luís Simões da Silva
Structural Concrete
Joaquim Barros
Advisory Committee
Gian Michele Calvi
Nemkumar Banthia
Reidar Bjorhovde

ISISE HIGHLIGHTS

COST Action TU1404 – "Towards the next generation of standards for service life of cement-based materials and structures".

A new COST Action, whose application has been led by ISISE member Miguel Azenha, has been recently approved. The Action is named TU1404 - "Towards the next generation of standards for service life of cement-based materials and structures", and currently involves 22 EU countries. The official kick-start of the Action occurs in November 21st at the first meeting of its Management Committee. Additional information in: http://www.cost.eu/domains_actions/tud/Actions/TU1404?

FCT Evaluation 2013 – Visit of Evaluation Panel, Department of Civil Engineering at University of Coimbra, 8th October 2014

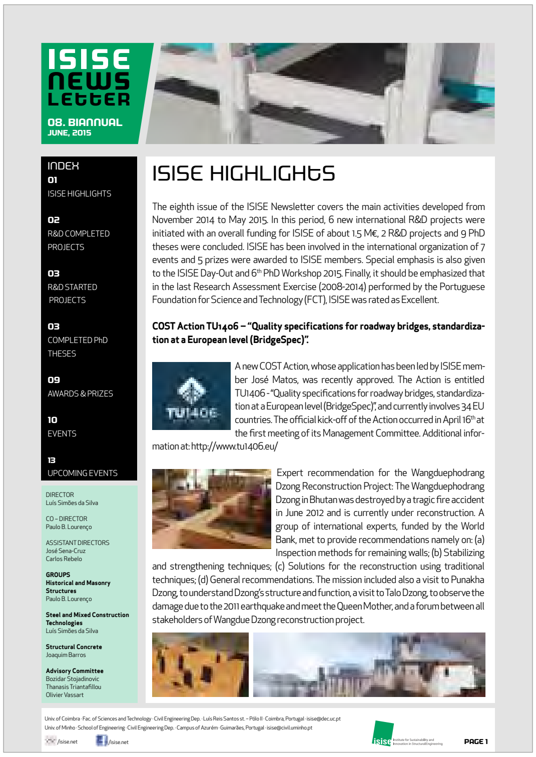
After notification of the first stage evaluation results ISISE was recommended to proceed to the second stage, that included the visit of the Evaluation Panel to the Department of Civil Engineering of the University of Coimbra on the 8th of October 2014. The panel members, Prof. William Powrie, Prof. Laurie Boswell and Prof. Barry Clarke accompanied by the FCT representative Dra. Maria Luís Serra were given the opportunity to clarify any unclear aspects of the written proposal submitted by ISISE in the first stage and also to visit the laboratories. During the visit the Evaluation Panel met the ISISE director and vice-director, leaders of the research groups and members of the research staff including permanent University staff and Post-doc and PhD students working in both universities of Coimbra and Minho. The visit was concluded with a Lunch where the Director and Vice-Director of the Faculty of Sciences and Technology of the Unversity of Coimbra were also present.

Univ. of Coimbra · Fac. of Sciences and Technology · Civil Engineering Dep. · Luís Reis Santos st. – Pólo II · Coimbra, Portugal · isise@dec.uc.pt
Univ. of Minho · School of Engineering · Civil Engineering Dep. · Campus of Azurém · Guimarães, Portugal · isise@civil.uminho.pt
PAGE 1

FCT Evaluation 2013 – Visit of Evaluation Panel, Department of Civil Engineering at University of Coimbra, 8th October 2014

After notification of the first stage evaluation results, ISISE was recommended to proceed to the second stage, which included the visit of the Evaluation Panel to the Department of Civil Engineering of the University of Coimbra on the 8th of October 2014. The panel members, Prof. William Powrie, Prof. Laurie Boswell and Prof. Barry Clarke accompanied by the FCT representative Dra. Maria Luís Serra were given the opportunity to clarify any unclear aspects of the written proposal submitted by ISISE in the first stage and also to visit the laboratories. During the visit the Evaluation Panel met the ISISE director and vice-director, leaders of the research groups and members of the research staff including permanent University staff and Post-doc and PhD students working in both universities of Coimbra and Minho. The visit was concluded with a lunch where the Director and Vice-Director of the Faculty of Sciences and Technology of the University of Coimbra were also present.

08. June 2015


ISISE NEWS LETTER
08. BIANNUAL
JUNE, 2015

INDEX
01 ISISE HIGHLIGHTS
02 R&D COMPLETED PROJECTS
03 R&D STARTED PROJECTS
03 COMPLETED PhD THESES
09 AWARDS & PRIZES
10 EVENTS
13 UPCOMING EVENTS

DIRECTOR
Luís Simões da Silva
CO - DIRECTOR
Paulo B. Lourenço
ASSISTANT DIRECTORS
José Sena-Cruz
Carlos Rebelo
GROUPS
Historical and Masonry Structures
Paulo B. Lourenço
Steel and Mixed Construction Technologies
Luís Simões da Silva
Structural Concrete
Joaquim Barros
Advisory Committee
Bozidar Stojadinovic
Thanasis Triantafillou
Olivier Vassart

ISISE HIGHLIGHTS

The eighth issue of the ISISE Newsletter covers the main activities developed from November 2014 to May 2015. In this period, 6 new international R&D projects were initiated with an overall funding for ISISE of about 1.5 M€, 2 R&D projects and 9 PhD theses were concluded. ISISE has been involved in the international organization of 7 events and 5 prizes were awarded to ISISE members. Special emphasis is also given to the ISISE Day-Out and 6th PhD Workshop 2015. Finally, it should be emphasized that in the last Research Assessment Exercise (2008-2014) performed by the Portuguese Foundation for Science and Technology (FCT), ISISE was rated as Excellent.

COST Action TU1406 – "Quality specifications for roadway bridges, standardization at a European level (BridgeSpec)".

A new COST Action, whose application has been led by ISISE member José Matos, was recently approved. The Action is entitled TU1406 - "Quality specifications for roadway bridges, standardization at a European level (BridgeSpec)", and currently involves 34 EU countries. The official kick-off of the Action occurred in April 16th at the first meeting of its Management Committee. Additional information at: http://www.tu1406.eu/

Expert recommendation for the Wangduephodrang Dzong Reconstruction Project: The Wangduephodrang Dzong in Bhutan was destroyed by a tragic fire accident in June 2012 and is currently under reconstruction. A group of international experts, funded by the World Bank, met to provide recommendations namely on: (a) Inspection methods for remaining walls; (b) Stabilizing and strengthening techniques; (c) Solutions for the reconstruction using traditional techniques; (d) General recommendations. The mission included also a visit to Punakha Dzong, to understand Dzong's structure and function, a visit to Talo Dzong, to observe the damage due to the 2011 earthquake and meet the Queen Mother, and a forum between all stakeholders of Wangdue Dzong reconstruction project.

Univ. of Coimbra · Fac. of Sciences and Technology · Civil Engineering Dep. · Luís Reis Santos st. – Pólo II · Coimbra, Portugal · isise@dec.uc.pt
Univ. of Minho · School of Engineering · Civil Engineering Dep. · Campus of Azurém · Guimarães, Portugal · isise@civil.uminho.pt
/isise.net /isise.net
PAGE 1

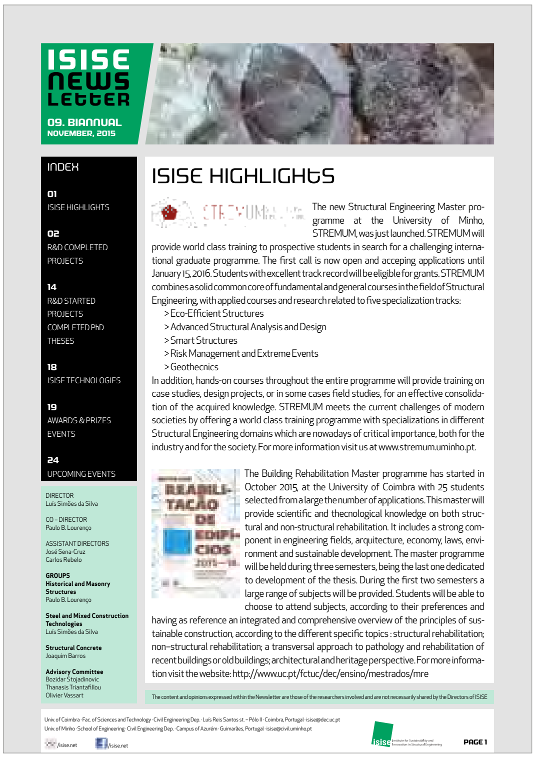
The eighth issue of the ISISE Newsletter covers the main activities developed from November 2014 to May 2015. In this period, 6 new international R&D projects were initiated with an overall funding for ISISE of about 1.5 M€, 2 R&D projects and 9 PhD theses were concluded. ISISE has been involved in the international organization of 7 events and 5 prizes were awarded to ISISE members. Special emphasis is also given to the ISISE Day-Out and 6th PhD Workshop 2015. Finally, it should be emphasized that in the last Research Assessment Exercise (2008-2014) performed by the Portuguese Foundation for Science and Technology (FCT), ISISE was rated as Excellent.

COST Action TU1406 – "Quality specifications for roadway bridges, standardization at a European level (BridgeSpec)".

A new COST Action, whose application has been led by ISISE member Jose Matos, was recently approved. The Action is entitled TU1406 - "Quality specifications for roadway bridges, standardization at a European level (BridgeSpec)", and currently involves 34 EU countries. The official kick-off of the Action occurred in April 16th at the first meeting of its Management Committee. Additional information at: http://www.tu1406.eu/

Expert recommendation for the Wangduephodrang Dzong Reconstruction Project: The Wangduephodrang Dzong in Bhutan was destroyed by a tragic fire accident in June 2012 and is currently under reconstruction. A group of international experts, funded by the World Bank, met to provide recommendations namely on: (a) Inspection methods for remaining walls; (b) Stabilizing and strengthening techniques; (c) Solutions for the reconstruction using traditional techniques; (d) General recommendations. The mission included also a visit to Punakha Dzong, to understand Dzong's structure and function, a visit to Talo Dzong, to observe the damage due to the 2011 earthquake and meet the Queen Mother, and a forum between all stakeholders of Wangdue Dzong reconstruction project.

09. November 2015


ISISE NEWS LETTER
09. BIANNUAL
NOVEMBER, 2015

INDEX
01 ISISE HIGHLIGHTS
02 R&D COMPLETED PROJECTS
14 R&D STARTED PROJECTS
COMPLETED PhD THESES
18 ISISE TECHNOLOGIES
19 AWARDS & PRIZES
EVENTS
24 UPCOMING EVENTS

DIRECTOR
Luís Simões da Silva
CO – DIRECTOR
Paulo B. Lourenço
ASSISTANT DIRECTORS
José Sena-Cruz
Carlos Rebelo
GROUPS
Historical and Masonry Structures
Paulo B. Lourenço
Steel and Mixed Construction Technologies
Luís Simões da Silva
Structural Concrete
Joaquim Barros
Advisory Committee
Bozidar Stojadinovic
Thanasis Triantafillou
Olivier Vassart

ISISE HIGHLIGHTS

The new Structural Engineering Master programme at the University of Minho, STREMUM, was just launched. STREMUM will provide world class training to prospective students in search for a challenging international graduate programme. The first call is now open and acceping applications until January 15, 2016. Students with excellent track record will be eligible for grants. STREMUM combines a solid common core of fundamental and general courses in the field of Structural Engineering, with applied courses and research related to five specialization tracks:
> Eco-Efficient Structures
> Advanced Structural Analysis and Design
> Smart Structures
> Risk Management and Extreme Events
> Geothecnics
In addition, hands-on courses throughout the entire programme will provide training on case studies, design projects, or in some cases field studies, for an effective consolidation of the acquired knowledge. STREMUM meets the current challenges of modern societies by offering a world class training programme with specializations in different Structural Engineering domains which are nowadays of critical importance, both for the industry and for the society. For more information visit us at www.stremum.uminho.pt.

The Building Rehabilitation Master programme has started in October 2015, at the University of Coimbra with 25 students selected from a large the number of applications. This master will provide scientific and thecnological knowledge on both structural and non-structural rehabilitation. It includes a strong component in engineering fields, arquitecture, economy, laws, environment and sustainable development. The master programme will be held during three semesters, being the last one dedicated to development of the thesis. During the first two semesters a large range of subjects will be provided. Students will be able to choose to attend subjects, according to their preferences and having as reference an integrated and comprehensive overview of the principles of sustainable construction, according to the different specific topics : structural rehabilitation; non–structural rehabilitation; a transversal approach to pathology and rehabilitation of recent buildings or old buildings; architectural and heritage perspective. For more information visit the website: http://www.uc.pt/fctuc/dec/ensino/mestrados/mre

The content and opinions expressed within the Newsletter are those of the researchers involved and are not necessarily shared by the Directors of ISISE

Univ. of Coimbra · Fac. of Sciences and Technology · Civil Engineering Dep. · Luís Reis Santos st. – Pólo II · Coimbra, Portugal · isise@dec.uc.pt
Univ. of Minho · School of Engineering · Civil Engineering Dep. · Campus of Azurém · Guimarães, Portugal · isise@civil.uminho.pt
/isise.net /isise.net
PAGE 1

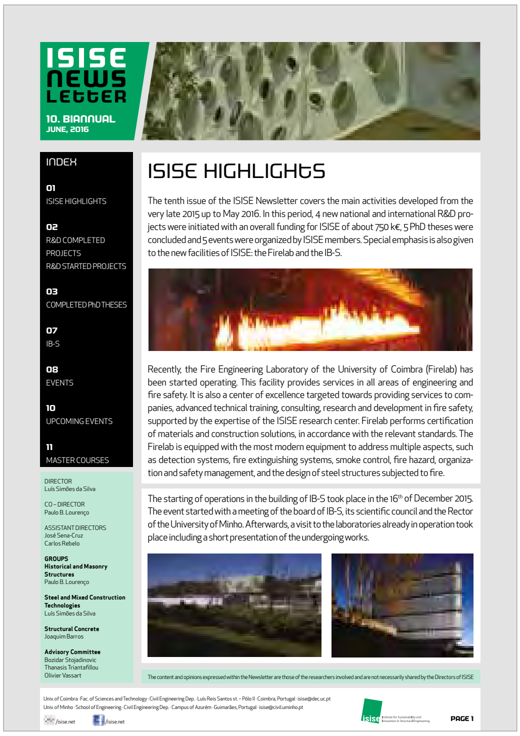
The new Structural Engineering Master programme at the University of Minho, STREMUM, was just launched. STREMUM will provide world class training to prospective students in search for a challenging international graduate programme. The first call is now open and acceping applications until January 15, 2016. Students with excellent track record will be eligible for grants. STREMUM combines a solid common core of fundamental and general courses in the field of Structural Engineering, with applied courses and research related to five specialization tracks:

- Eco-Efficient Structures
- Advanced Structural Analysis and Design
- Smart Structures
- Risk Management and Extreme Events
- Geothecnics

In addition, hands-on courses throughout the entire programme will provide training on case studies, design projects, or in some cases field studies, for an effective consolidation of the acquired knowledge. STREMUM meets the current challenges of modern societies by offering a world class training programme with specializations in different Structural Engineering domains which are nowadays of critical importance, both for the industry and for the society. For more information visit us at www.stremum.uminho.pt.

The Building Rehabilitation Master programme has started in October 2015, at the University of Coimbra with 25 students selected from a large the number of applications. This master will provide scientific and thecnological knowledge on both structural and non-structural rehabilitation. It includes a strong component in engineering fields, arquitecture, economy, laws, environment and sustainable development. The master programme will be held during three semesters, being the last one dedicated to development of the thesis. During the first two semesters a large range of subjects will be provided. Students will be able to choose to attend subjects, according to their preferences and having as reference an integrated and comprehensive overview of the principles of sustainable construction, according to the different specific topics : structural rehabilitation; non–structural rehabilitation; a transversal approach to pathology and rehabilitation of recent buildings or old buildings; architectural and heritage perspective. For more information visit the website: http://www.uc.pt/fctuc/dec/ensino/mestrados/mre

10. June 2016



The tenth issue of the ISISE Newsletter covers the main activities developed from the very late 2015 up to May 2016. In this period, 4 new national and international R&D projects were initiated with an overall funding for ISISE of about 750 k€, 5 PhD theses were concluded and 5 events were organized by ISISE members. Special emphasis is also given to the new facilities of ISISE: the Firelab and the IB-S.

Recently, the Fire Engineering Laboratory of the University of Coimbra (Firelab) has been started operating. This facility provides services in all areas of engineering and fire safety. It is also a center of excellence targeted towards providing services to companies, advanced technical training, consulting, research and development in fire safety, supported by the expertise of the ISISE research center. Firelab performs certification of materials and construction solutions, in accordance with the relevant standards. The Firelab is equipped with the most modern equipment to address multiple aspects, such as detection systems, fire extinguishing systems, smoke control, fire hazard, organization and safety management, and the design of steel structures subjected to fire.The starting of operations in the building of IB-S took place in the 16th of December 2015. The event started with a meeting of the board of IB-S, its scientific council and the Rector of the University of Minho. Afterwards, a visit to the laboratories already in operation took place including a short presentation of the undergoing works.

11. November 2016

The annual ISISE Day-Out and the PhD workshop were the most significant activities performed in the second semester of 2016. Nine PhD students presented their ongoing work to the 120 participants before a very successful outdoor activity in the downtown of Guimaraes. Videos are available in https://www.youtube.com/isisechannel. Also, in this period, nineteen new national and international R&D projects were started and two were concluded. Inside this newsletter the reader will find further details on this and on other achievements such as the nine PhD theses concluded in this period.

The 2016 ISISE Day-Out and 7th PhD Workshop took place last September 26th, at the University of Minho, Guimaraes, with more than 120 participants. This event is always a good way of interact and share experiences in-between ISISE members. Prof. Paulo B. Lourenco opened the event, while Prof. Luis Simoes da Silva made a short presentation about the main activities of ISISE. The invited speaker, Prof. Raul Fangueiro, gave a keynote lecture entitled

“Fibrous materials: challenges, opportunities and solutions”. Then the program include three sessions of Ph.D. presentations. During the afternoon, an integration activity took place, consisting of “treasure hunt” in the heart of Guimaraes. The event ended with the attribution of the “Best presentation award” to Slobodanka Jovasevic with a presentation entitled “In-situ bolted connections in lattice towers for wind energy converters”.

ISISE DAY OUT

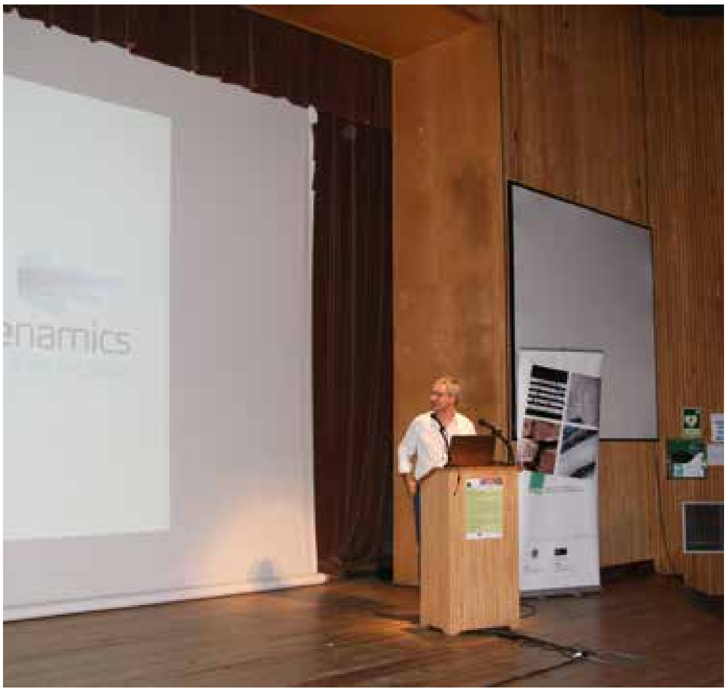
The **ISISE Day-Out** is an initiative that promotes the interaction between the ISISE members, as well as to have some nice time out of the workplace. The event involves some "brain teaser" activities, as well as scientific meetings. This led the members getting to know each other, encourages the sharing of knowledge and experiences, and even future partnerships.

Between the 16th and the 17th April of 2015 a joint event, the ISISE Day-Out and 6th PhD Workshop 2015 took place at Santa Cruz do Douro, Baião. There were over than 120 participants, among which the Advisory Committee of ISISE members, namely Prof. Olivier Vassart, Prof. Thanasis Triantafillou and Prof. Bozidar Stojadinovic.

The event started with a cruise between Oporto and Peso da Régua. During this trip "The Great Egg Drop" group activity was carried out. After arriving at Peso da Régua the group visited "Quinta da Pacheca", a wine producer property, and had the opportunity to know some of its history and the Oporto wine, as well as tasting different Oporto wines. The 6th PhD Workshop 2015 held at the Douro Palace Hotel, where several PhD students presented their current work.

The 2016 ISISE Day-Out and 7th PhD Workshop took place on 26th September of 2016, at the University of Minho, Guimarães, with more than 120 participants. Prof. Paulo B. Lourenço opened the event and Prof. Luís Simões da Silva did a short presentation about the main activities of ISISE. The invited speaker, Prof. Raúl Fangueiro, gave a keynote lecture entitled "Fibrous materials: challenges, opportunities and solutions". The program continued with three sessions of PhD presentations. During the afternoon, an integration activity took place, consisting of "treasure hunt" in the heart of the city of Guimarães, Portugal's birthplace. The event ended with the attribution of the "Best presentation award" to Slobodanka Jovasevic with the presentation entitled "In-situ bolted connections in lattice towers for wind energy".







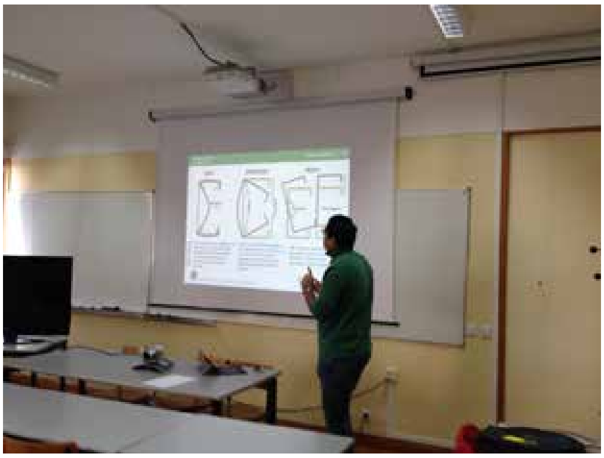




FRIDAY@ISISE

Friday@ISISE is an event organized by SMCT ISISE group, in cooperation with the Master and Doctoral courses in Steel and Composite Construction, which has been held regularly since 2015. In this event, researchers from ISISE and practicing engineers from different companies present their research work on several topics:

Date	Topic	Speaker
16-01-2015	Formulation and implementation of a 2D FEM Macro-Element for steel beam-to-column joints	Filippo Gentili
13-02-2015	Performance-based fire resistance, design method for wall panel assemblies, using thin-walled steel sections	Ashkan Shahbazian
13-03-2015	Impact and explosions in offshore structures – Analysis according the DNVRP-C204	Tiago Manco
24-04-2015	Experimental and numerical analysis of cold-formed steel columns at both ambient and fire conditions	Hélder Craveiro
05-06-2015	Consistent safety assessment among EC3: Stability design rules for columns, beams and beam-columns	Trayana Tankova
02-10-2015	Steel towers for wind turbines	Rui Matos
13-11-2015	A cyclic component based approach in steel beam-to-column end-plate joints	Hugo Augusto
08-01-2016	Steel and composite structures modelling	Pedro Vellasco
18-03-2016	Load distribution on timber-concrete composite floors	Sandra Monteiro
06-05-2016	Development and application of acoustic diffusers	Ricardo Patraquim
20-05-2016	Ultra low cycle fatigue of steel under cyclic high-strain loading conditions	João Pereira
04-11-2016	In-situ bolted connections in lattice towers for WEC	Slobodanka Jovasevic

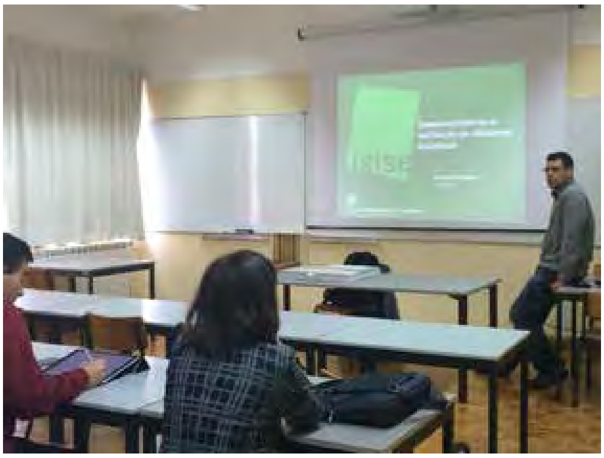


Speaker: Filipo Gentili

Speaker: Ashkan Shahbazian

Speaker: Hugo Augusto

Speaker: Pedro Vellasco



Speaker: Ricardo Patraquim

CONNECT@ISISE

Connect@ISISE is an event organized by HMS ISISE group, which has been held regularly since the start of ISISE. In this event, researchers and engineers from different parts of the world present their research work and interact with the group:

Date	Topic	Speaker
08-09-2014	Modelling Techniques of Historic Masonry Churches	Linda Giresini University of Pisa, Italy
07-01-2015	The seismic assessment of historical masonry structures: A discrete-element approach	Francesco Cannizzaro University of Catania & Gruppo Sismica s.r.l., Italy
06-02-2015	Behaviour of dry stone retaining walls: a DEM modelling	Eric Vincens École Centrale de Lyon, France
08-06-2015	Effect of underground excavations in historical buildings. A case study in Valencia	Pedro Calderón Universidad Politécnica de Valencia, Spain
20-07-2015	Domestic Architecture in Ugarit, Syria: Conservation proposal	Tarek Teba University of Edinburgh, UK
15-10-2015	Why preservation and safeguarding route of Romanesque	Rosário Machado, Romanesque Route, Portugal
15-10-2015	Characterization and strengthening of adobe masonry structures	Daniel Torrealva Catholic University of Peru, Peru
15-10-2015	The seismic retrofitting project methodology	Claudia Cancino, Getty Conservation Institute, USA
07-07-2016	Modern matters: Breaking the Barriers to Conserving Modern Heritage	Susan Macdonald, Getty Conservation Institute, USA

PROJECTS & NETWORK ACTIONS

Efficient harvesting of the wind energy | AEOLUS4FUTURE

Financing Institution(s): Marie Skłodowska-Curie Innovative Training Networks (ITN-ETN)
Promoting Institution(s):LULEA TEKNISKA UNIVERSITET (coordinator), THE UNIVERSITY OF BIRMINGHAM, UNIVERSIDADE DE COIMBRA, UNIVERSITA DEGLI STUDI DI FIRENZE, TECHNISCHE UNIVERSITEIT EINDHOVEN, INSTITUT VON KARMAN DE DYNAMIQUE DES FLUIDES, RUHR-UNIVERSITAET BOCHUM, GOTTFRIED WILHELM LEIBNIZ UNIVERSITAET HANNOVER, SIEMENS INDUSTRY SOFTWARE NV, SENVION GMBH
Coordinator(s) in UC: Carlos Rebelo, L. Simões da Silva

Researchers and collaborators: Ove LAGERQVIST (coordinator), Charalampos BANIOTOPOULOS , Hassan HEMIDA, Pietro TRICOLI, Luis SIMOES DA SILVA, Carlos REBELO, Claudio BORRI, Enzo MARINO, Gianni BARTOLI, Bert BLOCKEN, Ivo KALKMAN, Jeroen VAN BEEK, Christophe SCHRAM, Rüdiger HÖFFER, Peter SCHAUMANN, Michel TOURNOUR, Paula MARTINEZ, Fabian VORPAHL, Yakut CANSEV KÜÇÜKOSMAN, Abdolrahim REZAEIHA, Agota MOCKUT É, Andreu CARBÓ MOLINA, Gabriel SABAU, Mohammad Reza SHAH MOHAMMADI, Slobodanka JOVAŠEVIĆ, Milan KOVARBAŠIĆ, Gonçalo Daniel TEIXEIRA FERRAZ, Ana GLIŠIĆ, Giulio VITA, Zahra SEIFOLLAHI MOGHADAM, Mirjana RATKOVAC, Rana MOEINI

Partner Institutions: University of Belgrade (Faculty of Civil Engineering), University Ss Cyril and Methodius in Skopje, ANSYS, Inc., Germanischer Lloyd Industrial Services GmbH, MARTIFER - CONSTRUCOES METALOMECANICAS

Period:01/2015 to 12/2018

Relevant facilities: Computing cluster

Objectives:
The primary research aim is to develop a sustainable wind energy systems (WES) for a variety of EU needs. There are a number of detailed scientific and technical issues that are addressed by the project starting from identifying the wind energy potential (off-shore and on-shore, including the built environment) to the design of a sustainable and highly efficient WES. Also the new challenging load conditions imposed on wind farms located on places where existing type of wind turbine towers are not suitable require the development of new type of support structures for wind energy converters. This fosters new structural concepts taking advantage of high performance materials e.g. high strength steel and novel maintenance free fasteners. In addition, while most research efforts and practical applications of wind energy have focused on large-scale wind installations in remote offshore or onshore areas, much less attention has been given to wind energy installations near buildings. The project has a major training aim to create technical experts who will be able to lead the necessary industrial developments in the WES, and have a broad overview of a new and emerging multi-disciplinary field. The project thus enables a number of young scientists and engineers to obtain high level training in various technical aspects of the problem, to gain an overall understanding of how this work fits into the wider EU Directives and plans for the future and in doing so to improve their career prospects.

Description:
On April 2009, the European Parliament issued the "2009/28/EC" Directive that establishes a common framework for the production and promotion of energy from renewable sources. Based on this Directive, all EU Member States should reach a 20% share of energy from renewable sources by 2020. As wind energy is considered one of the most promising renewable energy resources, energy production technologies relying on wind energy are currently flourishing under the EU ambitious plan for 2020. Market demands to prepare a generation of researchers within the EU able to face the challenge of fulfilling the EU ambitious plan, to sustain the production of wind energy and to innovate and promote wind energy systems (WES) for the future need are clearly met in the AEOLUS4FUTURE. The primary research aim of the project is to develop a sustainable WES for variety of EUneeds. In the development of such a system there are a number of detailed scientific and technical issues that will be addressed by the project starting from identifying the wind energy potential (off-shore and on-shore, including the built environment) to the design of a sustainable and highly efficient WES. Also the new challenging load conditions imposed on wind farms located on places where existing type of wind turbine towers are not suitable require the development of new types of support structures for wind energy converters. This fosters new structural concepts taking advantage of high performance materials e.g. high strength steel and novel maintenance-free fasteners. In addition, while most research efforts and practical applications of wind energy have focused on large-scale wind installations in remote off-shore or on-shore areas, much less attention has been given to wind energy installations near buildings. As stated by the Small Wind World Report 2014, the world market for small wind turbines has continued to grow, with a cumulative total of at least 806,000 small wind turbines installed all over the world at the end of 2012. Thus, it is timely to mitigate the possible drawbacks of such systems by designing an efficient WES to reduce noise and vibration while harvesting the maximum possible energy from the wind. By creating affordable, low capital investment WES, this research will have a high impact not only on the

EU economy but will have an equally positive effect on economies of industrialized and developing countries.
Related to this, the project has a major training aim – to create technical experts who will not only be able to lead the necessary industrial developments in the WES, but will also have a broad overview of a new and emerging multi-disciplinary field. Hence, this project is focused towards addressing a number of issues which provides the appropriate training and tools that the next generation of experts will need. This training and educational need is recognised by beneficiaries: leading universities in the area of WES: LUH, UoB, UniFI, RUB, Tu/e, UC and LTU, and global industrial stakeholders VKI, SENVION and SISW. The letters of support and commitments are received from world's leading partners DNV GL, ANSYS, MARTIFER and from important university partners in the candidate countries of Western Balkan: CMU and UBFCE. Such wide support signifies the importance of the multi-disciplinary nature of the educational opportunities that will be provided and the expected high impact on the EU economy.

The project thus enables a number of young scientists and engineers to obtain high level training in various technical aspects of the problem, to gain an overall understanding of how this work fits into the wider EU Directives and plans for the future and in doing so to improve their career prospects. The training will provide young scientists with the multi-disciplinary knowledge that is currently lacking in any scientist or engineer, in particular: the development of more accurate loading models and advanced simulation tools capable of facing the increasing complexity of new offshore wind turbines; knowledge in risk assessment and risk managements; basic knowledge of sustainability aspects; designing innovative urban wind turbine technology to maximize power output while reducing noise and vibration levels; top-level knowledge in the experimental wind tunnel and numerical analysis of small and medium wind turbine in complex flows; and introducing the concept of on-site micro wind energy generation in urban planning.

Early Stage Researchers (ESRs) are associated with primary hosts institutions. Each work-package (WP) has expertise in laboratory and/or in-situ measurements, advanced numerical methods for computational analysis (e.g. FEA, CFD), and in deep theoretical expertise. At least one industrial partner is involved in each WP to insure higher technology readiness level (TRL) of the final achievements. AEOLUS4FUTURE training programme establishes links between all participants within WPs and promotes synergy effect at the network level.
A suite of inter-related projects has been designed considering variety of wind energy systems which are grouped in six research-based WPs. ESRs are being trained in the following research areas:

- Turbulence flow and turbulence modelling, gained knowledge will be applied for optimal efficiency of horizontal axis wind turbine (HAWT) and vertical axis wind turbine (VAWT) in built environment.
- Hydro-aero-elastic interaction of off-shore wind turbine (OWT) to the coupled wind-water waves forcing, knowledge required for accurate assessment of characteristic loads on blades, converters, supporting structure and foundation.
- Advanced structural analysis of high-rise towers creates possibilities for innovation in new types of structures driven by lower execution costs.
- Reliability analysis of substructures using coupled nonlinear methods is part of a novel integrated design approach. Such approach will reduce investment costs by using advanced analysis and maintaining the required safety margins according the rules for the public safety.
- Wind flow in built environment considering interaction between buildings will lead to maximum wind energy harvesting and improved wind turbine efficiency by developing methods for optimal choice of wind turbines for a particular location.
- Health monitoring of structures and condition monitoring of the mechanical and electrical systems, respectively. The knowledge will lead to reduced maintenance costs by development of advanced damage localization methods and integrated prognostic condition monitoring of the life time of the structure and wind turbines, respectively.

In the first year of the training program all ESRs are reading basic courses of the research disciplines involved. In the second year, the courses get a bit more specialized focusing on overlapping subjects. In the last year ESRs attend only highly specialized courses with the narrow area of the own project.

The project is unique in bringing together research groups of various scientific backgrounds to collaborate on one of the EU research priorities that will keep and maintain the European position of leading the world in reducing the CO2 emission and promoting clean sources of energy and generating costs savings to E28 countries of more than 400 million Euro per year.

Contacts:

Carlos Rebelo
Tel.: +351 239 797 209
Fax: +351 239 797 123
Email: crebelo@dec.uc.pt
URL: http://www.isise.net

Safety evaluation and retrofitting of infill masonry enclosure walls for seismic demands| ASPASSI

Financing Institution(s): FCT
Promoting Institution(s): University of Minho (UMinho)
Coordinator(s): Humberto Varum (FEUP)

Researchers and collaborators: Graça Vasconcelos, Nuno Mendes, Raul Fangueiro, Fernando Cunha, Andreia Martins

Partner Institutions: Faculty of Engineering of University of Porto, LNEC

Period: June 2016 to May 2019

Relevant facilities: Laboratory equipment and facilities of Civil Department of UMinho

Objectives: The presence of infill masonry (IM) walls in reinforced concrete (RC) buildings is very common. However, and even today, in the design process of new buildings and in the assessment of existing ones, infills are usually considered as non-structural elements, and their influence in the structural response is disregarded. The influence of IM walls is recognized to be crucial in the global behaviour and performance of RC framed building structures when subjected to earthquake demands, as confirmed in the poor performance of many buildings damaged in recent earthquakes in Europe. Many authors recognize the need for the inclusion of IM panels in the numerical models adopted in the seismic assessment of existing buildings and in the design process of new buildings.
The large in-plane (IP) shear demands that IM walls may attract, and the associated IP damage evolution are likely to increase their out-of-plane (OOP) vulnerability. The eventual IM walls OOP collapse can result in serious human injuries and casualties and high economic losses, as experienced in recent earthquakes. The rigorous knowledge of all the aspects related to the behaviour of infilled framed structures, of their components (structural and non-structural elements) and of the phenomena interaction is fundamental to guide the designers in the assessment and strengthening of existing buildings. Nevertheless, the available knowledge in this regard is still very limited. The project here presented intends to provide a strong technical scientific based contribution, which main goals are: (1) Characterization of the IM walls' behaviour when subjected to IP and OOP loadings; (2) Development of innovative retrofit solutions for IM walls; (3) Development of a simplified numerical tool for the analysis of RC buildings considering the IP and OOP infill panels' behaviour interaction in the seismic response; (4) Numerical model calibration based on experimental results, accounting for different aspects, such as, IP/OOP interaction, wall typologies, wall/frame contact conditions, retrofitting strategies applied, etc. The calibration will be valuable for the assessment of existing RC buildings and for the safety assessment of the Portuguese building stock.

Description:
The major objective of the contribution of Uminho for the project is to assess the effect of strengthening of masonry infills in the in-plane and out-of-plane behavior of rc frames with masonry infill walls. The strengthening is based on textile reinforced meshes already developed in the previous project RetroInf and comparison with the performance of commercial meshes (Fig. 1). In addition, the use of steel ties will be also used to assess the influence of the connection of the internal and external leaves in the out-of-plane behaviour of rc frames with masonry infills (Fig. 2).
First, it was decided to use steel connectors to enable the connection and consequent interaction between the leaves of the masonry infill, and thus, to assess the influence of having both leaves connected in the out-of-plane behavior of the masonry infill. Then, it was decided to use textile reinforced mortar (TRM) technique to investigate how this technique could enhance the in-plane and out-of-plane behavior of rc frames with masonry infills. This technique has been increasingly used in the strengthening of masonry infills and it revealed to have the potential for seismic strengthening/retrofitting of structures.
For the textile reinforced mortar technique two different types of meshes were used, namely a commercial textile mesh and a textile mesh developed at the university in collaboration with the textile department. The developed textile meshes are composed of reinforced braided rods with an external braid of polyester fiber and an internal core which can be composed by glass, carbon or basalt fibers. Based on previous results, it was seen that meshes with glass fibers exhibit a reasonable behavior while are considerably cheaper than meshes with carbon fibers. Taking into account these results, it was decided to strengthen the masonry infill walls with meshes composed of glass fibers, namely the commercial and designed meshes.
The validation of the mechanical performance of the meshes to work as a retrofitting technique will be based on the cyclic in-plane and out-of-plane testing on rc frames with masonry infills. For this, the developed meshes will be also applied in reinforced concrete (RC) with masonry infilled frames, designed to represent RC frames from the eighties.
In-plane and out-of-plane tests were designed on reduced scale RC frames, being the tests under development (Fig. 3). For the in-plane testing, an existing testing setup was updated and for the out-of-plane testing, a novel out-of-plane testing setup was designed based on airbags

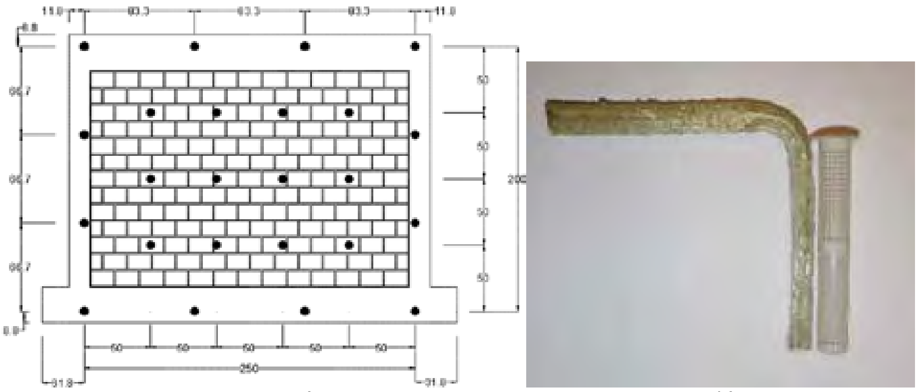
to better represent the out-of-plane forced induced by earthquakes. The out-of-plane testing procedure is automatic for which a software was developed.

The in-plane testing of the strengthened specimens is to be carried out similarly to the unstrengthened specimens (RetroInf project). The test setup and the loading protocol were kept unchanged with respect to those used in the unstrengthened specimens in order to have the same test conditions for comparison of the results.

The instrumentation of the specimen was defined to have the in-plane response of both leaves recorded, see Fig. 3 Four LVDTs (L1 to L4) are intended to be placed along the diagonals to monitor the diagonal deformation of the external and internal leaves. Twelve LVDTS (L5 to L16) shouldbe placed on the rendering layer to capture its possible debonding in relation to the rc frame in the out-of-plane direction. Six LVDTs (L17 to L22) should be positioned to monitor the possible uplifting and sliding of the specimen from ground and steel profiles and thus control the reliability of the test setup. Finally, two LVDTs, L23 and L24, are considered on the top beam to investigate the horizontal displacement at the top rc beam in the direction of the applied load.

Publications:

Contacts:
Graça Vasconcelos
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: graca@civil.uminho.pt
URL: http://www.isise.net



a) b)

Fig.1. Details of the mesh connectors; (a) pattern of the connectors; (b) plastic row plug and glass fiber connector

Fig.2. Helical ties used for connecting the leaves of brick infills

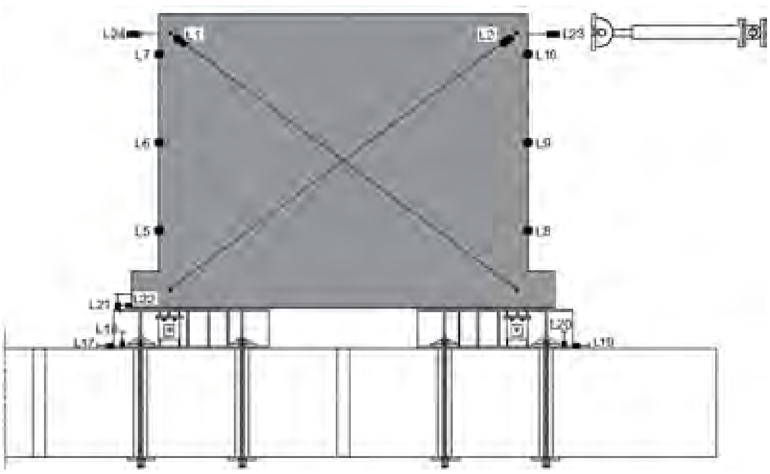


Fig.3. Testing setup for in-plane testing of retrofitted specimens

Behaviour charwacterization and rehabilitation of earthen construction | BE+EARTH

Financing Institution: FCT
Promoting Institution: University of Aveiro (UAveiro)
Local Coordinator: Daniel Oliveira (UMinho)

Researchers and collaborators: Daniel Oliveira, Paulo Lourenço, Rui Silva and Eduarda Luso (only UMinho researchers listed)

Partner Institutions: University of Aveiro, University of Minho, Technical University of Lisbon

Period: June 2013 to September 2015

Relevant facilities: Laboratory facilities: strong floors and reaction walls; several universal hydraulic tension-compression load frames, closed-loop servo-controlled actuators and data acquisition and control equipment; climatic chambers; diverse day-to-day laboratory equipment / Computational facilities: advanced FE numerical tools.

Objectives:
The main objectives of BE+EARTH are to analyse the behaviour of adobe and rammed earth constructions and contribute to the research on retrofit and performance enhancement solutions of the important adobe and rammed earth built heritage existing in Portugal.

Description:
Earth has been used as a building material since ancient times until the present days due to its advantages such as simple construction methods or interior comfort. Currently, one third of the world population lives in earthen houses, as a result of cultural, climatic and economic reasons. Large percentage of these buildings is currently associated to rural populations with low economic resources. There is a vast architectural heritage stock, mainly in developing countries, which needs to be preserved. Until recently, earth has been a common construction material in Portugal. Adobe and rammed earth were used through years in almost all types of buildings. This utilization progressively declined since the middle of the 20th century, due to the development of the cement industry.
At the present moment, Portugal still presents a vast number of earthen buildings, many of which are in use. There are numerous examples of buildings with cultural, historical and architectonic recognized value. In spite of this, there has been a general loss of traditional knowledge. On the other hand, little attention has been given to the study and conservation of this built heritage. As a consequence, many of the existing earthen buildings present various structural and non-structural anomalies and deficiencies.
When under horizontal actions, such as earthquakes, earth constructions structures can suffer severe structural damage and sometimes total collapse. The seismic behaviour of earthen structures is typically characterized by fragile failures. Besides seismic events, earthen constructions are also particularly vulnerable to other agents, like water and wind. But earth, as a building material, presents very attractive characteristics. It is low cost, locally available and recyclable. In addition, it possesses excellent thermal and acoustic properties, and is associated to quite simple construction methods that require small consumes of energy. These qualities are triggering an increasing interest, all around the world, among the community concerned with sustainable building.
In spite of the increased interest, the existing knowledge concerning earthen construction is still mainly empirical. Few countries have codes for the rehabilitation and building with earth, and the existent codes are frequently incomplete. On the other hand, the study of earthen structures has been mainly oriented towards the architectural and historical aspects, while the material and structural characterization has been systematically relegated to a second plan. This lack of knowledge, together with a certain prejudice against earthen materials have been contributing to the disappearing of the earthen building stock, namely in many recent rehabilitation interventions has been practice to replace these materials by materials called modern. The fact that many times the earthen constructions have been built or repaired by staff without adequate training, contribute further more to this reality.
The project BE+EARTH intends to provide a strong technical scientific based contribution, not disregarding the architectonic point of view. The main general objectives of this project are the behaviour analysis of adobe and rammed earth constructions along with the research of retrofit and performance enhancement solutions, considering the important patrimony existing in Portugal. The consolidation of this knowledge will have a fundamental role on the preservation of the earthen built heritage. In addition it will contribute to the development of earth construction as building solution following current structural demands, which will allow giving response to the increasing interest on this building solution.
The contribution of ISISE/UMinho to fulfil the proposed objectives includes the following integrated steps: a) experimental characterization of the structural behaviour of rammed earth; b) Assessment of the repair efficiency of the injection of mud grouts in the repair of rammed earth

walls; c) Assessment of the strengthening of rammed earth walls by means of geo-mesh reinforcing coatings; d) development of compressed earth blocks (CEBs) building system based on alkaline activation of fly ash; e) FEM modelling of the structural behaviour of rammed earth.

Publications:

PhD theses:

Silva, R. (2013) Repair of earth constructions by means of grout injection, PhD Thesis, University of Minho, hdl.handle.net/1822/28793

Msc theses:

Machado, J. (2013) Reparação estrutural de construções em terra através de injeção de caldas compatíveis, Msc Thesis, University of Minho, hdl.handle.net/1822/30797

Domínguez O. (2015) Preservation and repair of rammed earth constructions. Msc thesis, University of Minho.´

Battiston A. (2015) Numerical investigation on the seismic performance of rammed earth construction. Msc thesis, University of Minho, Portugal.

ISI papers:

Miccoli L., Oliveira D.V., Silva R.A., Müller U., Schueremans L. (2014) Static behaviour of rammed earth: experimental testing and finite element modelling, Materials and Structures, 10.1617/s11527-014-0411-7

Silva R.A., Soares E., Oliveira D.V., Miranda T., Cristelo N., Leitão D. (2015) Mechanical characterization of dry-stack masonry made of CEBs stabilised with alkaline activation, Construction and Building materials, 75, pp. 349-358, 10.1016/j.conbuildmat.2014.11.038

Silva, R.A., Oliveira, D.V., Schueremans, L., Miranda, T., Machado, J. (2016) Effectiveness of the repair of unstabilised rammed earth with injection of mud grouts, Construction and Building Materials, 127, pp. 864-871, 2016, DOI: 10.1016/j.conbuildmat.2016.10.064

Conference proceedings:

Silva R.A., Oliveira D.V., Miranda T., Soares E., Cristelo N., Lourenço P.B. (2014) Characterization of the shear behaviour of dry-stack masonry made with compressed earth blocks. CNME2014 - 9º Congresso Nacional de Mecânica Experimental, 15-17 October, Aveiro.

Silva R.A., Oliveira D.V., Miccoli L., Schueremans L. (2014) Modelling of rammed earth under shear loading, Peña, F., Chávez, M. (eds), 9th International Conference on Structural Analysis of Historical Constructions, Mexico City, 14-17 October 2014. ISBN 04-2014-102011495500-102.

Silva R.A., Oliveira D.V., Schueremans L., Miranda T., Machado J. (2014) Modelling of the Structural Behaviour of Rammed Earth Components, Lourenço, Topping, B.H.V., Iványi, P. (eds), 12th International Conference on Computational Structures Technology, Naples, 2-5 September 2014.

Silva R.A., Oliveira D.V., Schueremans L., Lourenço P.B., Miranda T. (2014) Shear behaviour of rammed earth walls repaired by means of grouting, Lourenço, Haseltine & Vasconcelos (eds), 9th International Masonry Conference, Guimarães, 7-9 July 2014. ISBN 978-972-8692-87-2.

Silva R.A., Oliveira, D.V., Schueremans, L., Lourenço, P.B., Miranda, T. (2014) Repair of rammed earth by injection of mud grouts: a case study from Portugal, Mazzolani F.M., Altay G. (eds), 2nd International Conference on Protection of Historical Constructions, Antalya, 7-9 May, p. 107-113, ISBN 978-978-518-361-9.

Contacts:

Daniel Oliveira
Tel.: +351 253 500 218/47 | Fax: +351 253 510 217
Email: danvco@civil.uminho.pt | URL: http://www.isise.net

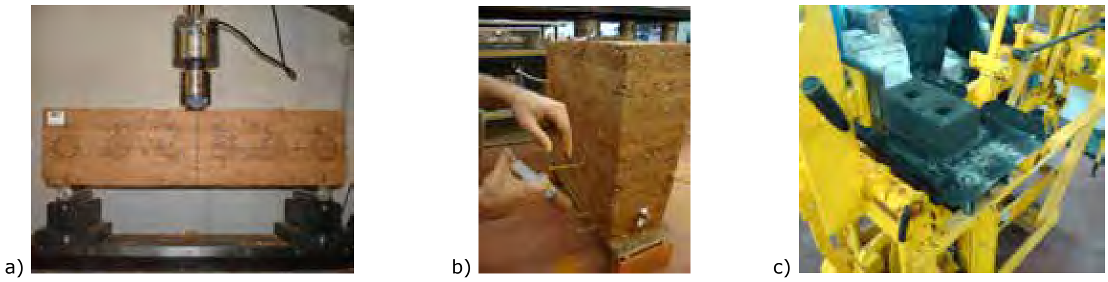


Fig. 1 Experimental program: (a) testing of a rammed earth beam (b) injection of a rammed earth wallet; (c) manufacturing of CEBs

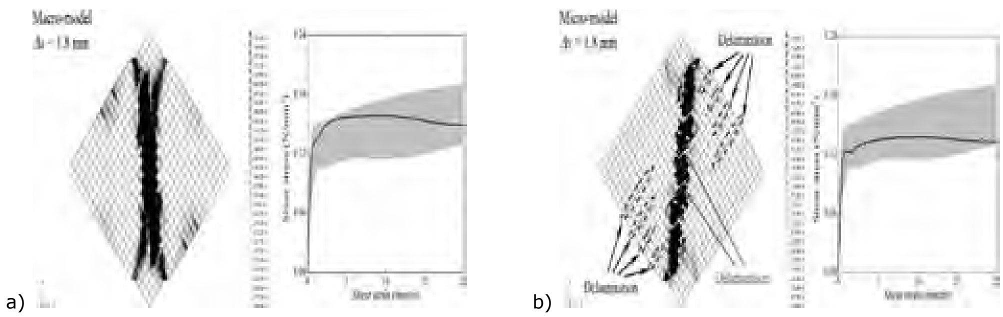


Fig. 2 FEM modelling of rammed earth: (a) macro-model; (b) micro-model

Reducing the vulnerability of cultural heritage buildings to blast loading | CH-SECURE

Financing Institution(s): FCT
Promoting Institution(s): University of Minho (UMinho)
Coordinator(s): Paulo B. Lourenço (ISISE-UM)

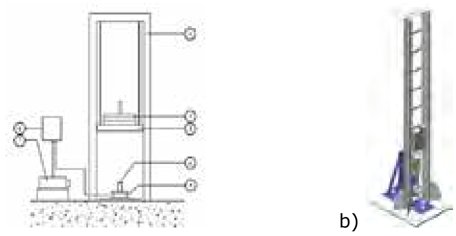
Researchers and collaborators: Paulo B. Lourenço (ISISE-UM); João M. Pereira (ISISE-UM); Ebrahim Hashemi (ISISE-UM)

Partner Institutions: Mechanical & Materials Technologies Centre (CT2M); Laboratory of Energetics and Detonics (LEDAP)

Period: March 2012 to August 2015
Relevant facilities: Drop Weight Towers; Fast video equipment; dynamic acquisition equipment; DIANA software with user supplied subroutines; Servo close-loop equipment; Reaction wall

Objectives:
This project focus on cultural heritage buildings, which possess specific problems associated with a high vulnerability, very high hazard and low damage limits in renderings due to the capacity to accommodate small deformations. The present work ranges from risk assessment to elaboration of recommendations, through experimental testing and applications. By learning from blast effects, both strengthening measures and recommendations will be proposed, to prevent sudden collapse and damage, enabling people to evacuate the buildings before failure and reduce casualties, and protect the value of the culture heritage. Significant contributions will be made with this work respecting to: (a) risk assessment methodologies and applications; (b) experimental characterization of historic materials and structural components; (c) design criteria and design rules; (d) innovative usage of controlled airblast for dynamic identification of structures and indication of weak structural and non-structural elements. With this work, it is intended to introduce this topic, which has a considerable lack of experience, at a national level, allowing future developments.

Description:
The first aspect to be tackled in this project was the experimental characterization of materials under high strain rates. Different building materials were considered for study under impact loading, to study strain rate effects. The considered materials were the usual components of existing masonry structures (clay brick and lime mortar), plus modern strengthening materials (Fibre Reinforced Polymers, FRP). Two different Drop Weight impact machines (Figure 1) were used for compression testing (Figure 1a) on brick (Figure 2), mortar and masonry specimens; and pull-out testing (Figure 1b) on brick and concrete specimens reinforced with GFRP (Glass-FRP) and CFRP (Carbon-FRP) strips, respectively. Regarding the uniaxial compression testing, the influence of the strain rate was studied on: (a) Ultimate strength (Figure 3); (b) Strain at ultimate strength; (c) Young's modulus; and (d) Fracture energy. Empirical relations of dynamic increase factors (DIF) for these materials and these material properties were developed. Regarding the pull-out testing (Figure 4a), the influence of the deformation rate (slip rate) was studied on: (a) maximum force (Figure 4b); (b) maximum slip; and (c) effective bond length. Empirical relations of DIF for these properties were developed.



a) b)

Fig. 1 Drop Weight impact towers: a) compression testing; b) pull-out testing

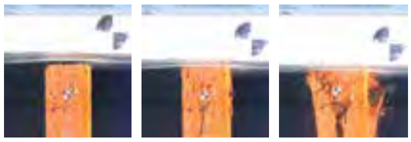


Fig. 2 High speed video sequence for brick under impact compression test

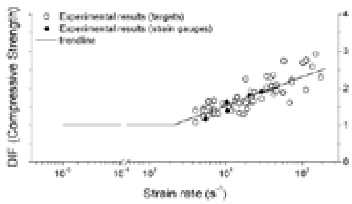
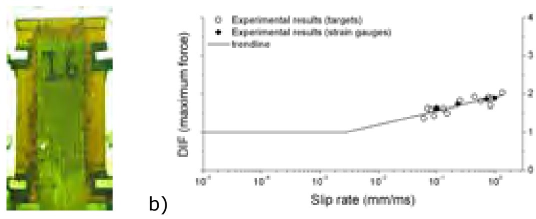


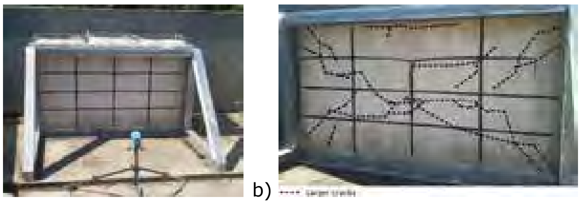
Fig. 3 DIF for Compressive strength of brick under uniaxial compression



a) b)

Fig. 4 Dynamic pull-out testing: a) high speed video; b) DIF for maximum force for pull-out tests

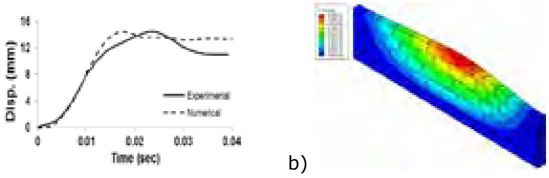
The vulnerability of the masonry envelop under blast loading is considered critical due to the risk of loss of lives. The second aspect under the scope of this project was the experimental assessment of the behaviour of masonry walls subjected to blast loading. A new test setup (Figure 5a) was developed for this purpose. Using confined underwater blast wave generators (WBWG), applying the extremely high rate conversion of the explosive detonation energy into the kinetic energy of a thick water confinement, allows a surface area distribution avoiding also the generation of high velocity fragments and reducing atmospheric sound wave. URM infill walls (Figure 5b) were tested with WBWG, using water plastic containers having in its centre a detonator inside a cylindrical explosive charge. Besides the usage of pressure and displacement transducers, pictures with high-speed video cameras were recorded to enable processing of the deflections and identification of failure modes.



a) b)

Fig. 5 Structural element testing: a) out-of-plane setup for walls under blast loading; b) URM wall under WBWG loading

The information gathered in the two previous tasks was used to develop numerical tools. Viscoplastic constitutive models capable of accommodating the strain rate dependency of material were developed. These constitutive models are based on the modern framework of incremental theory of multisurface plasticity, adequately considering the post-peak behaviour, and were developed both for interface composite model and macroscale orthotropic model. These subroutines were implemented and validated in an explicit dynamic finite element commercial code – ABAQUS (Figure 6). These models were used to perform parametric studies and to build empirical tools such as Pressure-Impulse diagrams (Figure 7) which relate the applied load with the damage level of these structural elements.



a) b)

Fig. 6 Development of numerical tools: a) comparison between numerical and experimental displacement of URM infill wall; b) masonry wall panel under impact using interface strain rate dependant constitutive model

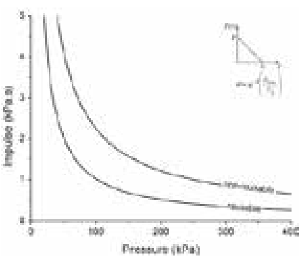


Fig. 7 Example of Pressure-Impulse diagram for URM wall panels

Different case studies, for both risk assessment and structural safety evaluation, were performed. First, a specific risk assessment methodology was applied in the context of public transportation networks, involving one of the largest transportation operators in Portugal. From the selected element in the Operators' network the elements with the highest risk associated with external explosion due to terrorist action were highlighted. Secondly, several structural safety assessments were performed on historical masonry buildings, both nationally (Figure 8) and internationally (Figure 9). These structural safety assessments involved several explosion scenarios in the vicinity of the building.

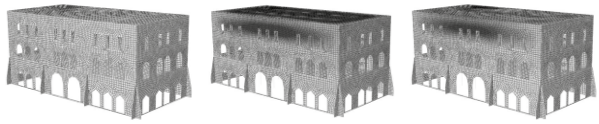


Fig. 8 Rossio Station - deformed shape evolution due to external explosion far from the structure

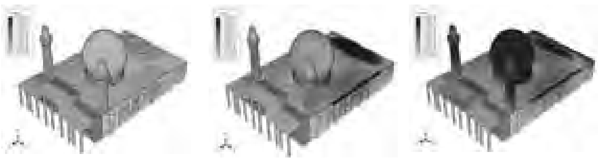


Fig. 9 Al-Askari holy shrine - deformed mesh evolution due to external explosion close to the structure

Relevant Publications:

International journals

Pereira JM, Lourenço PB (2017), Experimental Characterization of Masonry and Masonry components at High Strain Rates. J MATER CIVIL ENG, 29(2).

Pereira JM, Lourenço PB (2016), Experimental Bond Behavior of GFRP and Masonry Bricks under Impulsive Loading. MATER STRUCT, 49(11), pp. 4799-4811.

Pereira JM, Campos J, Lourenço PB (2015) Masonry Infill Walls under Blast Loading using Confined Underwater Blast Wave Generators (WBWG). ENG STRUCT, 92(1), pp. 69-83.

Rafsanjani SH, Lourenço PB, Peixinho N (2015) Dynamic interface model for masonry walls subjected to high strain rate out-of-plane loads. INT J IMPACT ENG, 76(1), pp. 28-37.

Pereira JM, Lourenço PB (2014) Risk assessment due to terrorist action on public transportation networks: a case study in Portugal. INT J PROTEC STRUCT, 5(4), pp. 391-416.

Theses

High strain rate constitutive modelling for historical structures subjected to blast loading, Seyedebrahim H. Rafsanjani, PhD Thesis, University of Minho, Portugal, 2015.

Security Evaluation and Design of Structures Subjected to Blast Loading, João M. Pereira, PhD Thesis, University of Minho, Portugal, 2014.

Experimental characterization of composite reinforcements subjected to impact and fire, João P. Pinhão, MSc Dissertation, University of Minho, Portugal, 2014 (in Portuguese).

Dynamic properties of clay brick and mortar at different strain rates, Abel Dias, MSc Dissertation, University of Minho, Portugal, 2013 (in Portuguese).

Contacts:

Paulo B. Lourenço
Tel.: +351 253 510 200/9 | Fax: +351 253 510 217
Email: pbl@civil.uminho.pt
URL: www.civil.uminho.pt/masonry

Development of a prefabricated emergency house prototype made of composite materials | CLICKHOUSE

Financing Institution: Adi
Promoting Institution: ALTO – Perfis Pultrudidos, Lda.
Coordinator: José Sena Cruz (Local coordinator)

Researchers and collaborators: UM - José Sena-Cruz, Joaquim Barros, Isabel Valente, Julio Garzón-Roca, Hassan Abdolpour, Gonçalo Escusa

Partner Institutions: ALTO, IST, UM

Period: March 2014 to June 2015

Relevant facilities: Laboratory equipment and facilities from the structural lab of UMinho (LEST).

Objectives:
The main objective of the CLICKHOUSE project is to develop a prefabricated housing prototype with advanced composite materials for being used as an emergency house or temporary building in disaster areas. As an accommodation for the surviving communities of a natural disaster, the CLICKHOUSE dwelling will be fully functional, incorporating water networks, sewage and electricity. The use of a prefabricated system and composite materials give rise to a series of advantages, such as the ease of transporting to the disaster area, the speed and ease of assembly/disassembly the house, a good resistance to aggressive agents, a total compatibility with regularity requirements of structure safety and thermal performance according to the latest recommendations and standards, as well as good stiffness/weight and strength/weight ratios.

Description:
After a natural disaster, survived communities have to be accommodated in temporary dwellings. Normally people inhabit in these temporary houses for long period of time, making necessary providing people with a relative high quality standard of living, as well as basic facilities like water, electricity and sewage. Different types of temporary houses are currently available, most of which made of steel, wood and plastic, but in many cases, these temporary dwellings do not offer a basic level of security and protection for its occupants, and/or result in very complex and expensive solutions.

In the field of temporary houses designing, the main aspect is using materials with high functional properties with aspect to the low prices. Building industrialization by prefabrication manufacturing lead to reduce the cost of building and improve the quality of manufacturing. Likewise, after a natural disaster, accessibility to the roads is limited; hence, transporting prefabricated dwellings which are compromised of various segments of low weight is very convenient. As an alternative to the classical temporary housing solutions and materials, the use of composite sandwich panels for configuring the enclosure surfaces, and glass fibre reinforced polymer (GFRP) pultruted profiles for forming the substructure, fit very well into this trend. In this context, the project "CLICKHOUSE – Development of a prefabricated emergency house prototype made of composites materials" aims to develop a prefabricated housing prototype using advanced composite materials for being used as an emergency house in disaster areas or just as a temporary building.

The main structural elements of the house, i.e. the beams and the columns, consists of pultruted composite profiles made of GFRP. This material presents a series of promising advantages such as lightness, low production costs, low maintenance, high durability, corrosion resistance and strength. For floor, roof, and both interior and exterior walls, sandwich panels are utilized. Nowadays, composite sandwich panels provide an efficient structural system for being used in different application areas. In this system, an interior core is enclosed by two skins, having the core and the skins different mechanical functions. Hence, while skins bear the bending loads, the core deals with shear loads and stabilizes the skins against buckling and wrinkling. Bond between skins and core should be of sufficient strength to withstand the shear and tensile stresses introduced between them. In the case of the present project, GFRP was used for the skins and polyurethane foam comprises the core. It is interesting to mention that the existence of a foam between both skins also provide the house with the required level of thermic and acoustical isolation.

In a first step, a floor module prototype of the CLICKHOUSE has been selected to be studied, as well as to serve as a reference to design all the other elements of the project. The selected prototype have consisted of four columns, four beams, and two sandwich panels as floor slabs. Columns and beams have been materialized by tubular GFRP pultruded short elements with a cross section of 120×120 mm^2 and wall thickness of 10 mm. The composite panels have presented an overall height of 70 mm, a width of 1000 mm and a length of 3000 mm. GFRP skins have had a thickness of 5 mm and have been produced by the hand-layup technique, using dry fibres impregnated with an isopthalic polyester resin; multiple plies of GFRP fabrics and mats has been used in the process of composition. The core material have consisted of polyurethane foam blocks of 60 mm of thickness and a nominal density of 48 kg/m^3.

Connecting the different elements forming the prototype is a very important aspect. Connections must be resistant and stiff, but at the same time they must permit an easy and fast assemblage/ disassemblage of the prototype. In total, three types of connections exist in the system: (i) beam-column; (ii) beam-panel, and; (iii) panel-panel. In the case of the beam-column connections, a bolted connection by means of a steel tubular profile of 120×120 mm^2 has been used to transfer the loads from the beams to the columns. For the beam-panel and panel-panel connection, a U-shaped GFRP pultruded profile has been adhesively bonded on each outer faces of panels; this profile has been then connected to a smaller GFRP square tabular profile, which, in the case of the panel-beam connection, is adhesively bonded to the beam elements. As can be seen, for decoupling functionality reasons, chemical connection such as adhesive has not been used for connecting the different elements.

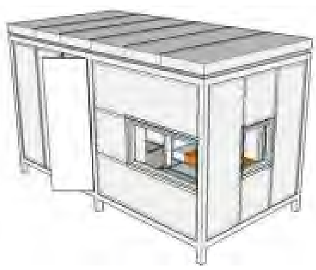
For assessing the performance of the prototype designed as a residential floor structure, an experimental program has been conducted. In this program, the prototype has been subjected to uniform distributed characteristics live load of 1.6 kN/m^2 to analyse its performance to deal with serviceability vertical loads; a characterization of the mechanical properties of the sandwich panel constituent materials has been carried out too. Moreover, an ambient vibration test has been conducted to study the capacity of the prototype to absorb the pedestrian vibrations. Additionally, the two sandwich panels forming the floor slab have been independently tested by four-point bending and three-point bending tests up to failure in order to evaluate the flexural response of the panels and the failure mechanism.

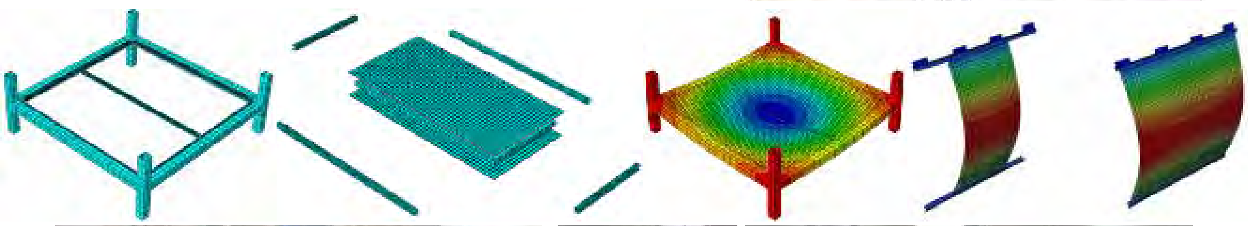
In addition to studies conducted in the floor panels, flexural and buckling tests were performed in the roof and wall panels, respectively. For the roof panels, configurations of one, two and three panels assembled together were used. The flexural performance as well the connection system between roof panels was evaluated, using a four-point bending test configuration. Serviceability and Ultimate Limit States were evaluated in accordance with the current regulations (EN 1990 and EN 1991), fulfilling all the safety and structural requirements. The connecting system between panels was observed to provide a semi-monolithic connection providing the loads to be correctly transferred to the supports.

The buckling tests were performed in the wall panels using pinned setup configuration in both ends, with allows the evaluation of the axial performance of the sandwich panels used for walls in the proposed dwelling. One single panel and two panels together were studied under in plane loading, both shown to fulfil all the regulation requirements previously mentioned.

Numerical models using the finite element method were developed in the process. These models allowed a better understanding of the prototype and contributed to important improvements and conclusions during the project. Besides, additional experimental work was carried out, which included testing studying the creep behaviour and the aging performance of the sandwich panels as well small connection prototypes, pull-offs and small-scale panels.

Contacts:
José Sena-Cruz
Tel.: +351 253 510 500 | Fax: +351 253 510 217
Email: jsena@civil.uminho.pt
URL: http://www.isise.net




Towards the next generation of standards for service life of cement-based materials and structures | COST Action TU1404

Financing Institution(s): COST Association

Promoting Institution(s): University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM)

Coordinator(s): Miguel Azenha (ISISE-UM)

Researchers and collaborators: 285 participants in the COST Action spread through 33 countries

Partner Institutions: University of Stuttgart (UStutt) (Germany); Eindhoven University of Technology (TU/e) (the Netherlands); European Convention for Structural Steelwork (ECCS) (Belgium); ArcelorMittal (AMBD) (Luxembourg)

Period: November 2014 to November 2018

Relevant facilities: Networking Action

Objectives:
Cement-based materials (CBM) are the foremost construction materials worldwide. Therefore, there are widely accepted standards for their structural applications. However, for service life designs, current approaches largely depend on CBM strength class and restrictions on CBM constituents. Consequently, the service life behaviour of CBM structures is still analysed with insufficiently rigorous approaches that are based on outdated scientific knowledge, particularly regarding the cumulative behaviour since early ages. This results in partial client satisfaction at the completion stage, increased maintenance/repair costs from early ages, and reduced service life of structures, with consequential economic/sustainability impacts. Despite significant research advances that have been achieved in the last decade in testing and simulation of CBM and thereby predicting their service life performance, there have been no generalized European-funded Actions to assure their incorporation in standards available to designers/contractors. Therefore, the main purpose of this Action is to bring together relevant stakeholders (experimental and numerical researchers, standardization offices, manufacturers, designers, contractors, owners and authorities) in order to accelerate knowledge transfer in the form of new guidelines/recommendations, introduce new products and technologies to the market, and promote international and inter-speciality exchange of new information, creating avenues for new developments.

Description and Methodology:
COST Action TU1404 is divided in three main Workgroups, which are in turn divided in group priorities.

WG1 –TESTING OF CEMENT BASED MATERIALS AND RRT+
GP1.a – Fresh properties and setting
GP1.b – Chemical and microstructural characterization
GP1.c – Transport properties and boundary effects
GP1.d - Mechanical properties and creep
GP1.e – Volume stability
GP1.f – Fracture properties and cracking

WG2 –MODELLING AND BENCHMARKING
GP2.a - Microstructural modelling
GP2.b - Multiscale modelling
GP2.c - Macroscopic modelling
GP2.d - Modelling of transport properties
GP2.e - Benchmarking calculations

WG3 –RECOMMENDATIONS AND PRODUCTS
GP3.a: Product development for testing and monitoring methods
GP3.b: Product development for software and design methods
GP3.d: Recommendations, pre-standard documents and associated coordination

Publications:

See all details in www.tu1404.eu

Contacts:
Miguel Azenha
Tel.: +351 93 840 45 54
Email: miguel.azenha@civil.uminho.pt
URL: http://www.isise.net

Fig. 1 Training School in DTU, August 2016

Fig. 2 Extended RRT+ program (more than 100 ton of raw materials shared)

Quality Specifications for Roadway Bridges, Standardization at a European Level (BridgeSpec) | COST Action TU1406

Financing Institution(s): COST Association
Promoting Institution(s): University of Minho (ISISE-UMinho)
Coordinator(s): José C. Matos (ISISE-UMinho)

Researchers and collaborators: José C. Matos (ISISE-UMinho); Joan R. Casas (UPC-BarcelonaTech); Eleni Chatzi (ETH Zurich); Alfred Strauss (BOKU); Irina S. Oslakovic (UTwente); Rade Hajdin (UBelgrade); Amir Kedar (Kedmor); Vikram Pakrashi (UCCork); Gudmundur Gudmundsson (Vegagerðin); Jan Bién (UWroclaw); Raffaelle Landolfo (Unina); André Orcesi (IFSTTAR); Yiannis Xenidis (UThessaloniki)

Partner Institutions: Universitat Politècnica de Catalunya - BarcelonaTech (UPC-BarcelonaTech); ETH Zurich (ETH Zurich); University of Natural Resources and Life Sciences (BOKU); University of Twente (UTwente); University of Belgrade (UBelgrade); Kedmor Engineers Ltd (Kedmor); University College Cork (UCCork); The Icelandic Road and Coastal Administration (Vegagerðin); Wroclaw University of Technology (UWroclaw); University of Naples "Federico II" (Unina); IFSTTAR; Aristotle University of Thessaloniki (UThessaloniki)

Period: April 2015 to April 2019

Objectives:
Asset management strategies rely on maintenance actions to keep infrastructures at desired levels of performance. In case of roadway bridges, specific performance indicators are established for their components and, when combined, allow to evaluate the overall performance. These indicators, which can be qualitative or quantitative based, are obtained during principal inspections through visual examination, non-destructive testing and by temporary or permanent monitoring systems. After being obtained, these indicators are then compared with performance goals in order to evaluate if quality control plans are accomplished.
It is possible to verify the existence in Europe of multiple methods used to quantify these indicators and how such goals are specified. Therefore, COST Action TU1406 main ambition is to develop a guideline for the establishment of QC plans in roadway bridges, by integrating the most recent knowledge on performance assessment procedures with the adoption of specific goals. This guideline will focus on bridge maintenance and lifecycle performance at two levels: (i) performance indicators, (ii) performance goals. By developing new approaches to quantify and assess the bridge performance, as well as quality specifications to assure an expected performance level, bridge management strategies will be significantly improved, enhancing asset management of ageing structures in Europe.

Description and Methodology:
In a first step, specific recommendations for the assessment of roadway bridges, namely, used methods for the quantification of performance indicators (PI) is established. A set of reference time periods for these assessment actions should be also presented. A second step is the definition of standardized performance goals (PG). Finally, a guideline for the establishment of quality control (QC) plans in roadway bridges would be developed. In these plans, it is emphasized the importance of advanced deterioration predictive models. Moreover, the concept of sustainable roadway bridge management, involving the evaluation of environmental, economic and social PI during the whole lifecycle, is also highlighted.

Fig. 1 COST Action TU1406 logo

WG1 Performance indicators
Management systems are supported in QC plans which in turn are supported by PI. Therefore, it is highly important to analyze such indicators in terms of used assessment frameworks (e.g. what kind of equipment and software is being used), and in terms of the quantification procedure itself. In this particular work group, the objectives are the definition of:
(a) Technical indicators: the goal in the first step is to explore bridge structures PI which capture the mechanical and technical properties and its degradation behaviour.
(b) Sustainable indicators: in addition to technical PI, which characterize the ultimate capacity as well as serviceability conditions, environmental-based sustainability indicators are also considered. These variables characterize the environmental impact of a structure in the course of its total lifecycle, expressed in terms of total energy consumption, carbon footprint (CO_2 emission), raw materials balance, etc. These indicators can be separated into direct and indirect indicators, where the former are related to the construction/maintenance itself and the latter are caused e.g. as a consequence of limited functionality;
(c) Other indicators: other sustainable indicators, economic and social based, may be used to evaluate bridge performance. These indicators, based on the technical performance of a structure, capture additional aspects that may influence the decision process and typically represent

the discounted (accumulated) direct or indirect costs associated with construction and maintenance. Summed up over the full life-time, they represent part of or the full lifecycle costs. They can, in the context of multi-objective optimization, be understood as a weighting scheme to arrive to a single objective function to be minimized.

WG2 Performance goals

The main objective of this workgroup is to define a set of goals for the PI previously identified in WG1. These goals will vary according to technical, environmental, economic and social factors. Specific recommendations will be given in order to ensure that the definition of such goals should be the most generalized as possible. In particular, it will be established:

(a) Technical goals: it will be analyzed what goals are actually used for technical PI in roadway bridges and its components (e.g. bearing, joint, etc.). It will be also evaluated which are being defined in the course of international research cooperation. Goals will be established, both for deterministic and probabilistic methods, for time-varying indicators and for different assessment procedures (e.g. visual inspection, non-destructive tests and monitoring systems);

(b) Sustainable goals: specific goals will be defined for sustainable indicators, environmental based. The most important factors for the definition of these goals will be identified as well as the most appropriate threshold values;

(c) Other goals: the definition of goals for other sustainable indicators, economic and social based, is extremely difficult as it largely depends on the established agreement between the owner and the roadway operator (concession model). Nevertheless, it will be important for the future of Europe to define such goals, or at least to provide some recommendations, so that standardized procedures can be implemented.

WG3 Establishment of a quality control plan

The desired service quality of the whole bridge can be affected by a single dysfunctional component or by the combination of several dysfunctional components. The decrease in bridge service quality clearly depends on the degree of components' dysfunctionality. This dependency can be modelled, among others, by Bayesian nets, which provide the time variation of each bridge component performance.

However, in order to assure a desired service quality with minimum interruptions, bridge owners launch preventative actions when the risk of service impairment, interruption or losses in lifecycle costs reaches some predefined level. Implicitly owners define herewith the accepted risk which can be different from country to country, based on social equity principles. This accepted risk depends upon the established PG for each component or combination of bridge components.

The QC plan mirrors these findings and is used for maintenance planning by defining a criteria for triggering maintenance interventions. Clearly, these QC plans have to be established for each individual bridge. They perform the basis for the asset management of this type of roadway infrastructure. The objective of this task is to establish a procedure, based on Bayesian nets or other heuristic rules used worldwide, which would allow bridge owners to define a QC plan for each individual bridge.

WG4 Implementation in a case study

During this task a set of roadway bridges, belonging to different COST countries and preferably with identical typologies, will be identified. Then, for those bridges, PI (identified in WG1) will be obtained. Such values will be then compared with pre-specified PG (identified in WG2) and, finally, a QC plan will be implemented (detailed description at WG3). Different methodologies for obtaining such indicators, as well as different threshold values, will be used as the basis for benchmarking. At the end of this task, a QC plan will be applied to such bridges, according to the recommendations established by WG3. The main objective of this study is to show the existing dispersion between obtained PI values, its goals and among QC plans.

WG5 Drafting of the guideline/recommendations

The work developed by other work groups (especially by WG1, WG2 and WG3) will be collected with the objective of writing a guideline, and recommendations, for the implementation of a QC plan for roadway bridges that could be adopted by several roadway agencies. The main goal will be the preparation of a document that can be easily adopted by engineers facing the management of new and existing bridges.

The format and content of this document should follow existing codes/guidelines/recommendations used today by agencies. Hence, existing documentation and work developed in other similar research programs and by standardization committees at national and international level will be analysed.

WG6 Dissemination

The Action will enable useful synergies and disseminate the results to several target groups and end users. This WG will assure the effective dissemination mechanisms to publish the progress and results of the Action.

A website was developed – http://www.tu1406.eu – containing information about the Action itself which will be continuously updated.

Workshops, conferences, training schools and teaching activities will allow to explain the performed scientific work to researchers, industry and stakeholders, as well as the practical approach of the developed guideline.

Publications:

Reports

Strauss, A., Mandic, A., Matos, J. C., Casas, J. R. "COST TU 1406 - Performance Indicators for Roadway Bridges", Technical report of the Working group 1: Performance indicators, ISBN: 978-3-900932-41-1, 2016;

Conference proceedings

Hajdin, R., Matos, J. C., Casas, J. R., Mandic, A., Strauss, A., "Performance Reliability-based Key Performance Indicators and Thresholds for Roadway Bridges (COST TU

1406)”, 9th International Forum on Engineering Decision Making (IFED), Switzerland (2016);

Hanley, C., Matos, J. C., Kelliher, D., Pakrashi, “Integrating multivariate techniques in bridge management systems for lifecycle prediction”, Civil Engineering Research in Ireland, Ireland (2016);

Matos J. C., Strauss A., Guimarães H., Zambon I., “An overview of performance indicators for arch bridges in Europe”, ARCH 2016, 8th International Conference on Arch Bridges, Poland (2016);

Matos J. C., Casas J. R., Strauss, A., Fernandes, S., “COST Action TU1406: Quality Specifications for Roadway Bridges, Standardization at a European level (BridgeSpec) – performance indicators”, fib Symposium 2016, South Africa (2016);

Matos J. C., Casas, J. R., “Quality Specifications for Roadway Bridges: Standardization at a European Level (BridgeSpec)”, SBE16 Malta, International Conference: European and the Mediterranean: Towards a Sustainable Built Environment, Malta (2016);

Casas, J. R., Matos, J. C., “Quality Specifications for Highway Bridges: Standardization and Homogenization at the European Level (COST TU-1406)”, IABSE 2016, China (2016).

Contacts:

José Campos e Matos
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: jmatos@civil.uminho.pt
URL: http://www.isise.net

Long-term structural and durability performance of concrete elements strengthened with the NSM technique | CutInDur

Financing Institution: FEDER funds through the Operational Program for Competitiveness Factors - COMPETE and National Funds through FCT - Portuguese Foundation for Science and Technology
Promoting Institution: University of Minho (UMinho)
Coordinator: José Sena-Cruz

Researchers and collaborators: José Sena Cruz, Miguel Azenha, Rui Ferreira, Vincenzo Bianco, Patrícia Silva, Pedro Fernandes, Mário Coelho, Tiago Teixeira

Partner Institutions: Not applicable

Period: March 2011 to September 2014

Relevant facilities: Laboratory equipment and facilities from the structural lab of UMinho (LEST); servo close-loop equipment, data acquisition and control equipment for experimental programs; universal testing machine; climatic chamber; tanks; FEMIX and DIANA softwares.

Objectives:
The main objective of present research project was to contribute to the knowledge on durability performance of the NSM technique with CFRP laminates under various specific application environments, load conditions and chemical degradation. The project involved three components: an experimental program, a numerical simulation and design recommendations. The experimental program was supported by accelerated ageing tests using two distinct scales: bond test specimens and flexural tests with slabs of quasi-real scale. With these specimens the following effects were studied: chlorides, sustained stress (creep), freeze-thaw, wet/dry, thermal cycles, and fatigue. The test results obtained from the experimental programs were used for predicting the service life of NSM technique supported in some numerical models.

Description:
Over the last two decades, extensive research has been developed on the strengthening of reinforced concrete (RC) structures using the externally bonded reinforcement (EBR) technique with fiber reinforced polymer (FRP) materials. This technique yielded several scientific publications, design guidelines and practical projects, worldwide. More recently, the near-surface mounted (NSM) FRP reinforcement technique has attracted an increasing amount of research, as well as practical applications. The NSM technique consists of inserting FRP bars into saw cuts grooves made in the concrete cover of the elements to be strengthened. The FRP is fixed to concrete with a groove filling material, e.g. epoxy adhesive. The NSM technique became a real alternative to the EBR one, due to the several advantages, namely: (i) reduction of amount of site installation work; (ii) less prone to the debonding; (iii) easier to anchor into adjacent members to prevent debonding failures; (iv) higher strengthening effectiveness; (v) more protected by the concrete cover and so are less exposed to accidental impact and mechanical damage, fire, and acts of vandalism; (vi) the aesthetic of the strengthened structure is virtually unchanged; (vii) in some cases, the ultimate strength of FRP can be reached. When compared with the EBR, the existing knowledge on the NSM reinforcement is much more limited. However, international institutions, such ACI (American Concrete Institute) recently included in the document ACI 440.2R-08 design guidelines for the flexural strengthening with the NSM technique and fib (Federation Internationale du Béton) TG 9.3 are currently considering revisions to their documents to include NSM-related provisions.

The project involved three components: an experimental program, a numerical simulation and design recommendations. The experimental program was supported by accelerated ageing tests using two distinct scales: specimens for bond tests and slabs of quasi-real scale (see Fig. 1). With these specimens the following effects were studied: moisture, chlorides, creep, freeze-thaw, thermal cycles and fatigue (see Fig. 2). The results obtained from the experimental programs were used for predicting the service life of structures strengthened with the NSM technique supported in numerical models. These numerical models were implemented in the finite elements software designated FEMIX. 2D and 3D models were used in the simulation of the structural elements. The concrete was simulated using an elasto-plastic multi-fixed smeared crack model. The FRP was assumed as linear elastic until the ultimate stress is reached. Adequate models were used to simulate the interfaces FRP bar/epoxy (BEI) and epoxy/concrete (ECI). The degradation effects referred before were reflected in the constitutive models of concrete, FRP, epoxy, BEI and ECI. Design recommendations were elaborated using the results obtained in the experimental programs and in the parametric studies performed by numerical simulations. Some results of creep and fatigue tests are shown in Figs. 3 and 4. Fig. 5 shows a panoramic photo of the durability tests.

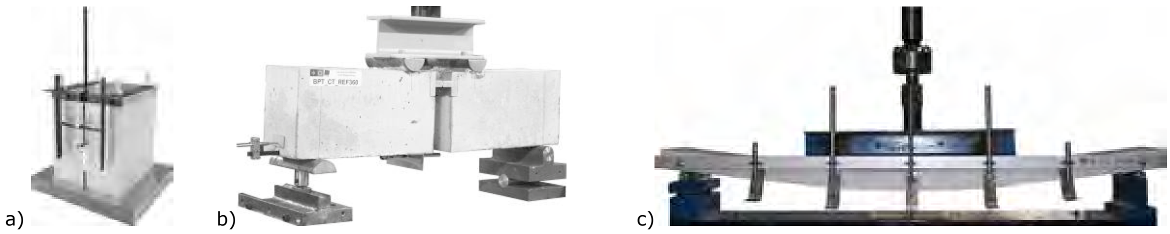


Fig. 1 Test configurations: (a) Direct pullout test; (b) Bending pullout test; (c) Flexural slab test.

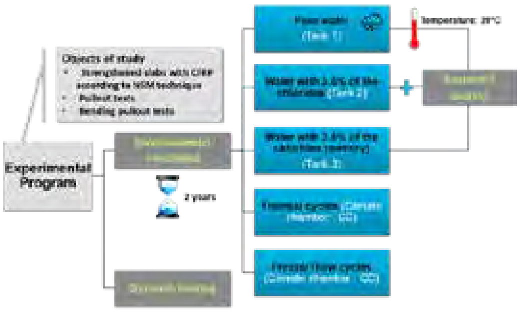


Fig. 2 Experimental program

Creep results of slabs

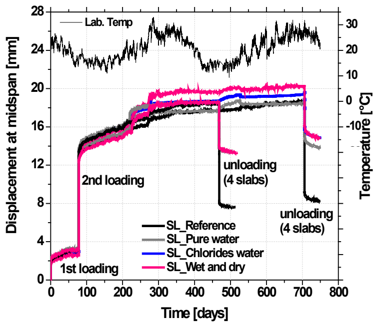


Fig. 3 Creep of slabs submitted to different environmental conditions

Fatigue results of direct pullout test

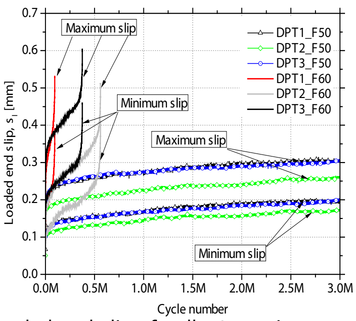


Fig. 4 Loaded end slip of pullout specimens versus cycle number for different load levels.

Publications:

Seminar - 1
Book - 1
PhD thesis - 3
MSc theses – 6
Papers in International Journals - 7
Papers in International Conferences - 8
Papers in National Conferences - 7
Reports – 7

Detailed results can be found in: www.sc.civil.uminho.pt

Awards

In the scope of the conference FRPRCS 11, held in Guimarães from 26-28 June, in the contest "Best Poster Award" the team of CutInDur won the prize for the best poster on the theme "Creep behavior of concrete elements strengthened with NSM CFRP laminate strips under different environmental conditions."

In the "I Workshop of the PhD Students in Civil Engineering" Patricia Silva won the prize for the best poster "Long-term behavior and durability of reinforced concrete slabs strengthened with NSM CFRP flexurally strips".

In the scope of COST Action TU1207, held in Kaiserslautern, Germany (23 October of 2014), in the contest "Best Poster Award" the team of CutInDur won the prize for the best poster on the theme "Long-term structural and durability performance of concrete elements strengthened with the NSM technique."

Acknowledgements:

This work was supported by FEDER funds through the Operational Program for Competitiveness Factors - COMPETE and National Funds through FCT - Portuguese Foundation for Science and Technology under the project CutInDur PTDC/ECM/112396/2009. The authors also like to thank all the companies that have been involved supporting and contributing for the development of this study.

Contacts:

J. Sena-Cruz
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: jsena@civil.uminho.pt
URL: www.sc.civil.uminho.pt

Fig. 5 Panoramic photo of the durability tests

Innovative carbon fibre reinforced polymer laminates with capacity for a simultaneous flexural and shear/punching strengthening of reinforced concrete elements | CutInov

Financing Institution(s): ADI (co-financed by the European Regional Development Fund (FEDER) through the Operational Program COMPETE)
Promoting Institution(s): University of Minho (ISISE)
Coordinator(s): Joaquim A. O. Barros

Researchers and collaborators: Joaquim A.O. Barros; J.M. Sena-Cruz, Salvador J.E. Dias, Eduardo N.B. Pereira, M. Rezazadeh, J.P.S. Laranjeira, M.R.M. Hosseini, M. Mastali, H. Ramezansefat

Partner Institutions: Clever Reinforcement Iberica- Materiais de Construção Lda
Period: 01 January 2014 to 30 June 2015

Relevant facilities: Servo close-loop equipment's for experimental programs; FEMIX V4.0 Finite Element package; Laboratory equipment and facilities of Civil Department of UMinho.

Objectives:

In the present project an innovative carbon fiber reinforced polymer (CFRP) laminate is proposed with the capability of providing, simultaneously, flexural and shear strengthening for reinforced concrete (RC) beams, and flexural and punching strengthening for RC slabs. This laminate is applied combining the procedures of the Near Surface Mounted (NSM) and Embedded Through Section (ETS) techniques. This laminate has a U configuration where the central part is used for the flexural strengthening, applied according to the NSM technique, and the extremities are used as shear/ punching reinforcement applied according to the ETS technique. To provide a U shape for the laminate, a portable device is developed, capable of being used in jobsite conditions to execute transitions zones in the laminate, by controlling the temperature and providing a supplementary fiber layer by filament winding with adhesive curing conditions.

Description and Methodology:

The current project aims to develop an innovative CFRP laminate and assess experimentally its potentialities for the simultaneous flexural and shear strengthening of existing RC beams and slabs. This hybrid strengthening technique combines the NSM technique for the flexural strengthening and ETS technique for the shear strengthening purposes in the same application using new U-shape CFRP laminates. This hybrid technique aims to provide, in addition to a better bond performance for the ETS and NSM CFRPs by providing the relevant anchorage benefits, a higher resistance to the susceptibility of occurring premature failure modes, such as concrete cover splitting and end concrete cover delamination failures. One of the experimental program was composed of five full-scale RC beams, one was kept unstrengthened as reference beam, while the reminding four RC beams were strengthened with different CFRP configurations and techniques (Fig. 1).

Fig. 1 Characteristics of the tested RC beams (dimensions in mm)

Fig. 2a evidences that all the strengthened beams had almost similar flexural stiffness up to the corresponding ultimate load carrying capacity.

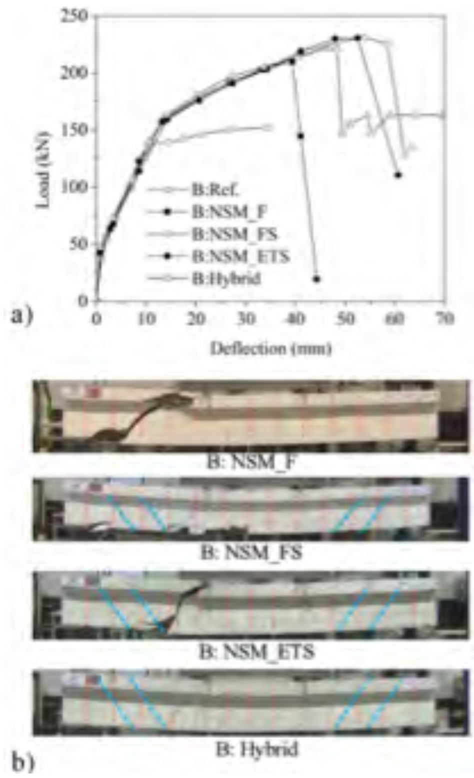


Fig. 2 Experimental results of the tested beams: a) load-deflection relationship, b) crack patterns at failure stage.

When compared to the load carrying capacity of the reference beam (B:Ref.), the strengthened B:NSM_F, B:NSM_FS, B:NSM_ETS and Hybrid beams presented an increase of 38%, 52%, 52%, and 46%, respectively. Despite the premature rupture of the transition zones of the new type of CFRP laminate, which indicates the necessity of executing improvements in the technology of producing these laminates, shear failure was not occurred.

Another experimental program was composed of two full-scale flat RC slabs, including one unstrengthened slab (reference slab) and the other strengthened with the new CFRP hybrid technique (Fig. 3).

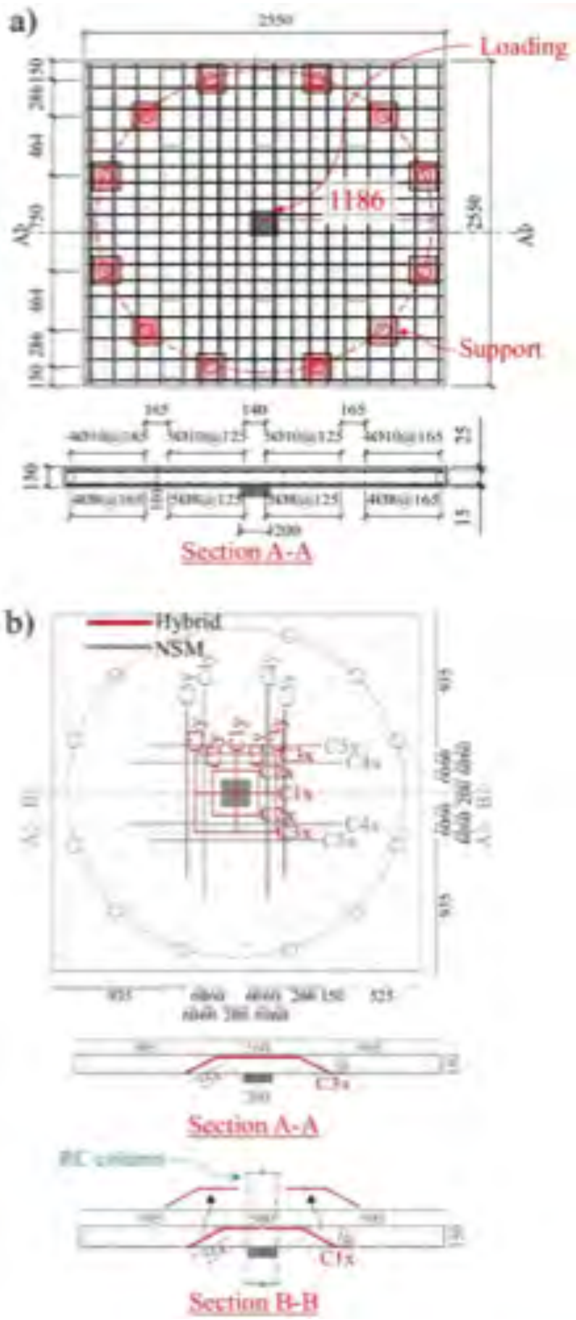


Fig. 3 a) Loading and support conditions, and steel reinforcement details, b) CFRP strengthening details.

This laminate bar can then be used to strengthen concrete elements, by inserting and bonding it in grooves made on the concrete cover, representative of the classic flexural NSM strengthening, and holes drilled through the cross section of the concrete element, reproducing an ETS shear strengthening. A transition zone between the central and each extremity was executed by thermo-mechanical treatment in the mechanism developed for this purpose.

The relationship between the applied load and the deflection at the center of the tested slabs is represented in Figure 4a. This figure shows an increase of about 30% in terms of the maximum load carrying capacity for the slab strengthened with CFRP hybrid technique when compared to the corresponding capacity of the control slab. Figure 4a, moreover, evidences the strengthening efficiency of the proposed CFRP hybrid technique in terms of increasing the load carrying capacity at serviceability limit states (SLS) and at steel yield initiation stage. The SLS conditions for this experimental program were adopted according to the requirements of the actual European design recommendations (L/250=9.5 mm, where L=2×1186 is the slab's span, see Figure 2a). Besides, the strengthened slab provided higher ultimate deformation capacity than the one of the unstrengthened slab, resulting in a higher ductility and energy absorption indexes for the strengthened slab.

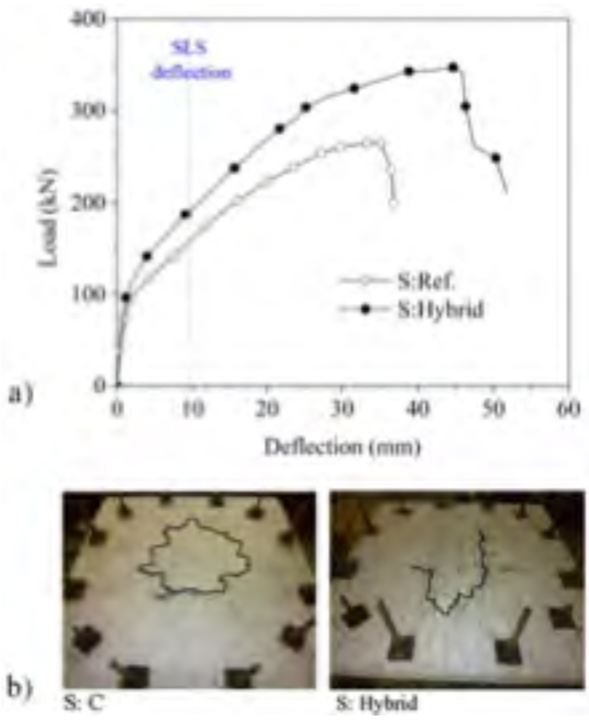


Fig. 4 Experimental results of the tested slabs: a) load-deflection relationship, b) crack patterns.

Outputs:
Publications: 10; International patent nº 108611, 2015

Contacts:
Joaquim António Oliveira de Barros
Tel.: +351 253510210/747
Email: barros@civil.uminho.pt
URL: http://www.isise.net

Development innovative sandwich panels made of fiber reinforced polymer (FRP) for the rehabilitation of degraded wooden floors of old buildings | EASYFLOOR

Financing Institution(s): ANI (under contract 2015/03480)
Promoting Institution(s): ALTO – Perfis Pultrudidos, Lda., University of Minho (UM), Instituto Superior Técnico (IST), Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM)
Coordinator(s): José Sena-Cruz (ISISE-UM)

Researchers and collaborators: José Sena-Cruz (ISISE–UM); Isabel Valente (ISISE–UM); Eduardo Pereira (ISISE–UM); Joaquim Barros (ISISE–UM); Gonçalo Escusa (ISISE – UM); Coordinators from partner institutions: João Ramôa Correia (CERIS-IST); Fernando Branco (CERIS-IST); Mário Garrido (CERIS-IST); Miguel Proença (CERIS-IST)

Partner Institutions: Civil Engineering Research and Innovation for Sustainability (CERIS)

Period: April 2016 to April 2019

Relevant facilities: Computational and laboratory equipment of Civil Engineering Department of University of Minho; LEST – Structural laboratory of the University of Minho; Computational and laboratory equipment of the partner institutions.

Objectives:
The main goal of the EasyFloor Project is to the development a hybrid sandwich panel of second generation made out of Carbon/Glass Fibre Reinforced Polymer (C/GFRP) for the bottom laminate skin and Ultra High Performance Fibre Reinforced Mortar (UHPFRM) as the top skin layer. The nucleus of the panel will be manufactured with a cellular foam material of low density. In order to tackle the current rehabilitation needs, the following objectives were established, in comparison with the current solutions: (i) enhancement of the assembly times in buildings make use of the advantages of fit connections; (ii) better structural performance (better stiffness/weight ratios); (iii) better fire response; (iv) better thermal performance; (v) market competitiveness; (vi) improve the seismic performance by reducing self-weight and increasing the in-plane stiffness of the sandwich panel.

Description and Methodology:
In the first place, a literature review on the rehabilitation of degraded timber floors in old buildings is performed. Furthermore, the interventions and the current solutions of sandwich panel systems are also assessed. Afterwards, the design of the sandwich panel will be carried out using genetic algorithms and taking into account the current regulations and recommendations: (i) EN 1990; (ii) EN 1991; (iii) EN 1992-1; (iv) CNR-DT 205/2007. The Preliminary concepts for the connection systems are developed for the panel-to-panel and panel-to-support connections based on existing joints for lightweight floor systems. Finally, an extended experimental program was established to evaluate the performance of the proposed sandwich panel and to assess if all the objects are attain. The EasyFloor project is divided in the following tasks:

<u>Task 1 – Preliminary studies and state of the art</u>

The main goal of this task is to provide a deep understanding of the needs for rehabilitation of old buildings and to evaluate the current solutions available for sandwich panels, in order to develop an innovative and competitive solution of sandwich panel which will tackle the main problems of the rehabilitation market. This task will also allow a better understanding about the current design techniques for sandwich panels in both numerical and analytical methods, which will provide the necessary skills to develop an innovative and enhanced solution attending to the objectives aforementioned. In addition, manufacturing techniques will be investigated and compared to assess the most competitive and effective manufacturing process for the sandwich panels.

<u>Task 2 - Research and development of hybrid sandwich panels and using both analytical and numerical models</u>

The main purpose of this task is to proceed to the design and development of: (i) hybrid sandwich panels; (ii) fit connections between panels; (iii) the connections between panels and other support elements, such as wall. The genetic algorithms will be used to provide an optimized solution in terms of: (i) panel geometry; (ii) concrete properties; (iii) laminate stack architecture of the bottom layer; (iv) laminate stack architecture of the ribs; taking into account the current design guidelines for both Ultimate Limit States (ULS) and Service Limit States (SLS) in accordance with Eurocode 0 and 1 (EN 1990 and EN 1991). Additionally, the Italian recommendation CNRDT 205/2007 will be taking into account to design the laminate component of the sandwich panel. The optimization of the sandwich panels will also take into account lowest the economical cost of raw materials, the self-weight and the environmental footprint of the solution, which will be the multi-objective function. Other restriction criteria will be used to establish boundary conditions that meet the thermal, acoustic and axial performance established in the objectives and during the manufacturing. Also, the UHPFRM to be used as the top skin layer of hybrid sandwich panel will be developed, taking into account the results obtained previously from the optimization.

Task 3 - Development of prototypes and specimens

In this task, prototypes and specimens will be produced by ALTO Perfis Pultrudidos, Lda. for laboratorial evaluation of the mechanical, thermal, acoustic and seismic performance and characterization their properties. The prototypes will consist in sandwich panels of both full-scale and small-scale dimensions and specimens will be made out of materials that assemble the hybrid sandwich panel together.

Task 4 – Experimental Program

The experimental program aims to verify if all the design requirements that were established previously in the objectives are fully satisfied. Thus, and experimental program comprising both full-scale and small-scale test was planned. The full-scale test will comprise monotonic tests up to failure to evaluate both ULS and SLS of the hybrid sandwich panels. The small-scale tests will comprise: (i) four-point bending tests up to failure; (ii) creep tests in controlled environment; (iii) axial performance; (iv) acoustic insulation to both airborne and impact sounds, and; (v) fire performance according to the standard ISO 834. Finally, several tests on the constitutive materials of the hybrid sandwich panel will be performed, namely: (i) compressive, tensile and shear tests on the foam core material; (ii) compressive and flexural tests will be performed in the UHPFRM, and; (iii) Tensile and flexural tests will be performed in the C/GFRP specimens.

Task 5 – Dissemination of the results

In this task, it is intended to promote the results attained during the project, which can be performed by participating in conference proceedings, organizing events, publishing articles, both national and international, submitting technical reports during the different stages of the project, and meeting potential clients in the market.

Task 6 - Project management

The project management will be performed by regular meetings between the promoting institutions and by preparing regularly technical reports assessing the progress of the EasyFloor Project in comparison with project task planning and milestones.

Publications:

Dissertations

[1] Cruz, F. Q. (2016) "*Desenvolvimento e caraterização de painéis sanduíche híbridos para a reabilitação de pisos de edifícios*" Master Thesis, Guimarães, Portugal.

Conference proceedings

[2] Escusa, G.; Sena-Cruz, J.; Cruz, F.; Pereira, E.; Valente, I.; Barros. J. (2017) "*The use of genetic algorithms for structural optimization of hybrid sandwich panels*". APFIS2017 – 6th Asia-Pacific Conference in FRP Structures, from 19 to 21 July 2017, 4 pp. [Accepted for Publication]

[1] Escusa, G.; Cruz, F.; Sena-Cruz, J.; Pereira, E.; Valente, I.; Barros. J. (2017) "Shear Behavior of a PUR foam". APFIS2017 – 6th Asia-Pacific Conference in FRP Structures, from 19 to 21 July 2017, 4 pp. [Accepted for Publication]

Contacts:

José Manuel da Sena-Cruz
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: jsena@civil.uminho.pt
URL: http://www.isise.net

Fig. 1 Shear tests performed in the foam core material – shear failure mode (Task 4)

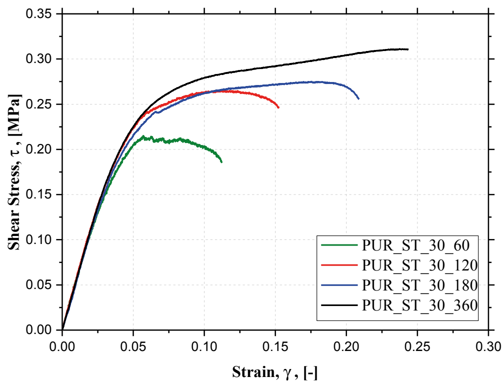


Fig. 2 Shear tests performed in the foam core material – results for the different geometries (Task 4)

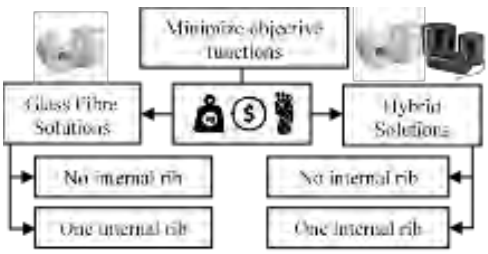


Fig. 3 Different types of design solution using genetic algorithms (Task 1 and Task 2)

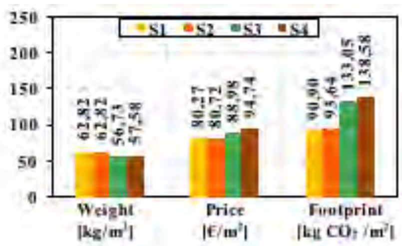


Fig. 4 Results obtained for the different optimizations solutions (Task 1 and Task 2)

Acoustic and Thermal Comfort | EcoSteelPanel

Financing Institution(s): QREN
Promoting Institution(s): Cool Haven – Habitações Modulares e Eco-Sustentáveis, S.A.
Coordinator(s): Joaquim Rodrigues (Cool Haven) and Luís Simões da Silva (ISISE-UC)

Researchers and collaborators: Joaquim Rodrigues (Cool Haven); Helena Gervásio (Cool Haven); Alexandre Henriques (Cool Haven); Luís Simões da Silva (ISISE-UC); Paulo Santos (ISISE-UC); Dulce Rodrigues (DEM-UC); Nuno Rosa (ISISE-UC); Luís Silva (Sucurema)

Partner Institutions: University of Coimbra and Sucorema

Period: November 2012 to April 2015

Relevant facilities: Computational equipment and data acquisition of Civil and Mechanical Engineering Department of FCTUC

Objectives:
EcoSteelPanel R&D project aims to develop a new sustainable Lightweight Steel Framing (LSF) solution that could be used as a rain water harvesting wall and improve thermal behaviour and energy efficiency of buildings. Regarding this last issue, the main goal is to take advantage of the water heat storage capacity in order to collect the heat from solar radiation in the LSF wall, acting as a thermal energy storage (TES) system and release it during the evening to the interior of the building. Given the usual low thermal inertia of LSF buildings, the benefits of this TES wall could be enlarged in this type of constructions. This innovative concept has an enormous potential at the architectural level, with multiple possibilities, such as 3D effects, colour variations, etc. The construction of the façade structural elements is carried out using optimized welding procedures, which guarantees the necessary panel tightness. Also, these welding procedures will allow a faster and precise manufacturing process and also allow to weld different materials and different thin plates without deformation. In order to guarantee the necessary quality and feasibility of the welded connection, an innovative concept of solid state welding, FSW (Friction Stir Welding) is used. This concept applied to the LSF modular construction requires research of new suitable tools for the multiple materials, as well the study of the welding behaviour with similar and different materials. For the success of this project, it is fundamental to do a research about the equipment requirements that allows the execution of the panels with different sizes and shapes, always ensuring the perfect panel assemblage.

Description and Methodology:
EcoSteelProject is divided in seven work packages as briefly described next.

WP1 Preliminary studies
The objective of this work package was to carry out several conceptual studies of the panel with different geometries, shapes, stamping, printing and multi-material welding with dissimulated connections. It was performed the study of the interface between man and machine, the development of technical reports and theoretical models which served as the basis for the definition of technical specifications, performed in work package 2.

WP2 Technical specifications
The main objective of this work package was the development of technical and structural specifications for the panels, and the specifications for the welding equipment, ensuring that the requirements related to the mechanical, physical and chemical characteristics of the panels and their structural characteristics are well defined. The requirements of the welding machine and its structural design were also developed.

WP3 Acquisition of new knowledge´s
This work package has the following objectives: (I) evaluation of water storage capacity; (II) assessment of water volumetric capacity for different panel thicknesses and for different building typologies; (III) evaluation of the acoustic and thermal performance of the panel with water and with water movements between different façades; (IV) evaluation of the mechanical strength of the weld connection used in the panel and microstructure analysis.

WP4 Development
This activity aims to develop the panel based on the technical specifications, and develop the panel connections. Several architectural solutions with different shapes and geometries were developed in order to test the behaviour of the panel with curved and inclined surfaces. A small scale experimental module was developed for water harvesting and for water movements taking into account the results obtained in work package 3. The system for fastening the panels to the welding machine was also developed. A set of controllers and the electrical project necessary for the equipment (load positioning) was developed. At this stage, the optimization of the parameters for thin plates was performed to avoid the plates deformation.

WP5 Prototype construction
The main objective of this activity is the construction of prototypes. A small-scale experimental module was also built in order to test the water movements and the thermal and acoustic behaviour of the panels. Based on the developed components (e.g. the rotary head of the welding

machine), a prototype of the friction welding machine (FSW) was built, to test and validate the produced panels.

WP6 Experimental tests
The conformity between experimental results with the requirements and the specifications defined for this project was fundamental for the validation of the R&D activities.

WP6 Promotion
The final work package aims the sharing of the results with the scientific community. The results were presented at the CMM conference (2015) and in other public presentations.

Publications:

Papers

Costa, M.I.; Verdera, D.; Costa, J.D.; Leitao, C; Rodrigues, D.M. 2015. "Influence of pin geometry and process parameters on friction stir lap welding of AA5754-H22 thin sheets", Journal of Materials Processing Technology, 225: 385 - 392. doi:10.1016/j. jmatprotec.2015.06.020.

Costa, M.I.; Verdera, D.; Leitão, C; Rodrigues, D.M. 2015 "Dissimilar friction stir lap welding of AA 5754-H22 /AA 6082-T6 aluminium alloys: influence of material properties and tool geometry on welds strength", Journal of Materials and Design.

Dissertations

Francisco Miguel Neto Caldeira: *Ligação por Friction Stir Welding de chapas finas em junta sobreposta*. Mechanical Engineer Department, University of Coimbra, 2013.

Sara Isabel Gonçalves Gouveia: Análise da influência da geometria da ferramenta na ligação por Friction Stir Welding de chapas finas em junta sobreposta Mechanical Engineer Department, University of Coimbra, 2014.

Rodrigo Horácio Rodrigues Rojas: *Aplicação industrial de processos de soldadura em estado sólido: Análise de viabilidade*. Mechanical Engineer Department, University of Coimbra, 2014.

Reports

Gervásio, H., Rodrigues J. "*Relatório técnico-científico final do âmbito do contrato nº2012/24805*", Coimbra, Portugal, 2015.

Conference proceedings

Rodrigues, D.M.; Costa, M.I.; Verdera, D.; Leitão, C. "Lap joining of very thin sheets by friction stir welding", 10th International FSW Symposium, 20th to 22th of May. Beijing, China, 2014.

Leitão, C.; Costa, M.I.; Rodrigues, D.M. "Influence of tool geometry and process parameters on defect formation in lap joining by friction stir welding of very thin plates", 2nd International Conference of the International Journal of Structural Integrity, 1st to 4th of September. Funchal, Portugal, 2014.

Costa, M.I.; Galvão, I; Leitão, C.; Rodrigues, D.M. "Dissimilar friction stir lap welding of heat and non-heat treatable aluminium alloys", Conferência Internacional Materiais'2015, 21th to 23th of June. Porto, Portugal, 2015.

Mira-Aguiar, T; Costa, M.I.; Verdera, D.; Leitão, C.; Rodrigues, D. M. "Tool Assisted Friction Welding", Conferência Internacional Materiais'2015, 21th to 23th of June. Porto, Portugal, 2015.

Rodrigues, D.M.; Mira-Aguiar, T; Costa, M.I.; Leitão, C. "Friction stir welding of very thin steel plates", 4th international Conference on scientific and technical advances on friction stir welding & processing. 1st to 2th of October, San Sebastian, Spain.

Costa, M.I.; Rojas, R; Mira-Aguiar, T; Leitão, C.; Rodrigues, D. M. "A comparative techno-economic evaluation of Friction Stir Welding versus Resistance Seam Welding", FSWP 2015 - 4th international Conference on scientific and technical advances on friction stir welding & processing, 1st to 2th of October, San Sebastian, Spain.

Leitão, C.; Mira-Aguiar, T; Costa, M.I.; Rodrigues D. M. "Analysis of the welding conditions based on torque sensitivity analysis", FSWP 2015 - 4th international Conference on scientific and technical advances on friction stir welding & processing. 1st to 2th of October, San Sebastian, Spain.

Contacts:

Luis Simões da Silva
Tel.: +351 239 797 216
Fax : +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

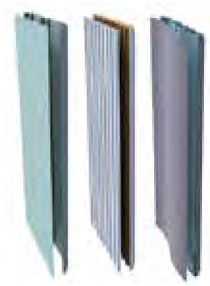


Fig. 1 Panel design (WP1)

Fig. 2 Experimental Prototypes (WP5)

Fig. 3 Tensile tests (WP3)

Sustainable solutions for high performance prefabricated decks | Eco-Tabuleiro

Financing Institution(s): COMPETE, FEDER, QREN

Promoting Institution(s): University of Coimbra

Coordinator(s): Alfredo Manuel Pereira Geraldes Dias (ISISE-UC)

Researchers and collaborators: Alfredo Manuel Pereira Geraldes Dias (ISISE-UC); Ricardo Joel Teixeira Costa (ISISE-UC); Sandra Raquel de Sousa Monteiro (ISISE-UC); Carlos Eduardo de Jesus Martins (ISISE-UC); André Filipe Silva Marques (ISISE-UC)

Partner Institutions: Pedrosa & Irmãos, Lda

Period: June 2013 to June 2015

Relevant facilities: Laboratory and equipment of Civil department of FCTUC; Testing equipment of Pedrosa & Irmãos, Lda facilities.

Objectives:
The main objective of the project was to develop timber-concrete solutions for application in road bridge decks for short/medium span. The solutions found where roundwood elements are used together with a concrete upper slab, are an interesting alternative in situations that have no visibility, such as the cases of some rural and forest roads, where the traffic volume is low. In such roads, many small watercourses and trenches to overcome can be found, and the construction of small span bridges (5 to 8 meters) using TCC decks with roundwood elements can be an economic and quick solution. These solutions become competitive due to the following reasons: i) the timber slab, besides the structural role, is also used as lost formwork which leads to a substantial reduction in the use of additional formwork in deck construction; ii) the timber resources (logs) to be used are often locally available, which might permit a saving in transportation and iii) the fact of using roundwood also reduces the processing costs.

Description and Methodology:
For the achievement of the project goals, the performed work was divided in several phases comprehending the following:

WP1 Definition of preliminary solutions
The objective of WP1 was to define a set of preliminary solutions for the composite deck, based on the regulations and requirements of the applicable standards, namely EN1995-1: Eurocode 5. Also the geometric and physical properties of the Portuguese Maritime Pine were considered for the preliminary design of the solutions. Relevant bibliography regarding timber-concrete connections was consulted for the selection of two types of connection.

WP2 Elements selection and classification
For maximum use of the mechanical properties of the timber elements, several samples of utility poles were selected and non-destructive and destructive tests were performed to evaluate the relevant mechanical properties, namely Modulus of Elasticity (MOE) and bending strength (fm). In this work phase, elements of new utility poles were used as well as elements of removed from service utility poles.

WP3 Support development and optimization
Timber, as known, presents good mechanical properties in the parallel direction with the grain, such as tension, compression and bending strength, however, in the perpendicular direction with the grain the mechanical properties are inferior. Compression strength perpendicular with the grain direction is one relevant mechanical property in the deck supports. Due to the low resistant values associated with this property, adequate supports systems must be considered and developed to satisfy the safety requirements, considering the acting loads in the structure.

WP4 Transverse load distribution
In road bridge decks the main acting loads are due to the vehicles passage. Such loads are transmitted to the deck through the vehicles tyres that have a small contact are, therefore, their effect is almost as a punctual load. For this type of loading the transverse distribution is a very important aspect because the grater the load distributed for the adjacent parts/timber elements the lower the stress in the element. For an adequate behaviour of the final composite solution, a comprehensive study regarding the transverse load distribution was performed.

WP5 Conception and development of timber-concrete connections
An adequate mechanical behaviour of Timber-Concrete Composite (TCC) structures relies heavily on the connection system used to connect both materials. An adequate connection system must not allow excessive slip in the timber-concrete interface. If an excessive slip is observed, the composite solution does not has

an effective behaviour and there is no advantage in the system. In this WP, two connection types were considered, based on the relevant literature, and mechanical tests were performed to evaluate the mechanical properties of the connection systems.

WP6 Cyclic behaviour of timber-concrete connections
The vehicles passage on the bridge decks origins instant stresses in the composite solution, namely in the connection system. These repeated loads may lead to a degradation of the mechanical properties of the connections, therefore, the connection type chosen was cyclic loaded for the evaluation of this load type in the connection stiffness and load carrying capacity.

Publications:

Papers

Marques, A. F. S., Martins, C. E. J., Dias, A. M. P. G., Costa, R. J. T., & Morgado, T. F. M. (2016). Assessment of Reuse Potential of Maritime Pine Utility Poles for Structural Applications after Removal from Service. BioResources, 11(4), 9340-9349. doi: DOI: 10.15376/biores.11.4.9340-9349

Martins, C. E. J., Dias, A. M. P. G., Marques, A. F. S., & Dias, A. M. A. (2017). Non-Destructive Methodologies for Assessment of the Mechanical Properties of New Utility Poles. BioResources, 12(2), 2269-2283. doi: 10.15376/biores.12.2.2269-2283

Dissertations

Marques, A. F. S. (2014). Comportamento Mecânico de Ligações Mistas Madeira-Betão com Elementos de Secção Circular. Master thesis, University of Coimbra.

Pereira, F. O. (2015). Avaliação das propriedades de postes de madeira com recurso a técnicas destrutivas e não destrutivas. Master thesis, University of Coimbra.

Contacts:

Alfredo Manuel Pereira Geraldes Dias
Tel.: +351 239 797 233
Fax: +351 239 797 123
Email: alfgdias@dec.uc.pt

Euro Latin America partnership in natural Risk mitigation and protection of the Cultural Heritage | ELARCH

Financing Institution(s): European Commission
Promoting Institution(s): University of Basilicata (Italy)
Coordinator(s): Michelangelo Laterza (Italy) and Paulo B. Lourenço (ISISE-UM)

Researchers and collaborators: Paulo B. Lourenço, Daniel V. Oliveira, Graça Vasconcelos, Luís F. Ramos, Jorge Branco, José Sena, Isabel Valente (only UMinho researchers listed)

Partner Institutions: University of Basilicata, University of Minho and 18 more Universities from Europa (7) and Latin America (11).

Period: October 2016 to May 2018

Relevant facilities: Laboratory facilities: strong floors and reaction walls; several universal hydraulic tension-compression load frames, closed-loop servo-controlled actuators and data acquisition and control equipment; climatic chambers; diverse day-to-day laboratory equipment - Computational facilities: advanced FE numerical tools.

Objectives:
ELARCH aims at establishing higher education cooperation between institutions from Europe and Latin America, to develop a comprehensive mobility scheme for building curricula in global disaster reduction issues, preservation of the cultural heritage and of the built and natural environment.
Researchers, future policy makers and practitioners will strengthen their curricula in architecture, engineering, geological sciences, environmental sciences, management and planning. Specific educational and interdisciplinary research activities will focus on innovative practices in conservation of the cultural heritage, life-cycle analysis and resilient/sustainable design, health monitoring and diagnostics, seismology, experimental studies, social/economic impact evaluation, disaster and asset management, national and international policy.

Description and Methodology:
Despite the advances of science and technology, natural risks are still resulting in dramatic human and economic consequences in the world's most vulnerable regions for the natural and built environment as well as for the cultural heritage. The capacity to mitigate the impact of risks relies on implementation of research and technology results into policy. Mitigation practices are more effective if incorporated into academic research and higher education curricula in an international and global context, representing an important opportunity for promoting innovation and creation of new jobs, international cooperation and dialogue.
ELARCH is a scholarship and mobility project funded under the Erasmus Mundus Action 2 Partnership (EMA2) coordinated by the University of Basilicata. The project is aimed at fostering scientific cooperation in the field of protection of heritages between European and Latin American Higher Education Institutions.
The scholarship programme is open to nationals from Bolivia, Peru, Ecuador, Paraguay, Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Mexico, Panama, Uruguay and Venezuela who want to study or work at one of the nine European partner Universities and to nationals from EU member countries who want to study or work at one of the eleven Latin American partner Universities.
The project is also supported by a number of associate organizations active in natural risk mitigation and international development.

Publications:
No publications are available yet as the project has started in October 2016.
By the end of the project, 40 MSc dissertations will be concluded, among several technical reports.

Contacts:
Paulo B. Lourenço
Tel.: +351 253 510 498
Fax: +351 253 510 217
Email: pbl@civil.uminho.pt
URL: www.hms.civil.uminho.pt

Fig. 3 Kickoff meeting at University of Minho

Environmentally-friendly solutions for Concrete with Recycled and natural components | EnCoRe

Financing Institution(s): MC-IRSES International Research Staff Exchange Scheme (IRSES)
Promoting Institution(s): Universita degli studi di Salerno, Italy
Coordinator(s): Enzo Martinelli (Universita degli studi di Salerno); Joaquim A. O. Barros (local, ISISE)

Researchers and collaborators: Joaquim A.O. Barros; J.M. Sena-Cruz, Mário Coelho, Cristina Frazão

Partner Institutions: Universidade do Minho (ISISE), Politecnico di Milano, Universidad de Buenos Aires, Universidad Nacional de Tucumán, Universidade Federal do Rio de Janeiro

Period: 01 January 2012 to 31 December 2014

Relevant facilities: -.

Objectives:
The main objective of the present Research Programme deals with the investigation of the physical, chemical and mechanical performance of concretes made out of recycled ingredients and components. In particular, this collaborative research project focuses on the three following objectives: investigate the physical and mechanical performance of concrete with recycled aggregates (RCA); investigate the possible contribution of recycled fibers on concretes with RCA; investigating the feasibility and the possible applications of concrete with natural fibers. The expected results of this Joint Programme of Research will lead to a significant advance on the possible production of concrete by recycling waste materials available in the local communities of the IRSES partners. Thus, significant impacts on both the technologies currently adapted in the building industry and the common practices in waste disposal are reasonably expected by this research.

Description and Methodology:
Due to obvious reasons, construction and demolition waste and other industrial by-products may be employed for obtaining recycled concrete constituents. For instance, recycled concrete aggregates (RCA) can be produced from existing concrete members that result from either industrial processes (i.e., precast structures) or demolitions of existing structures as a whole. In the latter case, concrete is not the only component of waste, as demolition rubbles of RC buildings also contain other materials, such as steel bars, masonry bricks, wood, plastics and so on. Moreover, waste resulting from industrial processes other than the building industry could, therefore, be efficiently disposed as concrete aggregates, as well. Sometimes similar industrial processes could even produce waste (i.e., mainly made out of either plastics or metals) that may efficiently be employed as dispersed reinforcement, by resulting a class of cement based materials designated as Fiber-Reinforced Concretes (FRC) or, more generally, Fiber-Reinforced Cementitious Composites (FRCCs). In such cases, the physical and chemical issues concerning the compatibility between the fibers and cementitious matrix, the durability of the resulting material, as well as its mechanical performance, should be deeply investigated. A further environmentally-friendly and cost-effective solution for producing FRCCs can be achieved by applying natural fibers as a reinforcement system. The characterisation of the key physical properties and mechanical properties of these novel class of cementitious materials made partly from the aforementioned replacements of recycled and natural constituents is the main goal of the EnCoRe Project (www.encore-fp7.unisa.it), a EU-funded initiative outlined in this article. Three objectives are addressed: 1) predicting the physical and mechanical performance of concrete with recycled aggregates; 2) understanding the possible contribution of recycled fibers used as a dispersed reinforcement in concrete matrices; 3) demonstrating the feasibility and possible applications of using natural fibers as a reinforcement in cementitious composites.

1. Recycled Aggregate Concrete (RAC)
EnCoRe has given particular attention to the partial replacement of both aggregates and cement with recycled components, such as Recycled Concrete Aggregates (RCA) and/or Fly Ash (FA). Fly-ash is a fine, glass-like powder recovered as a waste from the gases created by coal-firing electric power generators. Using FA in concretes provides a double benefit: firstly, it reduces the total amount of industrial waste and, secondly, it reduces the production of Portland cement with its significant atmospheric emissions of CO2. The use of both FA and RCA in concrete production is supposed to significantly improve the mechanical properties of RCA, and making them more comparable with those concretes made with cements and virgin aggregates. Starting with an ordinary concrete mixture as a reference, three groups made of four different concrete mixtures were designed and produced to investigate the effect of partial cement replacement by an "equivalent" amount of FA as a reactive pozzolan. In addition, the four mixtures per group also have different replacements of the ordinary aggregates by recycled ones. Figure 1 highlights the compressive strength evolution for samples made with mix "LN" - i.e. the natural aggregate concrete with the lowest amount of FA – which turns out to be very close to the reference one (mix "N"). On the other hand, the experimental results also show that partial replacement of natural aggregates with recycled ones leads to a

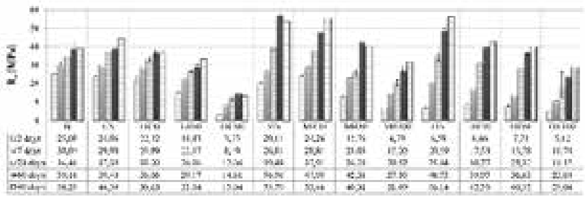


Fig. 1 Time evolution of the cubic compressive strength

2. Recycled Steel Fiber Reinforced Cementitious Composites (RSFRCC)

The recycling processes of used tyres mainly consist of separating the internal steel reinforcement from the rubber coating. Figure 2 shows an example of steel fibers obtained from processing out-of-use tyres, and, as a result of this process, they appear in a curling and twisted form, with their length and diameter quite irregular. These Recycled-Steel fibers (RSFs) can possibly be employed in concrete to replace the industrial ones (ISF), that act as a secondary reinforcement in a matrix of Fiber-Reinforced Cementitious Composites (FRCCs). The feasibility of this possible application has been assessed, namely for the production of thin mortar panels reinforced with RSFs for the shear strengthening with notable results (Figure 3).

Fig. 2 A sample of recycled steel fibers

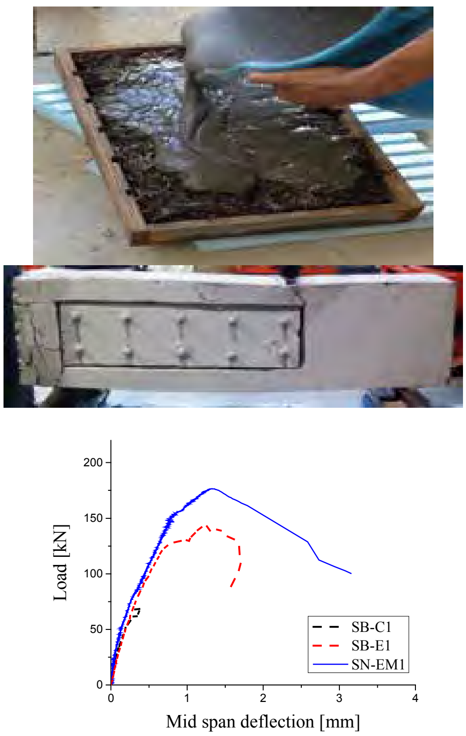


Fig. 3 Thin panels of mortar reinforced with RSFs for the shear strengthening of RC beams (SB-C1: reference RC beam, SB-E1: shear strengthened RC beam with panel exclusively bonded with epoxy; SN-EM1 beam: panel bonded and anchored with metallic bolts)

3. Natural Fiber Reinforced Cementitious Composites (NFRCC)

The use of natural fibers, in combination with steel fibers to produce High Performance Fiber Reinforced Cementitious Composites, has been investigated within the EnCoRe Project. Due to the large size differences between steel and natural fibers different combinations of hybridization with steel fibers have been adopted. In order to widen the investigation, a composite with raw sisal fibers, hybridized with either cellulose nanopulp, micro-crystalline cellulose powder and eucalyptus microfibers has been studied as well. The influence of pre-saturation of raw sisal fibers has also been investigated. Because of their highly hydrophilic nature and porous microstructure, natural fibers can absorb water as well. This can happen either during the mixing process or through dedicated pre-saturation. This water, accumulated in the porous natural fibers may also be released during cracking or at damaged locations where it may reactivate hydration reactions and initiating a delayed self-healing processes for "repairing" these cracks or damages (Figure 4).

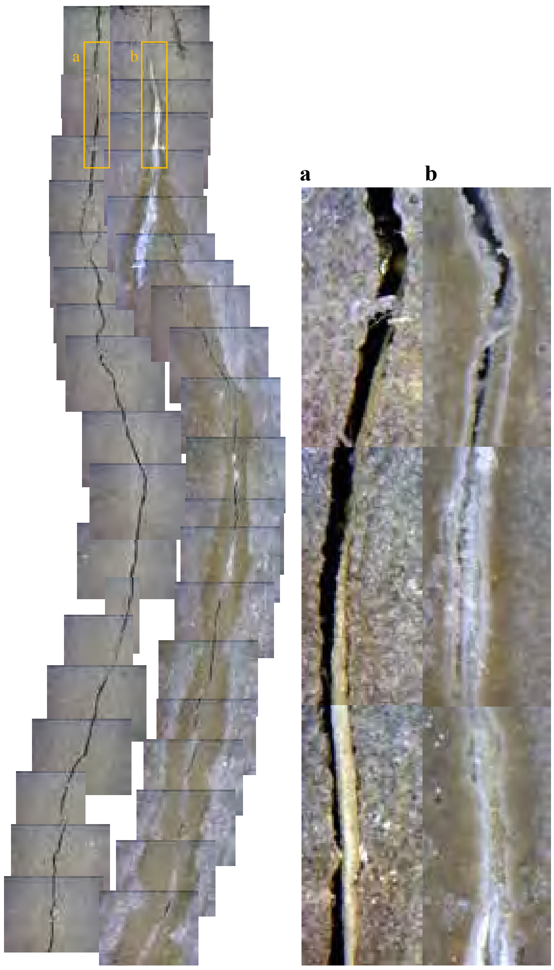


Fig. 4 Effect of natural water exposure time on recovery of composite: Crack before (left-a) and after 1 month in water (left-b): Sisal + Steel specimen; Magnification on 200x (Right-a,b)

Contacts:
Joaquim António Oliveira de Barros
Tel.: +351 253510210/747
Email: barros@civil.uminho.pt
URL: http://www.isise.net

European network for durable reinforcement and rehabilitation solutions | Endure

Financing Institution(s): Seventh framework programme, Marie- curie initial training networks (ITN), call FP7-PEOPLE-2012-ITN, Proposal number MC-ITN-2013-607851
Promoting Institution(s): The University of Sheffield (U.K)
Coordinator(s): Maurizio Guadagnini (Joaquim Barros in SC-UM)

Researchers and collaborators: Joaquim Barros, Sena-Cruz, Salvador Dias, Miguel Azenha, Isabel Valente, Chandan Gowda

Partner Institutions: Universidade do Minho (Portugal), The University of Sheffield (U.K), Universiteit Gent (Belgium), University of Patras (Greece), Technical university 'Gheorghe Asachi' of Iasi (Romania), Lulea Tekniska Universitet (Sweden), Budapest University of Technology And Economics (Hungry), Universitat De Girona (Spain), Universita Degli Studi di Padova (Italy), Politecnico di Milano (Italy), Technische Universitaet Kaiserslautern (Germany), Eidgenoessische Materialpruefungs- Und Forschungsanstalt (Switzerland), University of Latvia (Latvia), Net Composites (U.K)

Period: 01 September 2013 to 31 August 2017

Relevant facilities: FEMIX V4.0 Finite Element package; Laboratory equipment and facilities of Civil Department of UMinho.

Objectives:
The main aim of the endure Network is to train researchers in the underlying principles, major scientific challenges and practical problems in the use of composite materials as reinforcement for structural applications. This will be achieved through a combination of research training and industry guidance. The Network will aim: (i) to address the specific scientific challenges in the field and develop tests, models and guidelines to help with the standardisation process; and (ii) to bridge the gap between academia and industry and increase the competitiveness of the European composite and construction industry worldwide.
The specific objectives of the proposed network are: (i) to create the environment for delivering the best training for young researchers and further development of experienced researchers; (ii) to enable young researchers through their training and mobility to "cross-pollinate" industry and academia; (iii) to provide comprehensive solutions to current scientific challenges and support the development of standards, tests and models; (iv) to investigate the potential of new composite materials for applications in construction; (v) to develop innovative and sustainable strengthening techniques to improve or restore the performance of existing structures, including historic monuments and heritage buildings; (vi) to assist the European advanced composites industry to identify improvements (including recyclability) and new uses for their materials for applications in construction; (vii) to gather and maintain databases of information for the benefit of the wide research/industry community; (viii) to maintain an update on the state-of-the-art in the field; (ix) to disseminate the research findings and guidelines.

Description and Methodology:
Corrosion of steel reinforced concrete (RC) structures is considered to be the most significant factor in limiting the life expectancy of RC structures in Europe and other parts of the world. In Europe alone, the annual cost of repair and maintenance of the infrastructure is estimated to be about 50% of the construction budget, currently standing at more than €50 billion. Over the past thirty years, different measures have been taken to combat the corrosion problem. These have included the specification of increased concrete cover, the introduction of additives and inhibitors to make the concrete more impermeable and nonconductive, and the use of different types of reinforcing materials. The on-going requirement for more durable structures, as well as more efficient rehabilitation solutions is therefore the key driving force behind the introduction of Fibre Reinforced Polymers (FRP) in the construction industry as reinforcing or strengthening material for concrete structures. The growth of FRP in construction in recent years has been spectacular, doubling in size in the last decade. This expansion has been largely due to the use of FRPs in structural applications.
Despite the overwhelming popularity that FPRs are currently enjoying amongst researchers and the construction industry, there are major scientific questions that still remain unanswered. Key research areas include: development of advanced models for FRP-concrete/masonry interaction; definition of suitable serviceability conditions and determination of appropriate safety limits; development of advanced models for long-term behaviour and durability; advanced models for chemical/mechanical anchorage of externally bonded and near surface mounted reinforcement; strengthening of joints and statically indeterminate structures (especially for seismic upgrading); advanced models for concrete confinement; models for behaviour in fire and elevated temperature; continuous health monitoring and post strengthening assessment. Along with these scientific challenges, a bigger barrier to a more efficient and innovative use of any emerging technology is the poor

communication amongst researchers themselves, as well as between academia and industry. Interaction between the two sectors is still limited and too often potential users do not see past the initial material costs and fail to appreciate the long term benefit of using composites. As a result, practical applications are time and again a reflection of a traditional design practice that will eventually hinder the use of current and future new materials and techniques. Whilst design guidelines are necessary to enable the use of unfamiliar materials, they should be flexible enough to accommodate for future developments and facilitate the adoption of innovative products.

Therefore, the current research project endure ITN, will aim to develop and maintain a critical mass of research groups that will address the main scientific challenges, co-ordinate European research, and offer a link between academia and industry. This will be done not only through the mobility and work of new researchers, which will transfer ideas for the cross-pollination of the various sectors, but also through the development of material specification standards and pre-standard design guidelines. This ITN, as its predecessor Encore, will work in parallel with Task Group 5.1 of the International Federation for Structural Concrete (fib) and ISO, as well as the recently established RILEM technical committees 234-DUC and 223-MSC.

Fig. 1 proposes a map of the activities and the planned interactions among the project participants. The objectives of the project will be achieved through individual Work Packages. The first three Work Packages deal with the scientific objectives, whilst the other three are dedicated to the training activities, coordination of the network, outreach activities and dissemination of results.

The scientific work package will adopt appropriate combinations of proven research methods. A review of the literature will provide researchers with the necessary background knowledge and assist them in formulating well defined research questions. Laboratory investigations will provide controlled conditions under which the effect of specific parameters/issues can be examined in detail. Both small scale and large scale tests will be performed at the various participating institutions and these will be coordinated so as to maximize the number of parameters/issues investigated. Drawing from the expertise of some of the partners (UGent, Empa and POLIMI), novel measuring techniques adopting vision-based instrumentation, fibre optics and embedded sensors will be developed to map with increased accuracy local and global distribution of strain and their development. This will provide invaluable information, not attainable otherwise, for the investigation of bond and anchorage, cracking and deflection. Results from the experimental work, along with those available in the literature, will be analysed and compared implementing analytical and numerical models to gain additional insight into the physical, chemical and mechanical mechanisms associated with different phenomena. State-of-the-art non-linear finite element packages will be used along with bespoke developed algorithms.

Fig. 1 Map of activities work packages and interaction among participants

The knowledge gained from experimental, analytical and numerical investigations will be instrumental for the development of improved design guidelines and to assist in the development of new generation FRP reinforcements. The scientific WPs will also contribute to the work of the knowledge transfer WPs by providing data for the creation of informational databases, which will be open initially to Network researchers but ultimately shared with the wide research community, and through the preparation of technical reports that will be used for dissemination as well as for training activities, and joint research papers.

Contacts:

Joaquim António Oliveira de Barros
Tel.: +351 253510210/747
Email: barros€civil.uminho.pt
URL:http://www.isise.net

European pre-QUALified steel JOINTS | EQUALJOINTS

Financing Institution(s): Research Fund for Coal and Steel - European Union (EU - RFCS)
Promoting Institution(s): UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II, ARCELORMITTAL BELVAL & DIFFERDANGE S.A., CORDIOLI E C SPA*CORDIOLI & C SPA, EUROPEAN CONVENTION FOR CONSTRUCTIONAL STEELWORK, IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE, UNIVERSITE DE LIEGE, UNIVERSIDADE DE COIMBRA, UNIVERSITATEA POLITEHNICA DIN TIMISOARA
Coordinator(s): Raffaele LANDOLFO (UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II)

Researchers and collaborators: Raffaele LANDOLFO, Olivier VASSART, Francesco BESANA, Véronique DEHAN, Ahmed ELGHAZOULI, Jean-Pierre JASPART, Luis SIMOES DA SILVA, Carlos REBELO, Ashkan SHAHBAZIAN, Filippo GENTILI, Trayana TANKOVA, Dan DUBINA

Partner Institutions: Institute for Sustainability and Innovation in Structural Engineering (ISISE)

Period: 07/2013 to 06/2016

Relevant facilities: Computing cluster

Objectives:
The main aim of this project is to introduce in the European practice a qualification procedure for the design of moment resisting connection in seismic resistant steel frames, in compliance with EN1998-1 requirements. Further aims of the project are to qualify a set of standard for all-steel beam-to-column joints, and to develop prequalification charts and design tools that can be easily used by designers. The project is also intended as a pre-normative research aimed at proposing relevant design criteria to be included in the next version of EN 1998-1. Besides it would contribute to the advancement of knowledge in the field of seismic behaviour of steel moment resisting joints usually adopted in moment resisting frames (MR), in unbraced bays of dual moment-resisting/concentrically braced frames (MR+CB) and in moment-resisting/eccentrically-braced frames (MR+EB).

Description:
The cyclic behaviour of beam-to-column joints has a crucial role on the overall seismic response of both MR and dual frames. Recent studies highlighted the influence of joint rotation capacity on the seismic response of mid-rise MR frames designed according to EN 1998-1-1. As for dissipative zones, EN 1998 allows the formation of plastic hinges in the connections in case of partial-strength and/or semi-rigid joints, provided that the following requirements are verified: i) the connections have a rotation capacity consistent with the global deformations; ii) members framing into the connections are demonstrated to be stable at the ultimate limit state (ULS); iii) the effect of connection deformation on global drift is taken into account using nonlinear static global analysis or non-linear time history analysis. At the present time, EN 1993-1-8 provides models to compute the strength and the stiffness of connections but no reliable analytical tools are available to predict the rotation capacity and the cyclic performance in relation to the connection typology. EN 1998-1 requires design supported by specific experimental testing, resulting in impractical solutions within the typical time and budget constraints of real-life projects. As an alternative to design supported by testing, the code prescribes to find existing data on experimental tests performed on similar connections in the literature. It is clear that this procedure is unfeasible from the designer's point of view. On the other hand, although EN 1993-1-8 provides rules for full-strength joints, it is necessary to guarantee that these joints could have flexural overstrength larger than the beams which are connected, with plastic hinge located at the end of beams. As a matter of fact, due to the variability of steel strength and to the actual post-yield flexural overstrength of steel beams, these connections could not have enough overstrength. Indeed, the minimum joint extra-strength required by EN 1998 is 1.1x1.25 Mb.rd (being Mb,rd the beam plastic moment) could be largely overcome in many cases. In addition, it is necessary to give effective rules to control the column web panel. In fact, in non – dissipative joints the web should behave elastically, while in those dissipative web contribution to total plastic joint rotation should be under 30%. Hence, in such cases plastic rotation capacity must be prequalified by tests and numerically based procedures. In contrast to current European design methodology, the approach used in other countries with high seismic hazard is based on codified and easy-to-use design tools and procedures. In particular, following the widespread damages observed after Northridge and Kobe earthquakes, North American practice was directed at prequalifying standard joints for seismic resistance. The design approach based on prequalification would certainly be of interest for the European industry, especially if the spin-offs related to the use of simple and reliable design tools are considered. A number of European research projects have been carried out in the past aimed at investigating the effects of previous issues on the behaviour of steel joints, but none was devoted to the prequalification process of selected connections. Of course, the existing database of experimental results (i.e. SERICON and RECOS) represents an important starting point to deepen and examine the open issues

affecting the seismic behaviour of connections, which are: Effect of different steel grades of beams and columns on connection performance; The influence of stress concentration in the welds on the low cycle fatigue; Role of panel zone yielding in shear on the connection behaviour; Geometric parameters of the connection including beam depth, flange size and weld size; Strain rate and dynamic effects; Load and deformation history. All the previous parameters affect the yield mechanisms and failure modes which are the factors controlling both the resistance and ductility or rotational capacity of the connection. The prediction of yield mechanisms, failure modes, and the resistance associated with them are far from being understood. This is a crucial issue to be deepened to rationally use each connection type in seismic design. Following the previous considerations, it is proposed to develop a guide for the design of the connections specifically for the European market, including design rules and detailing. In line with the US practice, this project will provide an operative tool for the design of typical beam-to-column connections adopted in Europe. In such a way, designers can directly use pre-qualified connections without performing experimental test and/or literature reviews as long as the connection design, detailing and quality assurance measures are covered by the prequalification process.

Pre-qualified connections will simplify the design and certification because: (i) designers do not have to perform and present test data; (ii) the responsible authority does not have to carry out the conformity assessment each time a design includes such joints.

Contacts:

Carlos Rebelo
Tel.: +351 239 797 209
Fax: +351 239 797 123
Email:crebelo@dec.uc.pt
URL:www.isise.net

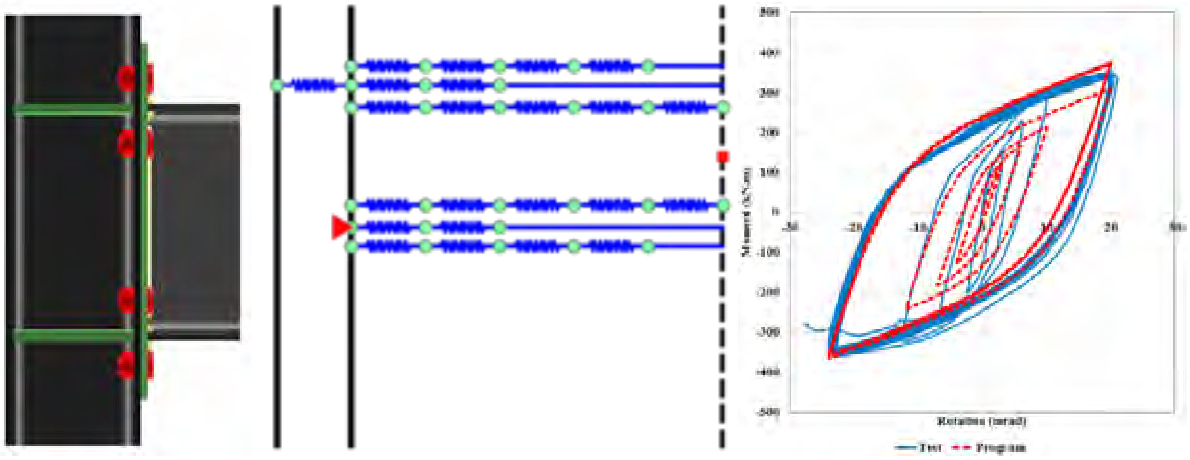


Fig. 1 Cyclic component-based method

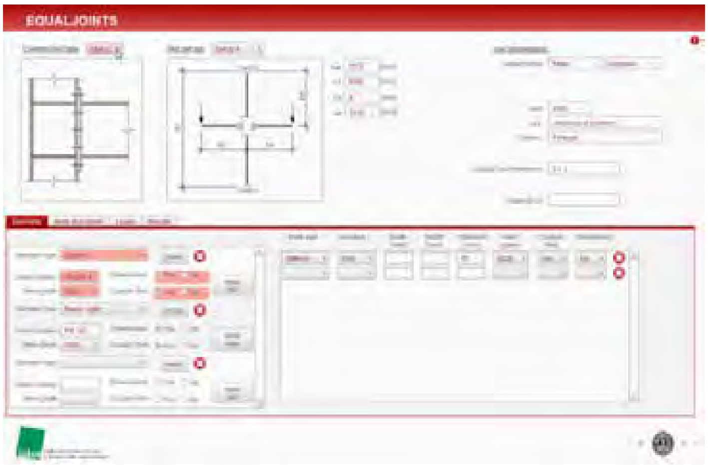


Fig. 2 Database

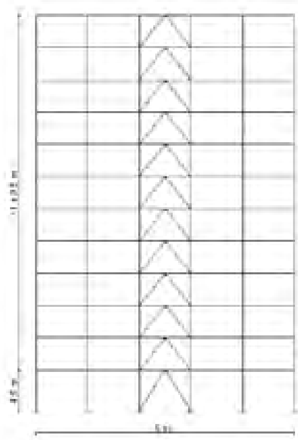


Fig. 3 CBFs pushover analysis

ERASMUS MUNDUS: European master on Sustainable Construction under natural Hazards and Catastrofic Events| Suscos

(Project EACEA – 520121-1-2011-1- CZ ERA_MUNDUS-EMMC)

Financing Institution(s): European Commission

Promoting Institution(s): University of Coimbra

Coordinator(s): Luis Simões da Silva (UCoimbra)

Researchers and collaborators: Luís Simões da Silva, Aldina Santiago, Carlos Rebelo, Helena Gervásio, João Pedro Martins, Maria Constança Rigueiro, Paulo Santos, Sandra Jordão, Rui Simões, Luís Borges, Tiago Abecasis (only UCoimbra researchers listed)

Partner Institutions: Czech Technical University (CZ); Technical University of Lulea, Lulea, Sweden; University "Politechnica" Timisoara, Romania; University of Liège, Liège, Belgium; University of Naples "Federico II", Naples, Italy

Period: September 2012 to August 2017

Relevant facilities: Laboratory facilities: strong floors and reaction walls; several universal hydraulic tension-compression load frames, servo-controlled actuators and data acquisition and control equipment; climatic chambers; heating equipment's; diverse day-to-day laboratory equipment; Computational facilities: advanced FE numerical tools.

Objectives:
The focus of master course SUSCOS_M is to provide attendees the engineering ability and know-how to design and construct structures in a balanced approach between economic, environmental and social aspects, enhancing the sustainability and competitiveness of the steel industry. The course is organized in three modules covering buildings; bridges and energy-related infra-structures from concrete, steel, timber, and composite structures with a practice oriented approach. The degree awarded is a Master Degree, provided as a multiple diploma.

Description:
SUSCOS is an advanced postgraduate program in Sustainable Steel Construction led by an international consortium of universities. The consortium comprises the 6 following universities: University of Coimbra, Portugal; University of Liège, Belgium; Czech Technical University at Prague, Czech Republic; Technical University of Lulea, Sweden, University "Politehnica" of Timisoara, Romania and University of Naples "Federico II", Italy. The 1st and 2nd semester is taught in one of the partner universities rotating in each edition. The MSc thesis can be developed at any of the partner universities. The successful conclusion of the MSc programmmes leads to the award of the following diplomas: Master Degree provided as a multiple diploma.

Education programme:
The MSc has a duration of 18 months (90 ECTS) organized in 3 modules.
The courses are lectured in English by academics from all partner institutions and invited teachers from associated members.

List of Subjects:
First semester
1C1 Design of sustainable constructions
1C2 Conceptual design of buildings
1C3 Conceptual design of bridges
1C4 Local culture and language
1E5 Advanced design of glass structures
1E7 Rehabilitation and maintenance of structures
2E12 Design for renewable energy systems

Second semester
1E6 Advanced design of timber structures
2C8 Advanced design of steel end composite structures
2C9 Design for seismic and climate changes
2C10 Design for fire and robustness
2C11 Business economics and entrepreneurship
2E14 Design of aluminium and stainless steel structures

Third semester
3C12 Theses

Web site: http://steel.fsv.cvut.cz/suscos

Contacts:
Luís Simões da Silva
Tel.: +351 239 797 216
Email: luisss@dec.uc.pt
URL: www.isise.net

Fig. 1 Origin of SUSCOS students

DEVELOPMENT OF SUSTAINABLE FIBERCEMENT BUILDING ELEMENTS CONTAINING VEGETABLE FIBERS AND URBAN RESIDUES |CAPES

Financing Institution(s): CAPES, PVE Program: Project 047/2012
Promoting Institution(s): State University of Feira de Santana (Brazil)
Coordinator(s): Paulo Roberto Lopes Lima

Researchers and collaborators: Joaquim A.O. Barros; José M. F. Lima, Cintia M. A. Fontes, Romildo D. Toledo Filho

Partner Institutions: Universidade do Minho (Portugal), UFRJ (Brazil)

Period: 01 March 2012 to 1 December 2015

Relevant facilities: FEMIX V4.0 Finite Element package; Laboratory equipment and facilities of Civil Department of State University of Feira de Santana and UFRJ.

Objectives:
The main objective of this project is the development of sustainable, safe and high performance building elements that are basic characteristics so that they can become a technological innovation, that is, they can be adequately disseminated in the market. Some ways of minimizing the impact of the asbestos cement industry are proposed in this project such as the use of recycled mineral additives instead of cement, the use of recycled aggretages and the use of renewable fibers as reinforcement.

Description and Methodology:
Civil construction is one of the industrial sectors with the greatest environmental impact. The fiber reinforced concrete technology is contributing significantly to this by using a matrix with high consumption of portland cement in its composition and fibers based on fossil fuel, or potentially harmful to human health such as asbestos. The objective of this project is the production of sustainable fiber cement building elements. Some ways of minimizing the impact of the asbestos cement industry are proposed in this project such as the use of recycled mineral additives instead of cement, the use of recycled aggregates and renewable fibers as reinforcement (vegetable, especially sisal fibers).

Experimental characterization:
The sisal fibers (Agave sisalana) were collected in the city of Valente, state of Bahia – Brazil. They were extracted from the sisal plant leaves by semi-automatic decorticators in the form of long fiber bundles. In laboratory, the long fibers were first washed in hot water (50 °C), to remove surface residues from the extraction process, and then cut into short fibers of 40 mm length. The fibers were subjected to a treatment with wetting-drying cycles to reduce water absorption and therefore its dimensional variation.
Construction and demolition waste (CDW) from a building demolition site in Feira de Santana (Northeast of Brazil) was used to produce the recycled aggregate. The composition of CDW was 56% of mortar, 27% of ceramic tiles and bricks, and 17% of concrete. The natural aggregate used was fine sand (NA). To determine the physical properties of the fine aggregates absorption and specific weight tests were carried out. The binder is composed of 33% of Portland cement CP II-F (Portland cement with filler), 27% of metakaolin (MK) and 40% of fly ash (FA). The mixtures were divided into three groups: matrices; cement composites with 4% in volume (Vf) of fiber and cement composites with Vf=6%. In each group, three mixtures were produced and the difference between them is resumed to the content of recycled aggregate. The aggregates substitution rate, in mass, was 10%RCA and 20%RCA. The water/binder ratio was kept constant and equal to 0.45.
Bending tests results (Fig. 1) indicated that the reinforcement provided by short sisal fibers for recycled cement matrices guaranteed a composite with multiple cracking and an increase of strength after the first crack.

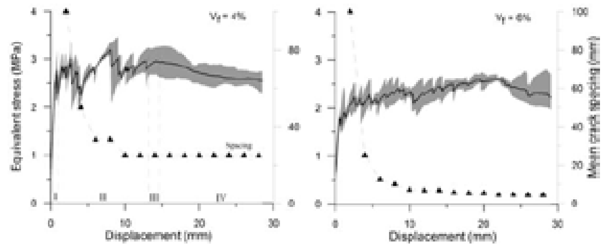


Fig. 1 Flexural behavior of short sisal fiber cement composites

Numerical analysis
For assessing the potentialities of sisal fiber reinforced cement composite (SisFRCC) for the development of new constructive elements of semi-structural character, advanced FEM analysis were performed with the FEMIX computer program. It was adopted a multidirectional fixed smeared crack constitutive model implemented under the framework of the Reissner−Mindlin theory adapted to the case of layered shells. The values of parameters of the constitutive model were determined by fitting, as much as possible, the force−deflection relationship obtained in the experimental tests. The tensile stress crack-width obtained from this inverse

analysis that simulates the post-cracking behaviour of this composite SisFRCC is represented in Fig. 2.

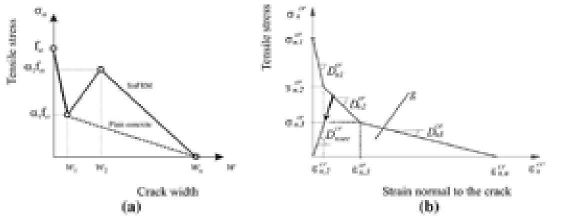


Fig. 2 Diagrams for modelling of SisFRCC: (a) tensile stress-crack width diagram; (b) fracture mode I

SisFRCC reinforced with Vf = 4% of sisal fibers is explored for the development of the constructive element represented in Fig. 3.

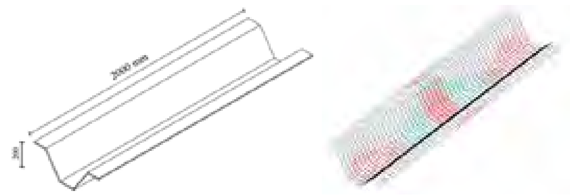


Fig. 3 Filler block solutions for precast one-way slab. (A) conventional block; (B) proposal fibre cement block

Blocks for prefabricated slabs:
Unlike a conventional block (see Fig. 5A) proposed by the Brazilian NBR 14859,108 a thin shell folder type element was developed (see Fig. 4b) to ensure lighter weight, and to permit the passage of electrical, hydraulic air conditioning ducts in the bottom part of the slab. Due to its lightweight and relatively high flexural capacity, a larger size (mainly in depth and height) can be used, resulting in faster assembling of the prefabricated slab.

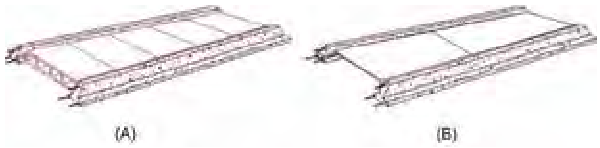


Fig. 4 Filler block solutions for precast one-way slab. (A) conventional block; (B) proposal fiber cement block.

To determine the load carrying capacity of the developed SisFRCC, blocks, load tests were carried out. Figs. 5 shows that these elements have a load capacity higher than the required by the standards, and much higher ductility than traditional blocks.

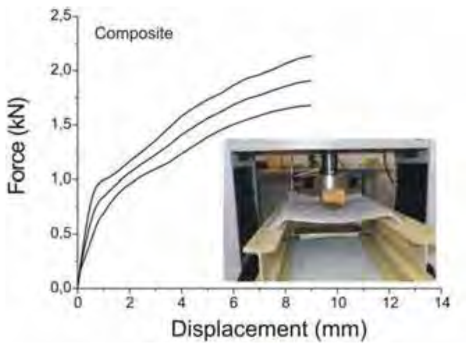
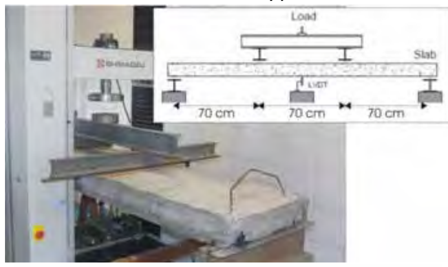


Fig. 5 Load-displacement responses of filler blocks under flexion

The potential of the developed SisFRCC block for this type of one-way prefabricated slabs was assessed by producing and testing a representative strip of this structural system and using these new blocks. All slab strip prototypes were tested as simply supported with a 2.1 m free span and submitted to a four line-loading configuration, as schematically represented in Fig. 6a. The structural behavior of the slabs was analyzed through load versus displacement curves shown in Fig. 6b. The load-displacement response is similar in the slab strips having the two types of filler blocks, as expected due to the marginal contribution of these blocks for the structural behavior of this type of slabs.

a) 

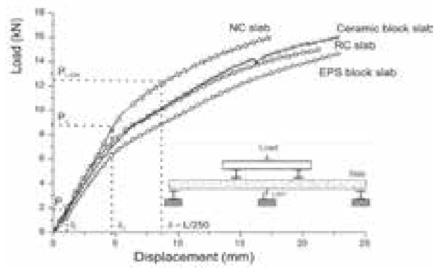
b) 

Fig. 6 Four point bending test setup

After cracking load and up to the yield initiation of the flexural reinforcement of the pre-fabricated beams, the slabs with SSFRC blocks presented higher stiffness than slabs with the other two types of blocks (ceramic and EPS), which can be justified by the observed cracking process. In fact, the continuity of the cracks in the pre-fabricated beams and SisFRCC blocks, demonstrates the contribution of these blocks for the flexural capacity of the corresponding slabs, as is visible in Fig. 6. The cracking continuity in pre-fabricated beams and SisFRCC blocks also indicates good bond conditions between these blocks and concrete cover layer. Therefore, in spite the main aim of the proposed SisFRCC blocks is to demonstrate the possibility of producing cost competitive blocks of larger in plane dimensions for quicker execution of this type of slabs, of higher load carrying capacity and suitable geometry for suspending and hiding infrastructures, and to constitute elements of much higher ductility and material integrity due to safe reasons for the operators, the structural response of the tested slabs demonstrates these SisFRCC blocks can be optimized for providing non negligible contribution for the load carrying capacity of this type of slabs.

Contacts:
Paulo Roberto Lopes Lima
Tel.: +55 75999384145
Email: lima.prl@pq.cnpq.br
Joaquim António Oliveira de Barros
Tel.: +351 253510210/747
Email: barros@civil.uminho.pt
URL: http://www.isise.net

Experimental and Numerical Analysis of Cold-Formed Steel Elements Subjected to Fire | FIRE_COLDFSTEEL

PTDC/ECM/116859/2010

Financing Institution(s): Portuguese Foundation for Science and Technology (FCT)
Promoting Institution(s): University of Coimbra (UC)
Coordinator(s): João Paulo Correia Rodrigues

Researchers and collaborators: João Paulo Correia Rodrigues (UC); Luís Miguel dos Santos Laím (UC); Luís Carlos Fonseca Ribeiro (PERFISA).

Partner Institutions: University of Coimbra (UC); PERFISA - Fábrica de Perfis Metálicos, SA; Institute For Sustainability and Innovation in Structural Engineering (ISISE).

Period: July 2012 to June 2015

Objectives:
The overall purpose of this research was to investigate the structural behaviour of cold-formed steel (CFS) members under fire conditions so as to develop adequate simplified calculation methods for the safe and economical fire design rules of CFS members, similar to those that exist for hot rolled steel. This goal is intended to achieve with the aid of both experimental tests and advanced numerical analyses. Therefore, the research plan was implemented in two great phases which were accomplished at University of Coimbra (UC). The main objectives of the experimental research were obviously to assess the true fire behaviour (critical time and temperature) of the members, characterize their failure modes and to provide reliable experimental data for numerical studies, in order to develop and validate a suitable finite element model capable of obtaining reliable results from a parametric study outside the bounds of the original experimental tests. It is noticed that after the numerical models are calibrated, they may be very useful for extrapolations, saving time and money. So, at the end, basing on the experimental and numerical results, it was intended to undertake an analytical study for the development of simplified calculation methods for fire design of CFS members.

Description and Methodology:
This project was divided into three main parts (work packages). The most significant aspects of the work performed on each of the Work Packages is hereafter described on a task per task basis and highlighting the objectives.

<u>WP1 Experimental Analysis of Cold-Formed Steel Members</u>
This WP presented a series of flexural and compression tests at ambient temperature and under fire conditions focused on sections made of one and more CFS profiles, namely, channel and lipped channel profiles also known as U and C profiles, respectively. These profiles were combined in different manner in order to build lipped I-, R- and 2R-shaped cross-sections. The built-up lipped I members consisted of two C profiles connected back to back, the built-up R beams consisted of one C profile inside one U profile, generating a closed built-up member, and finally the built-up 2R members consisted of two C profiles connected back to back which were then connected over by two U profiles (fig. 1). It was performed in detail the experimental programme, the testing procedures and the test set-up for bending and compression tests (fig. 2). The load applied on the members, the bending moments, the vertical and horizontal displacements of the members, as well as, their lateral rotation, the rotation of their supports and still some longitudinal strains are shown as results of these experimental tests at ambient temperature so as to characterize the structural behaviour of the CFS members at ambient temperature in the best possible way. The main purpose of these tests was to assess the failure loads and modes of the studied members and also to compare the structural response of these different kinds of members at ambient temperature. It is noticed that these tests were carried out to provide a reference for fire tests.
When it comes to fire, three sets of experimental tests were conducted in order to evaluate the influence of the stiffness of the surrounding structure to the members, in other words, the first set of the experimental tests was carried out on CFS members without any kind of restraint to thermal elongation of the members, whereas the second and third sets were undertaken on the same type of members, but with axial restraint and with combined axial and rotational restraint at their supports, respectively. The load applied on the members, the bending moments, the restraining forces, the vertical and horizontal displacements of the members, as well as, the temperatures in the furnace and at several points of the members were shown as results of these experimental tests so as to characterize the structural behaviour of the CFS members subjected to fire. The main goal of these tests was to assess the critical time and critical temperature of the studied members with the different boundary conditions mentioned before. This means that the fire tests conducted tried to reproduce as faithful as possible standard fire resistance tests, i.e. fire curves identical to the standard fire curve and thermal action given by flame action. It is noticed that the standard fire exposure curve is defined by a temperature-time relationship and increases monotonically during the rating period and is the same for almost all building occupancies.

Before the heating rate starts the structural member to be tested is firstly loaded. This loading is normally a percentage (30, 50 or 70%) of the design value of buckling load of the member at ambient temperature, calculated in accordance with the methods proposed in the currently available design rules (EN 1993-1-1, EN 1993-1-3, EN 1993-1-5). So, the load intended to simulate the serviceability load of the member when this one is inserted in a real building structure. During the period of heating, the load was kept constant until member reached its failure (transient-state tests). This period (the time between the beginning of the heating and the failure of the member, corresponds to the fire resistance of the member and its temperature at the ending of the test to the critical temperature (for cross-sections with uniform temperatures).

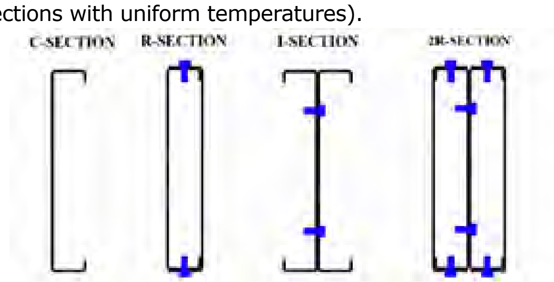


Fig. 1 Scheme of the cross-sections of the tested members

Fig. 2 Experimental set-up for CFS columns

WP2 Numerical Simulations: In this Work Package, numerical models were developed for the different types of sections studied, and validated against the experimental results obtained in WP-1. The numerical results presented and discussed were obtained through shell finite element analyses performed using the ABAQUS program. It was intended to describe in detail all parameters, considerations and assumptions took into account in a three-dimensional nonlinear finite element model to predict the behaviour of CFS members in fire, such as, the beams previously tested in Laboratory. The numerical results were thereby compared with those given by the experimental tests (fig. 3) in order to calibrate the developed finite element model. The effect of some parameters such as mesh density, eccentricity of the applied load on the beams and diameter of the screws used in the connection of the profiles in order to obtain the built-up CFS members were also taken into account in this numerical research work. These numerical models were subsequently used for conducting parametric studies, which were the basis for the development of a Simplified Design Method in WP-3. A comprehensive study was carried out, in order to define the cases to analyse in the parametric studies. Based on a previous evaluation of the commercially available section shapes and their usage in construction, the cross-section dimensions and ranges of variation of the parameters were decided.

WP3 Simplified Design Methods: This Work Package aimed at correcting the current simplified methods of EN1993-1-2 for CFS members, extending the simplified methods to built-up CFS members. Firstly, the results presented in the previous WP were then compared with those given by the predictions from the currently available design rules both at ambient temperature and under fire conditions, involving the EN1993-1.1, -1.2 and -1.3, for instance. Afterwards, also based on the results of the parametric studies carried out in WP-2, a Simplified Design Method (SDM) for CFS members of any studied section shape at high temperatures was tried to develop. Finally, these methods are expected to be a useful tool for the designers and constitute a first step for a future part for Eurocode 3 related to fire design of CFS members.

Fig. 3 Experimental (a) and numerical (b) configuration of the deformed R beam with no restraints after fire test

Publications:

Papers

Laím, L., Rodrigues, J.P.C., Simões da Silva, L. (2013), Experimental and numerical analysis on the structural behaviour of cold-formed steel beams, Thin-Walled Structures, Vol. 72, pp. 1-13.

Laím, L., Rodrigues, J.P.C., Simões da Silva, L. (2014), Experimental analysis on cold-formed steel beams subjected to fire, Thin-Walled Structures, Vol. 74, pp. 104-117.

Craveiro, H.D., Rodrigues, J.P.C., Laím, L. (2014), Cold-formed steel columns made with open cross-sections subjected to fire, Thin-Walled Structures, Vol. 85, pp. 1-14.

Laím, L., Rodrigues, J.P.C., Craveiro, H.D. (2016), Flexural behaviour of axially and rotationally restrained cold-formed steel beams subjected to fire, Thin-Walled Structures, Vol. 98, pp. 39-47.

Laím, L., Rodrigues, J.P.C. (2016), Numerical analysis on axially-and-rotationally restrained cold-formed steel beams subjected to fire, Thin-Walled Structures, Vol. 104, pp. 1-16.

Craveiro, H.D., Rodrigues, J.P.C., Santiago, A., Laím, L. (2016), Review of the high temperature mechanical and thermal properties of the steels used in cold formed steel structures – The case of the S280GD+Z steel, Thin-Walled Structures, Vol. 98, pp. 154-168.

Craveiro, H.D., Rodrigues, J.P.C., Laím, L. (2016), Buckling resistance of axially loaded cold-formed steel columns, Thin-Walled Structures, Vol. 106, pp. 358-375.

Craveiro, H.D., Rodrigues, J.P.C., Laím, L. (2016), Experimental analysis of built-up closed cold-formed steel columns with restrained thermal elongation under fire conditions, Thin-Walled Structures, Vol. 107, pp. 564-579.

Laím, L., Rodrigues, J.P.C. (2016), On the applicability and accuracy of fire design methods for open cold-formed steel beams, Journal of Building Engineering, Vol. 8, pp. 260-268.

Fire Behaviour of Reinforced Concrete Structures Incorporating FRP Composites | FIRECOMPOSITE

Financing Institution(s): FCT
Promoting Institution(s): University of Lisbon | Instituto Superior Técnico, University of Minho | Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM)
Coordinator(s): João Ramôa Correia (IST-UL) and Joaquim Barros (ISISE-UM)

Researchers and collaborators: IST-UL - João Ramôa Correia, Fernando Branco, Eduardo Júlio, João Firmo, Jorge de Brito; ISISE-UM - Joaquim Barros; Eduardo Pereira, Sena-Cruz, Ventura-Gouveia, Lúcio Lourenço

Partner Institutions: University of Lisbon | Instituto Superior Técnico (IST-UL); University of Minho (ISISE-UM)
Period: 01/06/2016 – 31/05/2019

Relevant facilities: Laboratory and computational equipment of Civil Engineering department at EEUM; laboratory and computational equipment of IST.

Objectives:
This research project centres on the behaviour at elevated temperature and under fire of (i) new concrete elements reinforced with all-FRP bars or hybrid steel-FRP prestressed reinforcement and (ii) existing concrete elements strengthened with advanced FRP systems (ETS, prestressed strips, strips with bent extremities or bonded with cement-based adhesives). The main motivation is to improve the understanding of their fire response, to optimize both FRP materials/geometries and fire protection systems, to develop fire design guidelines and ultimately to enable extending the structural use of FRPs in buildings. This implies coupling the experimental research programme with the development of supporting numerical modelling tools.

Description and Methodology:

1. Object
This project addresses the fire behaviour of reinforced concrete (RC) members incorporating fibre reinforced polymer (FRP) materials for two different applications: new construction with FRP rebars and strengthening with advanced FRP systems.

2. Motivation
In spite of their higher initial costs, FRP rebars are being increasingly used in new RC construction owing to their several advantages over conventional steel reinforcement: high strength, lightness and corrosion resistance. However, there are several uncertainties and well-founded concerns about their fire performance, since the material properties of FRPs and their adherence to concrete are severely deteriorated at relatively low temperatures (65-120 ºC). Consequently, the main design guidelines discourage the use of FRP rebars in constructions likely to be exposed to fire (buildings), until a better understanding is obtained about their fire response.
In recent years, advanced FRP systems have been developed for both new construction (hybrid reinforcement) and strengthening (prestressed CFRP strips, CFRP strips bent in the anchorage zones, FRP bars embedded through the section – ETS), granting several advantages over conventional FRP systems. However, the behaviour of these advanced FRP systems at elevated temperature is still unknown and needs to be investigated.
The analysis of the literature shows that the effort of adapting the available FE codes to model the fire response of RC members incorporating FRPs may justify the development of special-purpose tools to overcome difficulties due to the variation with temperature of material properties and, in particular, of FRP-concrete interfaces. FEMIX software allows an efficient integration of new material and interfacial constitutive models, thus enabling the simulation of the thermal-hygrometric-mechanical response of RC-FRP members under fire.

3. Innovation and proposed developments
This project will experimentally assess the adherence between FRP rebars and concrete at elevated temperature, as well as the fire behaviour of RC members with this type of rebars, including the effects of bar surface finishing, lap splices and type of end anchors. The project is also assessing the fire response of RC structural systems with hybrid reinforcement (comprising prestressed FRP and steel bars), which showed high potential at ambient temperature (ensuring ductile failure modes).
Regarding the strengthening of RC members with advanced FRP systems, the project will assess the fire behaviour of the following techniques: (i) flexural strengthening with near surface mounted (NSM) FRP strips, either prestressed or bent in the ends (conferring improved anchorage and thermal protection) and (ii) shear strengthening with ETS-FRP bars. In both cases, the project will assess the effectiveness of cement based adhesives, less susceptible to thermal degradation than epoxies, and fire protection systems, namely in the FRP anchorage zones, which proved to be very effective with conventional FRP strengthening systems.
The numerical modelling methodology comprises the incorporation in FEMIX software of the constitutive relations as a function of temperature of both FRP materials and interfaces. Thermal and thermo-mechanical uncoupled analyses will be performed. After validation with the results of experimental tests, the models will be used to optimize the geometry of the strengthening and fire protection systems.

4. Research approach, methods and co-operation between research team members

To carry out the proposed innovation, the research project comprises an extensive experimental programme (Tasks 2 to 5), including materials development and characterisation, with small-scale tests, intermediate-scale bond tests on FRP-concrete specimens and full-scale fire tests on loaded FRP-RC and FRP-strengthened RC beams.

The research team includes four industrial partners: (i) the FRP systems will be supplied by , one of the biggest European manufacturers, (ii) the cement-based adhesive will be developed in collaboration with Civitest company; (iii) the fire protection materials will be selected in collaboration with , a company specialized in fire protection; (iv) the test specimens will be manufactured with the technical assistance of , a contractor specialized in structural rehabilitation, who will also provide feedback about the practical feasibility of the solutions to be developed.

For the experimental study, in addition to standard mechanical tests of all materials at ambient temperature, tensile tests at elevated temperatures will be performed at UM and IST (Task 2) on FRP bars and strengthening systems, including different formulations of cement-based adhesives. Dynamic mechanical analyses and thermogravimetric and differential scanning calorimetry tests will first be performed at IST on FRP, adhesives and fire protection materials, to analyse their thermophysical and thermomechanical behaviour. These experiments will provide the glass transition and decomposition temperatures of the FRPs and adhesives, together with their thermo-physical properties (density, specific heat and thermal conductivity) as a function of temperature. These data will be used as input for the models to develop in Task 5.

In a second phase of the experimental programme (Task 3), the FRP-concrete adherence at elevated temperature will be tested in concrete prisms by means of (i) pull-out tests with FRP bars and (ii) double lap shear tests with NSM-FRP strips. Tests will be performed at IST on a universal testing machine with an attached thermal chamber under steady state condition, i.e., specimens will be heated up to different temperatures (20 ºC to 250 ºC) and then loaded up to failure. In the pull-out tests, the influence of the bar surface finishing (ribbed, sand coated, external wound fibres) and diameter and concrete strength will be assessed. In the double-lap tests, the influence of the type of adhesive (epoxy or cement-based) will be investigated. In these tests, the applied load, the slip at the FRP loaded and free ends, temperatures and strain distributions will be measured. A model describing the bond stress-slip dependence on temperature will be developed and implemented in FEMIX (Task 5).

In a third phase of the experimental programme (Task 4), full-scale fire resistance tests will be conducted at IST on loaded FRP-RC and FRP-strengthened RC beams. Tests will be performed in a furnace according to the conditions of ISO 834 standard, to determine temperature profiles, the evolution of strains and deflections, the failure modes and fire resistance of the beams. For the FRP-RC beams, the different tests will allow investigating the influence of (i) bar surface finishing, (ii) bar diameter, (iii) bar configuration, (iv) lap-splices, (v) concrete strength and cover thickness, and (vi) prestress levels (for hybrid reinforcement). For FRP-strengthened RC beams, tests will allow evaluating the effects of (i) adhesive material (for both ETS and NSM techniques), (ii) FRP strip bending configuration, (iii) prestress level (for NSM) and (iv) different fire protection configurations (with thicker board insulation in the anchorage zones).

The objective of the numerical models to be developed in Task 5 is the simulation of the fire behaviour of FRP-RC and FRP-strengthened RC beams, both unprotected and protected with different fire protection systems. As mentioned, FEMIX has been widely used (and validated) to simulate the structural behaviour at ambient temperature of concrete structures with FRPs. In addition, the software is already able to perform uncoupled thermal-mechanical analysis of this type of elements, provided that the necessary input data is available. The main developments comprise (i) the implementation in FEMIX of the temperature dependent material and interface properties; (ii) the simulation of the pull-out and double-lap tests, to calibrate (based on an inverse analysis) the global FRP-concrete bond constitutive relation vs. temperature, and (iii) the implementation of those laws to accurately simulate the fire behaviour of FRP-RC and FRP-strengthened RC beams, retrieving their thermal responses, strain, stress and deflection evolution, and fire endurance estimates, (iv) development of a software for a design-oriented post-processing of results of FRP-RC and FRP-strengthened RC structures. After calibration of the models, parametric studies will be developed to predict the behaviour of RC members with arbitrary cross-sections under fire conditions, thus allowing optimizing the configuration of the FRP and fire protection schemes.

At the end of this project, a manual will be delivered (Task 6), comprising design rules, tables/abaci and technical specifications regarding the fire behaviour of FRP-RC and FRP-strengthened RC members for building applications. For most current cross-sections and spans, tables/abaci for FRP-RC members will indicate the minimum concrete cover for different fire resistance requirements, depending on the reinforcing bars type, detailing and prestress level (for hybrid reinforcement). For the various types of FRP-strengthened RC members, specific tables/abaci will provide the minimum fire protection thicknesses needed to fulfil different performance levels related to fire resistance (30, 60, 90 or 120 min).

5. Expected results This project will provide (i) in-depth understanding of the fire behaviour of RC members with FRPs, for both new construction and rehabilitation; (ii) new cement-based adhesives and tailored fire protection systems that will enable extending the safe use of FRPs in buildings; (iii) numerical models able to simulate the fire response of those members, and (iv) a manual for the fire design and application of the solutions to be developed.

Contacts:

Joaquim Barros
Tel.: +351 253510210/747
Email: barros@civil.uminho.pt
URL: http://www.isise.net

Optimization of frames for effective assembling | FRAMEUP

(RFCS – Research Fund for Coal and Steel)

Financing Institution(s): RFCS – Research Fund for Coal and Steel
Promoting Institution(s): Lulea University of Technology (LTU)
Coordinator(s): Milan Veljkovic (LTU)

Researchers and collaborators: M. Veljkovic, P.Andrade, J.P. Jaspart, J. F. Demonceau, L.V.Long, M.A.Hernandez, L.S. Silva, C.Rebelo, R.Simoes, H.Gervásio, G.Vicente, N.Lundholm, A.Lundholm, M.Feldmann, D.Pak, D.Pyschny, C.Remde, S.Herion

Partner Institutions: Lulea University of Technology, Sweden; University of Liège, Belgium; ACCIONA Infraestructuras S.A., Spain; University of Coimbra, Portugal; PartConstruction AB, Sweden; RWTH Aachen University, Germany; V&M Deutschland GmbH, Germany.

Period: July 2011 to June 2014

Relevant facilities: Laboratories with modern equipment for mechanical testing and instrumentation, computational equipment of civil engineering departments.

Objectives:
The project aims to develop and test a new concept of execution technique for a skeletal system with 3D modules structurally integrated, and to establish the structural performance of the joints developed for this application. The new execution technique starts with the assembling of the roof and the top floor at ground level, in order to get a rigid body which will be lifted up by lift towers and jacks. Then the procedure is successively repeated to assemble the lower floors. With this execution method the protection of the structure against the weather adversity, as rain and moisture, is assured by the own structure. The research intends to define the limits of application where the concept is competitive when compared to the existing building alternatives taking into account a complete sustainability assessment.

Description:
The idea under investigation in this project is the TOP-DOWN CONSTRUCTION, i.e., the technique of starting the construction by the roof and lift it enabling the assembly of the lower floor, repeating the lifting process as times as required to finish the building.

The research will be developed in 5 stages. In the first stage it will be developed the concept of a new type of execution technique for a skeletal system primarily used to construct buildings with prefabricated steel 3D modules. The concept will be tested by computer simulations using a tool for virtual engineering which allows the identification of the possible conflicts in the execution process, including the transfer of the modules from the trucks to the skeletal system which is an integral part of the new execution technique. The execution technique starts with the assembling of the roof and the top floor in order to get a rigid structure that will be lifted up by jacks. Each storey is assembled at the ground level and then lifted up to create place for the next storey. This method will allow the protection of every storey, completed with 3D modules with a traditional composite slab or with a concrete deck, from the atmospheric precipitation and moisture damage during the assembling phase. This method using jacks instead of cranes expects to be safer and drier. It also provides the reducing of the construction site area and the minimization the neighbourhood disturbance.

The second stage involves the development, testing and the establishment of the structural performance of a new type of joints. The joints will be carried out for tubular cross sections of columns and beams. The joints will be designed in order of supporting all the acting forces (erecting and service stages) and improving the required time of assembling and disassembling.

In the third stage, the limits of application of the execution technique will be evaluated concerning the structural safety and feasibility, including a robustness assessment of the building.

The fourth stage consists on the construction of the pilot building with 3 storeys and respective monitoring during execution and service phases.

At the last stage it is intended to achieve a holistic view of the optimized building technology with 3D modules using the innovative erection technique. The type of innovative execution technique used is influenced by the architectural demands which determine the structural solution. Therefore, the following buildings with 2D prefabricated walls will be compared with the 3D modulus integrated into the skeletal system:

- buildings with composite slab floors and light-weight walls,
- buildings with hollow core decks and light-weight walls.

Special focus will be given to the comparison of the evaluation criteria for life cycle analysis (LCA) with the same system boundaries and life cycle costs (LCC) focusing on energy efficiency (thermal performance) of the building alternatives considered. Monitoring of the energy consumption will be performed on a pilot building and results will be compared with available calculation methods.

Publications:

Dissertations

Palma, T. J. M.; "Desempenho estrutural do edifício FRAMEUP em situação de incêndio" (in portuguese), Master thesis in civil engineering, Faculty of science and technology of the University of Coimbra; 2015.

Reis, A. M. M.; "Comportamento de ligações entre vigas e pilares de secção tubular em situação de incêndio" (in portuguese), Master thesis in civil engineering, Faculty of science and technology of the University of Coimbra; 2015.

Mendes, A. J.; "Análise sísmica *pushover* de pórticos metálicos com elementos tubulares" (in portuguese), Master thesis in civil engineering, Faculty of science and technology of the University of Coimbra; 2014.

Silva, T. A. O.; "Estudo de ligações viga-pilar usando perfis rectangulares ou quadrados ocos (in portuguese), Master thesis in civil engineering, Faculty of science and technology of the University of Coimbra; 2014.

Simões, T. J.; Beam-column steel joints between square or rectangular hollow sections, Master thesis in civil engineering, Faculty of science and technology of the University of Coimbra; 2013.

Reports:

Veljkovic, M., Andrade, P., Heistermann, T., Guillon, J., Jaspart, J., Demonceau, J., et al., "FRAMEUP – Optimization of frames for effective assembling, Final Report", 2014.

Conference proceedings

Vicente, G.; Simões, R.; Rebelo, C.; Simões da Silva, L.; Veljkovic, M.; "Moment Resisting Bolted Joints Connecting Steel Tubular Sections", EUROSTEEL 2014, Naples, Italy; 2014.

Contacts:

Luis Simões da Silva
Tel.: +351 239 797 216
Fax: +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

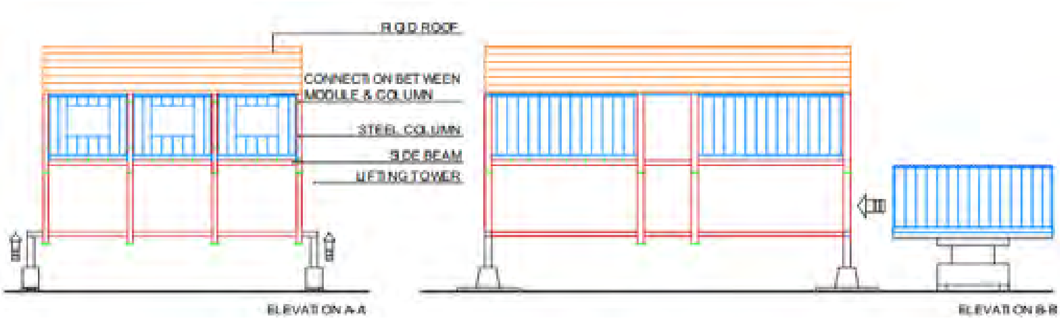


Fig. 1 Top-down construction (2D sketch)

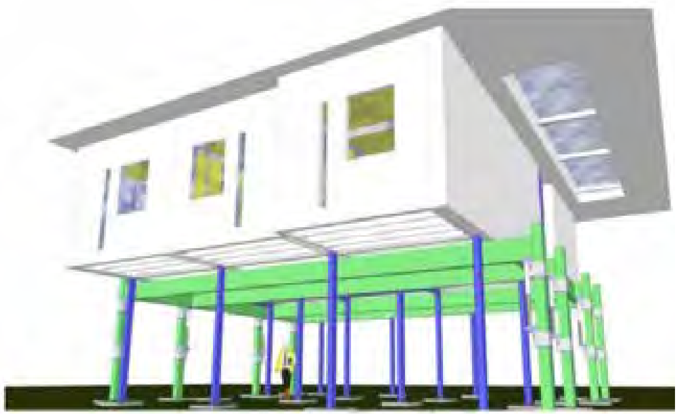


Fig. 2 Top-down construction (3D sketch)

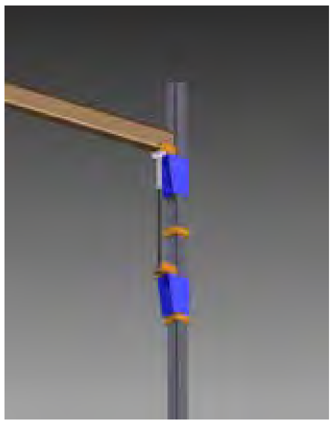


Fig. 3 Lifting System

Free from Damage Steel Connections | FREEDAM

Financing Institution(s): RFCS
Promoting Institution(s): University of Salerno (UNISA)
Coordinator(s): Vicenzo Piluso, Luís Simões da Silva (ISISE coordinator)

Researchers and collaborators: Aldina Santiago (ISISE- UC); Ana Francisca Santos (ISISE-UC). Coordinators from partner institutions: Vincenzo Piluso (UNISA); Gianvittorio Rizano (UNISA); Massimo Latour (UNISA); Antonella Bianca Francavilla (UNISA); Giovanni Ferrante Cavallaro (UNISA); Raffaele Landolfo (UNINA); Mario D'Antoniello (UNINA); Mariana Zimbru (UNINA); Jean-Pierre Jaspart (ULG); Jean-Francois Demonceau (ULG); Marina D'Antimo (ULG); José Manuel Silva (OFEL); Igor Guerra (OFEL); Maria Gabriella Castellano (FIP); Danillo Di Fusco (FIP).

Partner Institutions: University of Coimbra (ISISE-UC); University of Napoles (UNINA); University of Liége (ulg) (Belgium); O FELIZ – Metalomecânica (OFEL) (Portugal); FIP INDUSTRIALE (FIP) (Italy).

Period: July 2015 to June 2018

Relevant facilities: Computational and laboratory equipment of Civil Engineering department of FCTUC; Computational and laboratory equipment of other partner institutions.

Objectives:
The research project is aimed at the development of an innovative beam-to-column connection equipped with friction dampers located at the bottom flange level of the connect beam in order to dissipate the earthquake input energy. The friction resistance is calibrated by acting on the number and diameter of the bolts and their tightening torque governing the preloading. The flexural resistance results from the product between the friction damper resistance and the lever arm. Such connections exhibit wide and stable hysteresis loops without any damage to the connection steel plate elements, so they can be referred as "Free from Damage Steel Connections" (FREEDAM).

Description and Methodology:

In a first step, the characterization of the friction damper under cyclic loading conditions and also under exceptional loading conditions will be assess in order to have a completed characterization of this component within the framework of the component approach in accordance with the Eurocode 3 part 1-8. Then, following the component approach, full-scale beam-to-column joints with friction dampers will be designed and experimentally tested under cyclic loading conditions and also under exceptional loading conditions to assess the robustness behaviour of the connections. In addition, numerical analyses will be also developed to widen the range of the investigated parameters. At the end, complete mechanicals model able to characterize the moment-rotation behaviour of the proposed connections will be provided following the Eurocode 3 approach.
Finally, as the natural continuation of the experimental activities on materials and joints, pseudo-dynamic tests and/or cyclic push-over tests of a real-scale two storey will be carried out.

<u>WP1 Tribological characterization of materials for friction dampers</u>: This part of the project is aimed at the identification of the best friction material for the use on the beam-to-column connections. The selection of the best material takes into account two fundamentals needs for the use of friction materials in structural application for seismic design. Such needs are, the attainment of a high friction coefficient and also, a consumption of the friction material as low as possible. In addition, it is necessary to evaluate the slip-force behaviour under cyclic actions, as those occurring during a seismic event, by carrying out a wide experimental activity on different types of materials under different loading actions. Furthermore, information about the robustness of this new connection typology under exceptional loading condition (as blast or impact) is assess by carrying out experimental impact tests on the friction damper.
At the end of this work package, only two materials will be selected for the successive experimental tests on full-scale connections. As main results if this work package, within the framework of the component approach for prediction the joint behaviour, a new joint component namely "friction damper pre-stressed with high strength bolts" will be completely characterized.

<u>WP2 Seismic response of beam-to-column connections equipped with friction pads</u>: The specimens will be designed by exploiting, for the components different from the friction pad, the available models contained in Eurocode 3 part 1-8 and, for the new component, i.e. the friction damper, the results coming from the experimental activities carried out within the Work Package 1. The experimental activity will be carried out with reference to external and internal beam-to-column joints. The specimens will refer to only two typologies, one with a beam of limited size, the other one with a big beam in order to evaluate size effects. The experimental studies carried out at the component level, i.e. friction damper, and at the full-scale level, i.e. beam-column sub-assemblages, will be accompanied by numerical analyses employing finite elements in order to widen the range of the investigated parameters starting from FEM models validated on the base of experimental results.
At the end of such experimental activity on full-scale joints, complete mechanicals model able to characterize the moment-rotation behaviour of the proposed connections

will be provided following the Eurocode 3 approach. In addition, a technical sheet providing all the pre-qualified design procedures to be respected in order obtain pre-determined levels of performance will be defined.

WP3 Seismic response of frames with friction joints, robustness and sustainability: This work package is aimed to the development of design rules and the specification of modelling parameters for steel moment resisting frames characterised by connections equipped with friction dampers. Several issues will be investigated as follows:

1. **Design criteria for gravity loads at ultimate limit states:** regarding gravity loading conditions, the attention will be focused on how the structural detail of the friction damper has to be calibrated in order to allow the exploitation of the bending resistance of the beam section.
2. **Design criteria for serviceability limit state requirements under seismic actions:** attention will be paid on the need to reduce the deformability of the joint components in order to reduce as less as possible the lateral stiffness of the structure, because of a semi-rigid behaviour of the connections.
3. **Design criteria for ultimate limit state requirements under seismic actions:** the stroke end limit state is mainly of concern. Therefore, particular attention will be devoted to the setting up of a design procedure to calibrate the stroke of the friction dampers as a function of the maximum design spectral acceleration expected with reference to the collapse prevention limit state.
4. **Design criteria for structural robustness:** The robustness of the connection, will be verify by experimental impact tests on full-scale joints. Furthermore, theoretical and/or numerical models to consider the behaviour of the proposed innovative connections under exceptional actions will be developed within this work package. It is expected significant benefits are expected in the catenary action resulting, as example, in case of a column loss due to blast loading or impact loading. In fact, the slippage of the friction dampers up to the stroke end, before the bolt engage in shear and the stem plate engage in bearing, allows to obtain an increased vertical component of the beam axial forces resulting from catenary behaviour after column loss.
5. **Sustainability analysis:** it is believed that the proposed structural typology provides a significant benefit in terms of sustainability due to the fact that all the structural parts do not undergo to any damage after an earthquake. Therefore, also the building sustainability issues will be examined demonstrating the increased sustainability with respect to traditional solutions.

WP4 Development of prototypes for industrial production: Starting from the experimental and analytical results of previous work packages, this specific work package is aimed to the setting up of an industrialization strategy to boost the introduction in the market and in the designers' world of the proposed innovative joints. In particular, with the contribution of the industrial partner, the friction dampers can be conceived as industrial devices to be sold in pre-defined and ready to install kits. To this purpose, the friction devices will be identified and classified according to use categories depending on slip resistance and displacement capacity. Furthermore, a software for the selection of the dampers will be developed with an open-source platform to be downloaded directly on-line by designers.

WP5 Experimental analysis of a prototype building and dissemination of results: In this work package as the natural continuation of the experimental activities on materials and joints, pseudo-dynamic tests and/or cyclic push-over tests of a real-scale two storey will be carried out with reference to both a building with traditional connections and a building with beam-to-column joints equipped with friction dampers. The tests will be carried out in order to validate the proposed system and in order to evaluate the reliability of the mechanical models proposed in the previous work packages. In addition, in this work package, all the activities devoted to the dissemination of the results will be carried out. Under this point of view, an informative international workshop will be organized and an open source e-book containing all the practical examples, design rules and results of the research projects will carried out involving all the research units.

WP6 Coordination: During the whole project a coordination activity will be necessary in order to focus the research efforts of the units on the objectives defined by the different work packages. The coordinator will have the task to supervise continuously the progress of the activities to be carried out by the different units by organizing periodically meetings and by examining the results reported in the progress reports. At the end of the research project workshops will be organized in order to disseminate the results to the designers' and industrial world.

Publications:

Papers

Dissertations

Fernandes da Silva, L.C, (2016), "Design of a 'Free from Damage' Column Base Connection for Seismic Actions", Master thesis, University of Coimbra

Reports

Conference proceedings

Santos, A.F, Santiago, A., Simões da Silva, L., Latour, M., Gianvittorio, R., "Experimental assessment of friction dampers under impact loading", Copenhagen, 13- 15 September – EUROSTEEL 2017.

Santiago, A., Simões da Silva,L., Fernandes da Silva, L.C., Ferrante Cavallaro, G., Francavilla, A., Latour, M., Piluso,V., Rizzano,G., "Experimental behaviour of base plate joints equipped with self-centering system and friction dampers", Copenhagen, 13- 15 September – EUROSTEEL 2017.

Contacts:

Luís Simões da Silva
Tel.: +351 239 797 216
Fax: +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

RFSR-CT-2012-00025 - Fire Resistance of Innovative and Slender Concrete Filled Tubular Composite Columns | FRISCC

Financing Institution(s): EC-RFCS
Promoting Institution(s): Universidad Politécnica de Valencia (UPV), Spain.
Coordinator(s): Manuel L. Romero (UPV)

Researchers and collaborators: Manuel L. Romero (UPV); Ana Espinós (UPV); Leroy Gardner (IC-UK); Finian McCann (IC-UK); João P. C. Rodrigues (UC); Luís Laím (UC); P. Schaumann (LUH); I. Kleiboemer (LUH); Gisèle BIHINA (CTICM); Gorka Iglesias (Condesa).

Partner Institutions: Universidad Politécnica de Valencia (UPV), Spain; Centre Technique Industriel de la Construction Métallique, (CTICM), France; Gottfried Wilhelm Leibniz Universität Hannover (LUH), Germany; Imperial College of Science, Technology and Medicine, UK; Universidade de Coimbra (UC), Portugal; Asociación de investigación de las industrias de la Construcción (AIDICO), Spain; Conducciones y Derivados, S.A. (Condesa), Spain.
Period: July 2013 to June 2016

Objectives:
The main objectives of this research project are:
1. Evaluation of the existing design methods, review the existing usage and review the results of previous tests, in order to define properly the tests parameters.
2. To provide full range of experimental evidence about the fire behaviour of CFST columns by carrying out a number of fire tests, a necessary basis for the development of both validated and numerical modelling and simple calculation rules. Some experimental tests at room temperature in case of elliptical CFST columns have be provided, due to lack of tests.
3. To modify the actual simple calculation methods in fire part of Eurocode 4 related to concrete-filled columns with circular and square hollow sections, based not only on the previous tests but also on an extended parametric study based on a validated numerical model.
4. To extend the previous methods to the columns with rectangular, elliptical and innovative section system as the concrete-filled hollow section with steel core profile embedded.
5. To develop the user-friendly design tool in order to increase significantly the application efficiency of the developed simple design rules above.
6. To disseminate the results to the practitioners and steel work associations, including actions to incorporate the proposed actions within the Eurocode 4.

Description and Methodology:
This project was divided into five main parts. The most significant aspects of the work performed on each of the Work Packages is hereafter described on a task per task basis and highlighting the objectives.
WP1 Evaluation of the existing design methods: In WP 1, a comprehensive evaluation of the existing design methods was performed. The existing usage was investigated, and the previous experimental tests available in the literature were reviewed, in order to define properly the tests parameters to be used in the subsequent work packages. A technical report describing practical applications of slender CFST columns and the current use of innovative types of composite sections was developed in Task 1.1.
It was observed that, when compared to steel solutions, CFT columns can generate significant savings as they usually do not require any fire protection. Different simple design methods from Eurocode 4 Part 1.2 were assessed, among which Annex H model proved to be unconservative for slender columns.
A review of the test results available in the literature on CFST columns subjected to fire was carried out in Task 1.2. With all the documentation reviewed in this task, a database was created, which allowed to know which range of values of the parameters had already been experimentally studied and to have a basis to decide the values to test in the experimental program of this project. From the analysis of the results of previous tests, the exact parameters to be varied during experimental tests of this project were decided in Task 1.3, such as the section shape (CHS, SHS, EHS, RHS), cross-sectional dimensions, sectional slenderness, member slenderness, load eccentricity and percentage of reinforcement. Using the test data from the analysis of previous experimental programs obtained in Task 1.2, a comprehensive evaluation of the existing design methods was carried out in Task 1.4. When compared against fire tests results, the methods in Clause 4.3.5.1 and Annex H of EN1994-1-2 resulted conservative for stocky columns, and unconservative for columns with a slenderness greater than 0.5. The accuracy of other methods existing worldwide for evaluating the fire resistance of concrete filled tubular columns was also verified against a number of test results available from previous experimental programs.
Between these methods, Kodur's simplified design equation used in North America, the Strength Index (SI) formulation by Han and co-workers used China and the fire resistance design formula used in Japan were evaluated. From the three methods, the method used in Japan was the one which provided the more accurate predictions, while the SI formulation used in China lead to unsafe results for slender

columns and Kodur's simplified design equation was found to be valid only for reduced load levels.

WP2 Experimental Tests: The aim of this Work Package was to provide a full range of experimental evidence on the fire behavior of CFST columns by carrying out a number of fire tests, a necessary basis for the development of reliable numerical models and simple calculation rules.

A complete definition of the different experimental tests to be carried out within this project was performed by the partners in Task 2.1, as well as the design of the corresponding test setups: fire tests on isolated columns (UPVLC-AIDICO), fire tests on columns in sub-frames (UC), tests on concrete-filled CHS with embedded steel core profile (LUH) and room temperature tests on concrete-filled EHS columns (IMPERIAL).

In Task 2.2, the material properties – steel and concrete – at elevated temperatures were experimentally investigated. The mechanical properties of concrete at elevated temperatures were tested by Universidade de Coimbra. In turn, the coupon tests of the steel tubes at elevated temperatures were performed by Imperial College. The steel coupons and concrete cylinders were prepared at UPVLC and sent to the laboratories of Imperial College London and Universidade de Coimbra for testing.

The experimental program carried out by UPVLC-AIDICO on isolated concrete-filled CFST columns within Task 2.3 and Task 2.4 consisted of a total of 36 fire tests. The experimental program carried out by Universidade de Coimbra within Task 2.3 and Task 2.4 on CFST columns in sub-frames (figs. 1 and 2) consisted of twenty-one fire resistance tests. Experiments on concrete-filled elliptical hollow section (CFEHS) tubes were conducted at Imperial College London in Task 2.4.

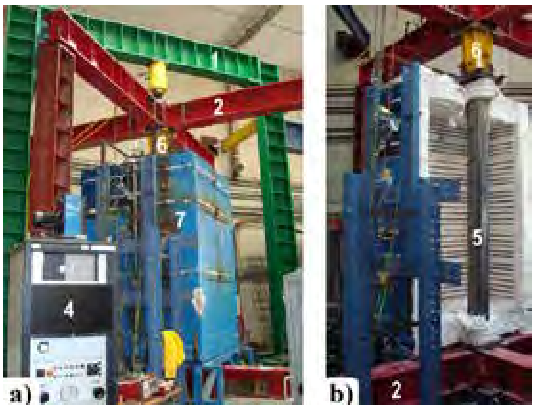


Fig. 1 General (a) and detailed (b) view of the experimental set-up: 1 - reaction frame; 2 - restraining frame; 3 - hydraulic jack; 4 - servo hydraulic central unit; 5 - specimen; 6 - special device; 7 - electric furnace

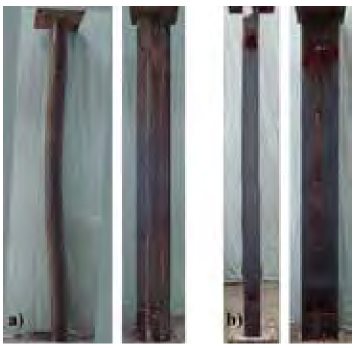


Fig. 2 Deformed circular (a), square (b), rectangular (c) and elliptical (d) column after fire test

WP3 Numerical Simulations: In this Work Package, numerical models were developed by the different partners for the different types of sections studied, and validated against the experimental results obtained in WP-2. These numerical models were subsequently used for conducting parametric studies, which were the basis for the development of a Simplified Design Method in WP-4. Based on a previous evaluation of the commercially available section shapes and their usage in construction, the cross-section dimensions and ranges of variation of the parameters were decided. Two different boundary conditions were considered at the top end of the column: slip between the steel tube and concrete core being allowed or prevented.

WP4 Simplified Design Methods: This Work Package aimed at correcting the current simplified methods of EN1994-1-2 for circular and square CFST columns, extending the simplified methods to elliptical and rectangular CFST columns.

Based on the results of the parametric studies carried out in WP-3, a Simplified Design Method (SDM) for CFST columns of any section shape (CHS, SHS, RHS and EHS) at elevated temperatures was developed by UPVLC and CTICM in Tasks 4.1 and 4.2 through statistical analysis of the extensive database of numerical results.

WP5 Design tools, Dissemination and Code additions: This Work Package aimed at developing a user-friendly design tool in order to increase the application efficiency of the proposed simple design rules, and to disseminate the results of the project to the practitioners and steel work associations. In order to provide a platform from which the results of the FRISCC project could be disseminated to the structural engineering community, a day-long workshop was organised by Imperial College London and CONDESA in Task 5.1. As planned in Task 5.2, the Simple Design Method proposed in this project by UPVLC for isolated concrete-filled tubular columns was implemented by CTICM into a user-friendly design tool based on Visual Basic programming language. In Task 5.3, proposals for code additions have been carried out by UPVLC, CTICM and LUH, as members of the SC4.TC4 Project Team for the development of the 2nd generation of EN Eurocodes. The developed Simple Design Method will be proposed for its inclusion into the new revision of Eurocode 4.

Publications:

- Rodrigues, J.P.C., Laím, L. (2017a), Fire resistance of restrained composite columns made of concrete filled hollow sections, Journal of Constructional Steel Research, Vol. 133, pp. 65-76.
- Rodrigues, J.P.C., Laím, L. (2017b), Fire response of restrained composite columns made with concrete filled hollow sections under different end-support conditions, Engineering Structures, Vol. 141, pp. 83-96.
- Rodrigues, J.P.C., Laím, L. (2016), Experimental investigation on axially and rotationally restrained circular and elliptical concrete-filled hollow columns subjected to fire, In: Proceedings of the 9th International Conference on Structures in Fire (SiF 2016), Princeton, USA, p. 560-567.
- A. Espinós, M. L. Romero, V. Albero, A. Hospitaler, G. Bihina, C. Renaud (2016), Simplified design method for evaluating the fire resistance of concrete-filled steel tubular columns, In: Proceedings of the 9th International Conference on Structures in Fire (SiF 2016), Princeton, USA.

Long-term structural and durability performances of reinforced concrete elements strengthened in flexure with CFRP | FRPLongDur

Financing Institution(s): FEDER funds through the Operational Program for Competitiveness Factors - COMPETE and National Funds through FCT - Portuguese Foundation for Science and Technology
Promoting Institution(s): University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM)
Coordinator(s): José Sena Cruz (ISISE-UM)

Researchers and collaborators: José Sena Cruz (ISISE-UM); Pedro Fernandes (ISISE-UM); José Ricardo Cruz (ISISE-UM); Joaquim Barros (ISISE-UM); Miguel Azenha (ISISE-UM); Susana Bravo Cabral (LNEC); Julien Michels (EMPA – Switzerland)

Partner Institutions: LNEC – National Laboratory of Civil Engineering, Portugal; EMPA – Swiss Federal Laboratories for Materials Science and Technology

Period: June 2016 to May 2019

Relevant facilities: Laboratory equipment and facilities from the structural lab of UMinho (LEST); servo close-loop equipment, data acquisition and control equipment for experimental programs; universal testing machine; climatic chamber; tanks; FEMIX software. Laboratory equipment of other partner institutions

Objectives:
The main objective of this research project is to contribute to the knowledge on long-term structural behaviour and durability performance of RC elements strengthened in flexure with CFRP laminates according to the EBR and NSM techniques, under various real environments. The project involves the three following parts: (i) an experimental program, (ii) numerical simulations, and finally (iii) design recommendations. Two distinct scales will be used: (i) specimens for material (MT) and bond characterization (BT), and (ii) full scale slabs (ST). With these prototypes, the following effects will be studied: sustained stress (creep), carbonation, moisture, chlorides, thermal and freeze-thaw cycles, and additionally the initial FRP strain level (un- and prestressed composite reinforcement). For this purpose several series of prototypes (MT + BT + ST) will be placed in distinct sites of Portugal, each one being representative of the above listed environments to be studied, currently considered as the most critical ones.

Research plan and methods:

The present project intends to mainly contribute to the knowledge on the long-term structural behaviour and durability performance under the most significant environments of reinforced concrete (RC) elements strengthened in flexure with carbon fibre reinforced polymer (CFRP) laminates. Up to now, this key issue has not been sufficiently treated in the literature and especially often not in a systematic manner. The most used strengthening techniques will be studied in the present project: the externally bonded reinforcement (EBR) and the near-surface mounted (NSM) reinforcements. In some particular cases, the use of prestressed FRP materials for strengthening RC structures is useful or even required. This system combines the benefits of passive EBR FRP systems with the advantages associated with external prestressing. For this reason, this technique is also included in the present research project. However, in order to enable the construction industry to take full advantage of this technology, the long-term and durability performance under real environmental actions must be studied in detail. Typically, the long-term behaviour and durability performance is assessed through artificial accelerated aging tests. This laboratory approach is adopted to obtain design rules for the use of FRP materials in the strengthening context. However, information about correlation between artificial and real aging environments is too scarce. Consequently, the relation between on one hand the designed service life based on the artificial accelerated aging tests, and on the other hand the real service life of RC structures strengthened with FRP materials may significantly vary depending on the respective exposure and adapted aging technique. This critical issue must be deeply analysed. Figure 1 summarizes all the fundamental aspects of the present project. In addition to the reference specimens placed in the laboratory, four critical environmental actions are selected: aging induced mainly by carbonation (CB), chlorides from sea water (CH), freeze/thaw attack (FT), and finally elevated temperatures (ET). Distinct scales will be used for assessing influence of these environmental actions, ranging from smaller material specimens to full scale slabs. In order to render the approach more realistic, the slabs will be submitted to a constant long-term load as they often are in real structures. Four distinct strengthening solutions will be studied: non-prestressed systems EBR and NSM; prestressed systems EBR-MA and EBR-GA. Series composing of materials (concrete, CFRP and epoxy) and bond specimens as well as slabs will be placed in distinct sites in Portugal, each one being representative for one of the above mention real environments. The obtained results will be continuously analysed, and also supported by analytic and numerical simulations. Parametric studies will be developed in order to predict the real service life of RC structures strengthened with FRP materials.

The project is divided into six tasks: one for management (Task 1); three for the experimental programs (Tasks 2 to 4); one for analytic and numerical simulations, parametric studies, design recommendations (Task 5); and one for the documentation (including summarizing the project and obtaining the main goals) and dissemination of the project not only to scientists, designers, manufacturing companies, and contractors, but also the public in general. The latter target aims to sensitize the audience for a proper use of these composites materials in civil structures. Several strategies are planned to properly disseminate the results (Task 6).

The experimental research will be developed during at least 10 years (7 years more after the official end of the project). A set of tests with the materials and bond specimens will be performed after 1, 2, 3, 4, 6, 8, and 10 years of real aging. Additionally, for this type of specimens and in order to find out correlations between real and artificial accelerated aging tests, artificial accelerated aging tests will be performed in the laboratory. All the slabs to be included in each series will be permanently submitted to a constant stress state by means of sustained loads. The degradation indicators will be given by an installed monitoring system.

Contacts:

José Sena Cruz
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: jsena@uminho.pt
URL: www.sc.civil.uminho.pt

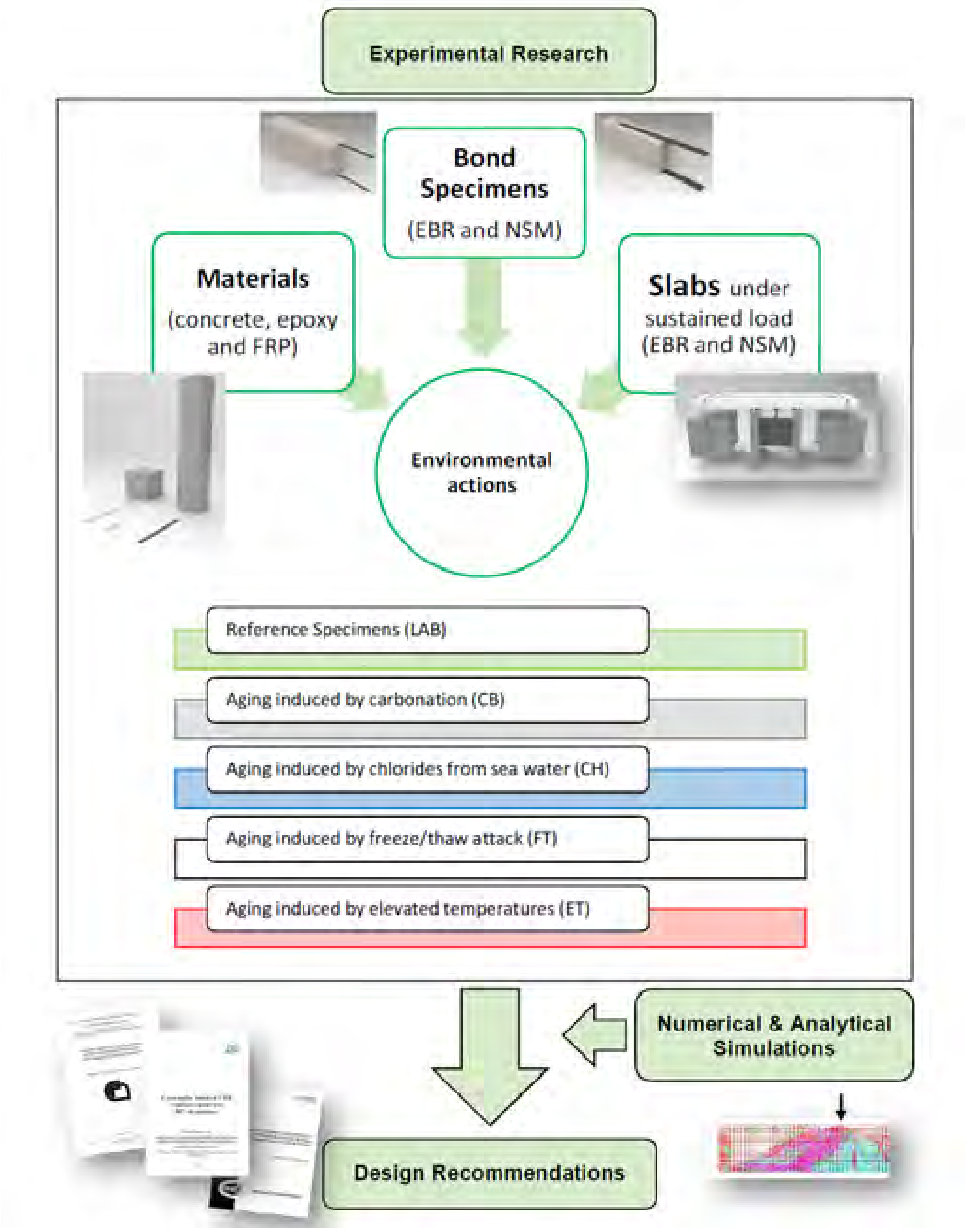


Fig. 1 Research project flowchart

Short and long-term structural behavior of concrete elements flexurally strengthened with prestressed CFRP laminates | FRPreDur

Financing Institution: FEDER funds through the Operational Program for Competitiveness Factors - COMPETE and National Funds through FCT - Portuguese Foundation for Science and Technology
Promoting Institution: University of Minho (UMinho)
Coordinator: José Sena-Cruz

Researchers and collaborators: José Sena Cruz, Julien Michels, Paulo França, Paulo Costeira, Tiago Teixeira, Luís Correia, Gonçalo Escusa

Partner Institutions: Not applicable

Period: July 2013 to June 2015
Relevant facilities: Laboratory equipment and facilities from the structural lab of UMinho (LEST); servo close-loop equipment, data acquisition and control equipment for experimental programs; universal testing machine; climatic chamber; tanks; FEMIX software.

Objectives:
The main objective of the present research project is to contribute to the knowledge on short and long-term structural behaviour of RC elements strengthened in flexure with pre-stressed CFRP laminates under various specific application environments, load conditions and chemical degradation. The project involves the three following components: an experimental program, numerical simulations and design recommendations. The experimental program will be supported in reinforced concrete slabs flexurally strengthened with prestressed CFRP laminates. The influence of the prestressed system, prestressed level and the existing damage on the immediate and time-dependent losses under the effect of chlorides, sustained stress (creep), freeze-thaw, wet/dry and thermal cycles, will be the main variables to be studied. The test results obtained from the experimental programs will be used for predicting the service life behaviour of prestressed slabs, as well as the ultimate strength supported in some numerical models.

Description:
Over the last two decades, extensive research has been developed on the strengthening of reinforced concrete (RC) structures using the externally bonded reinforcement (EBR) technique with fibre reinforced polymer (FRP) materials. This technique yielded to several scientific publications, design guidelines and practical projects, worldwide. Among the commercially available FRP's, Carbon (CFRP) materials have been successfully applied to strengthen many structures due to their higher stiffness, strength and fatigue life, "no" creep rupture and less susceptibility of aggressive environments. More recently, the use of prestressed FRP materials for strengthening RC structures is emerging. This specialized application combines the benefits of passive EBR FRP systems with the advantages associated with external prestressing. Prestressed FRP applications have been showing several advantages, not only in terms of serviceability, but also in terms ultimate limit states, when compared with the passive ones. In attempt to develop this type of application, several systems have been developed to induce the prestress in the FRP. Nevertheless, the systems that tension the FRP against the RC element to be strengthened prevailed, with or without the use of additional anchors at the ends. The existing knowledge and literature concerning this technology, however, are limited compared with the conventional non-prestressed applications.

The evaluation of short and long-term structural behavior of RC elements flexurally strengthened with prestressed FRP materials is a critical key issue to be determined in order to facilitate the industry to take full advantage of this new technology. Literature treating this topic is extremely sparse. Since the prestressing with FRP materials is an emerging technique, short and long-term performance needs to be focused on.

The main objective of the present research project is to contribute to the knowledge on short and long-term structural behavior of RC elements flexurally strengthened with pre-stressed CFRP laminates under various specific application environments, load conditions and chemical degradation. The project involves the three following components: an experimental program, numerical simulations and design recommendations. The experimental program will be supported in reinforced concrete slabs flexurally strengthened with prestressed CFRP laminates. The influence of the prestressed system, prestressed level and the existing damage on the immediate and time-dependent losses under the effect of chlorides, sustained stress (creep), freeze-thaw, wet/dry and thermal cycles, will be the main variables to be studied. The test results obtained from the experimental programs will be used for predicting the service life behavior of prestressed slabs, as well as the ultimate strength supported in some numerical models. These numerical models will be implemented in the FEMIX program, which is a general purpose finite element software system. 2D and 3D models will be used in the simulation of the structural elements.

Design recommendations will be elaborated using the results obtained in the experimental programs and derived from parametric studies performed by numerical simulations.

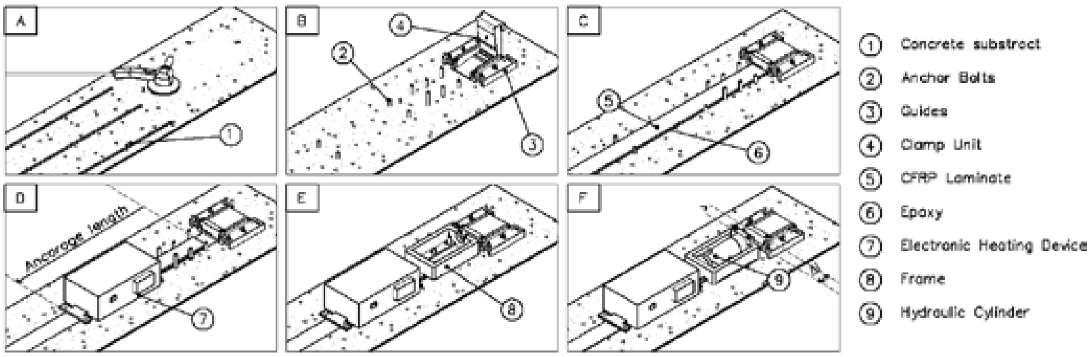


Fig. 1 Application procedures with the GA system

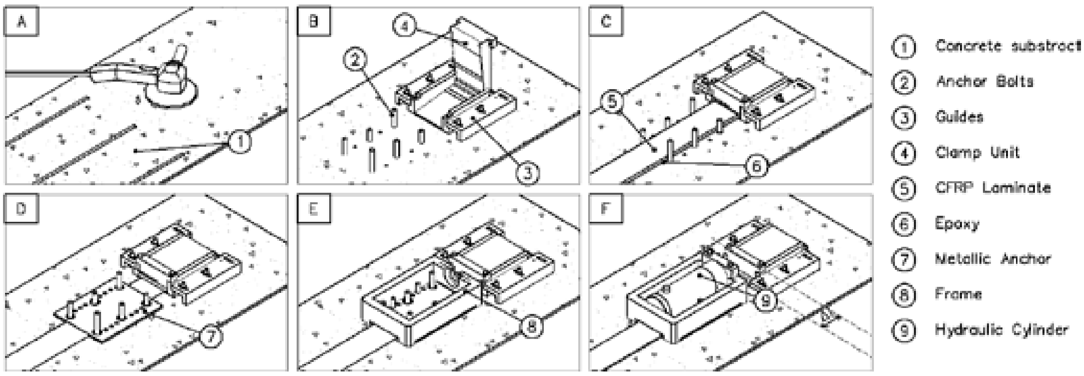


Fig. 2 Application procedures with the MA system

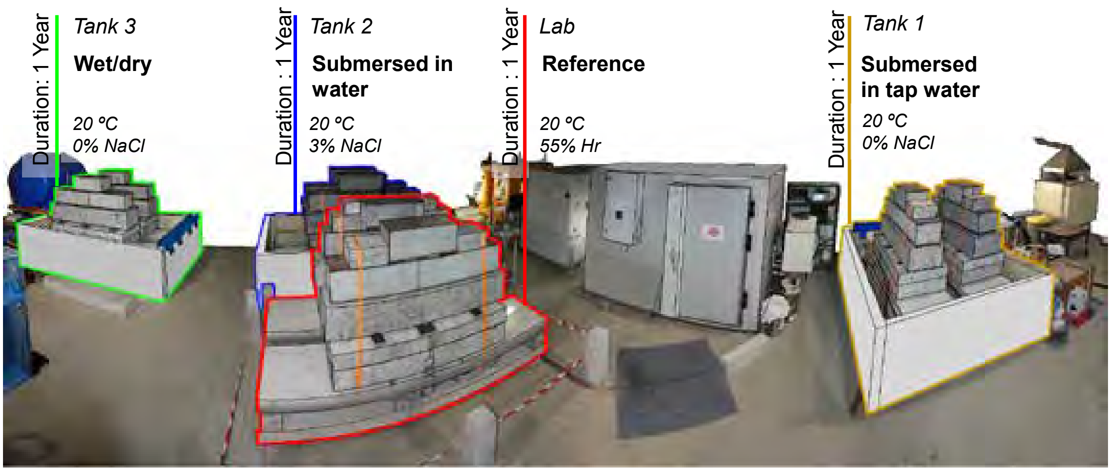


Fig. 3 Panoramic photo of the durability tests

Contacts:
J. Sena-Cruz
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: jsena@civil.uminho.pt
URL: www.sc.civil.uminho.pt

Artefacts for hotel industry and urban furniture incorporating wastes | GEO-DESIGN

Financing Institution(s): Norte 2020
Promoting Institution(s): W2V – Waste to Value, University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM), University of Trás-os-Montes e Alto Douro (UTAD), Centre of Chemistry of Vila Real (CQVR), Francisco M. Providência designer, Centro para a Valorização de Resíduos (CVR)
Coordinator(s): Tiago Miranda (ISISE-UM)

Researchers and collaborators: Fernando Castro (UM), Francisco Providência (Francisco M. Providência), Cândida Vilarinho (UM), Tiago Miranda (ISISE-UM), Nuno Cristelo (UTAD), Daniel Oliveira (ISISE-UM), Pedro Tavares (UTAD), Luís Sousa (UTAD), Rosa Silva (CVR), Irene Morais (CVR), Susana Silva (W2V).

Period: November 2016 to November 2019

Relevant facilities: Laboratory equipment of the promoting institutions.

Objectives:
Taking advantage of the synergy and work between designers (architects and product design) and researchers from R&D units of two universities of the North of Portugal, the project proposes the implementation of innovative products with a strong design component, intended for architecture (particularly in the hotel industry and urban furniture), using innovative materials. Combining the use of existing industrial waste in the North of Portugal region to a high-quality design and an intense R&D activity, we propose the development of products that respond to specific market trends. In this project, we intend to develop products of high aesthetic and functional quality, responding to new trends in the global architecture market, which seeks aesthetically attractive products due to their distinctive, sophisticated features, low cost, while meeting international standards and desires of consumers (designed based consumer goods). Another advantage of this project is the design and manufacture of products destined for a niche market (architects) that can be "designed" as and responding to current and specific needs of consumers in the field of indoor and outdoor spaces, specifically the hotel and urban furniture. In addition to the development of new and innovative products, and materials that will be built, the project also intends to develop the technological process inherent in manufacturing, in particular with regard to the pre-treatment of wastes and molding processes, forming and finishing, as well as test, pilot-scale production, and assessment of the economic and environmental impact of this process applied to a wide range of industrial wastes.

Description and Methodology:
The project is divided into 9 activities, encompassing more than 40 tasks over a period of 3 years. The activities are structured in such a way as to guaranty the development of products that will then, during the project, be studied for applications in real situations. In this scope, product development philosophies are assumed considering market needs, ending with the development of a collection of, performance optimized, prototypes that fully satisfy the requisites imposed and incorporating the technical and scientific knowledge gathered during the project.

Activity 1: SELECTION OF PRODUCTS AND MATERIALS FOR DESIGN DEVELOPMENT - Identify and select, market available, raw-materials and waste that can be used in the project. Specifically, cements, limes and relevant chemical products from drafting of geopolymers. The physical and chemical characterization of those products will be done, complemented where possible, with the information contained in available technical data sheets. 10 product types and 10 wastes with potential interest will be chosen.

Activity 2: PRODUCT DESIGN - Development and design of products aimed towards urbanism and construction with application in hotel industry and urban furniture, in addition to the definition of fabrication processes, identification of the most relevant and critical properties and elaboration of the products data sheets.

Activity 3: LABORATORY PRODUCTION AND EXPERIMENTS - Perform the development and study of the waste formulation, respective characterization and selection of those that show the greatest potential in technical terms and properties, specifically in terms of the mechanical performance and durability.

Activity 4: INDUSTRIAL PROTOTYPE DEFINITION - Integral planning of the pilot installation (industrial prototype) to be constructed and that will serve for the tests to validate the formulation and products. Identification installation adaptations that are required, define project installation layout.

Activity 5: PILOT INSTALATION CONSTRUCTION: Build the pilot installation, in according to the project and respective layout defined in the previous activities, adapting installations, acquiring materials, components and auxiliary means. Additionally the required industrial licensing will be obtained, as well as, the inherent waste management licensing. The prototype installation should be capable of a maximum 1 ton daily production of products. It is therefore a very simple and small installation that will, however, require the observation of any legal requirements, since despite the size, it stills stands as an industrial activity installation. For this reason, it is necessary to adapt the industrial license of W2V, in accordance with the Industrial Responsibility System (Decreto-Lei n.º 169/2012 de 1 de agosto). Since waste will be used as the raw materials, in legal terms, this requires the acquisition of a license for use of waste materials. Therefore it is the objective of this activity to, not only acquire and build the components that allow the practical industrial validation at prototype scale, but also, give this installation the necessary legal conditions to work, while allowing, the execution of all the tests, validation and optimization of the formulations and products that demonstrate importance for the success of this R&D project.

Activity 6: TESTS AND VALIDATION IN THE PILOT INSTALATION - This activity has the main objective of testing and producing the artefacts, incorporating in their composition industrial waste. The tests will validate the results obtained in the laboratory. Towards that end, the prototype installation will have the capability of producing a total of 1 ton of products daily. The installation will work in tests cycles, varying the type of matrix (lime or geopolymer), of wastes and, the product to fabricate. The objectives of this activity are:

- Test the production of artefacts in different matrixes and containing diverse wastes;
- Validate the results obtained in the laboratories;
- Optimize fabrication processes and composition of the formulations;
- Develop new products and respective prototypes;
- Evaluate from a technical viewpoint the process and products;
- Evaluate the process from a cost and fabrication perspective;
- Test the application of the products in simulated and real situations;
- Demonstrate the process and products.

The validation in this activity will therefore be accomplished, essentially, through the technological, technical and cost components since, the quality validation will be performed in the following activity.

Activity 7: TESTS AND VALIDATION OF PRODUCTS AND PROTOTYPES - The goal of this activity is to perform the complete characterization of the final products in accordance with the quality norms and specification applicable to each type of product. These characterizations will support the future marking of the products with CE, an indispensable condition for their placement on the market. This is to say, after validation of the products, from a fabrication, technical and technological and, cost perspective, in the present activity, the validation of the final use terms.

Activity 8: TECHNICAL-ECONOMIC-ENVIRONMENTAL EVALUTAION - In this activity, the goal is to evaluate the processes of waste use in the fabrication of artefacts for construction from a technical, economic and environmental perspective, as well as, defining business models and exploration of project results.

Activity 9: PROMOTION AND ADVERTISEMENT - In this activity, the goal is to promote and advertise the project results. All advertisement situations must be approved by all the members of the consortium, without the need for unanimous deliberation. This is due to the need to preserve confidential critical innovation aspects, in order to not impair the ability to explore the results in the future, namely, through the appropriate protection of intellectual property.

Contacts:
Tiago Miranda
Tel.: +351 253 510 492
Fax: +351 253 510 217
Email: tmiranda@civil.uminho.pt
URL: https://geodesignproject.com

Fig. 1 First mixtures tested in laboratory

Fig. 2 Geopolymer development

Fig. 3 First developments of the prototypes for pavement modules

Monitoring and preventive conservation of historical and cultural heritage | HeritageCARE

Financing Institution(s): Interreg-SUDOE program co-funded by the ERDF
Promoting Institution(s): University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UMinho)
Coordinator(s): Luís F. Ramos (ISISE-UMinho)

Researchers and collaborators: Luís F. Ramos (ISISE-UMinho); Miguel Azenha (ISISE-UMinho); Eduardo B. Pereira (ISISE-UMinho); Giovanna Masciotta (ISISE-UMinho); Maria José Morais (ISISE-UMinho); Teresa Ferreira (Lab2PT-UMinho); Paulo B. Lourenço (ISISE-UMinho)

Partner Institutions: University of Minho (UMinho) (Portugal); Regional Direction of North Culture (DRCN) (Portugal); Centre of Graphic Computation (CCG) (Portugal); Foundation Santa Maria La Real of Historic Heritage (FSMLR) (Spain); University of Salamanca (USAL) (Spain); Andalusian Institute of Historic Heritage (IAPH) (Spain); University of Clermont Auvergne (UCA) (France); and University of Limoges (UL) (France)

Period: September 2016 to August 2019

Relevant facilities: ND testing equipment and software at the Civil engineering Department of UMinho; Laboratory ND testing equipment of other partner institutions.

Objectives:
Currently, no systematic policy for the preventive conservation of built cultural heritage exists in the South-West Europe (Fig. 1). The actual approaches for inspection, diagnosis, monitoring and curative conservation are intermittent, unplanned, overpriced and lack a methodical strategy. The available financial resources are scarce and they are mostly addressed to listed structures. Besides, owners and stakeholders often conceal an inborn reluctance to invest in preventive conservation and maintenance programs.
In light of these considerations and driven by the principle "prevention is better than cure", the HeritageCARE project has recently been launched within the Interreg-SUDOE program co-funded by the ERDF, with the purpose of unfolding an integrated and sustainable strategy for the preventive conservation of built cultural heritage within the South-West Europe. This project involves 3 Countries (Portugal, Spain and France), 8 beneficiary partners and 11 associated partners (Fig. 2).
The ultimate goal of the HeritareCARE project is the creation of a non-profit self-sustaining entity which will keep supervising the accomplishment of the methodology and the sustainability of the results once the project is concluded.

Description and Methodology:
The main objective of the project will be to develop a very practical methodology for preventive conservation for owners of heritage constructions, which will include the definition of methods, inspection tools and actions for the conservation of the heritage to the Society in general, including monitoring over time of the impact of the methodology on conservation/maintenance actions by owners. The project is focused on three Service Levels (Fig. 3) applied to heritage constructions and integrated assets.

WP1 Definition of a methodology for inspection, diagnosis and advice to owners: This WP will be focus on the survey of the construction typologies and integrated objects inside the buildings, the main damage mechanisms and the most common deterioration processes for buildings and objects within the SUDOE space. The requirements for the tools needed to implement the methodology by the institution to be created will be defined.
A very important milestone in this WP will be the creation of a non-profit Association/Foundation/ Cooperative, named HeritageCARE, which will operate in the three countries of the project consortium and will implement the methodology. The typology of the Services Levels will be defined, its organizational structure, and the interaction with the Society, The National and Regional Governmental Institutions and the Construction Sector.

WP2 Development of tools for inspection, diagnosis, management, and visualization of Heritage buildings: The main aim of this WP is the development of the transversal and necessary tools for the application of the methodology defined in WP1.
Firstly, inspection plans and forms will be developed for computer applications with sensors integration, as well as databases for owner's management. Secondly, different information from wide sources will be merged in a web platform. Finally, tools will be created to support the management of the heritage construction, which will include virtual models to gather all the information of the construction and the integrated objects.

WP3 Implementation and validation of Service Level I methodologies: This WP intends to implement and validate the methodology defined in WP1 and application of tools developed in WP2 in a set of buildings selected for Service Level I.
A minimum of 20 case studies per country (60 in total) will be selected, in which fieldwork (preventive inspections)

will be carried out. Inspection reports will be delivered to owners, with a clear indication of short, medium and long term preventive conservation measures/actions.

After completion of the fieldwork, an analysis of the results of the application of the methodology will be performed by both the HeritageCARE project team and the building owners, including impact indicators results. In parallel with the implementation actions of Service Level I, dissemination actions will be carried out with the stakeholders, through the dissemination of a good practice guide on preventive maintenance of buildings and of their assets.

WP4 Implementation and validation of Service Level I and II methodologies: This WP intends to implement and validate the methodology defined in WP1 and application of the tools developed in WP2 in a set of buildings selected for the Service Levels II and III. In this case a minimum of 5 case studies per country (15 in total) for Service Level II and one case study per country (3 in total) for Service Level III will be selected. In the selected cases, additional information surveys will be carried out.

After the Service Level II and III have been completed, all the results will be analysed, including an examination of the technical and scientific activities of HeritageCARE project.

In parallel with the implementation of Service Levels II and III, dissemination actions will be carried out, including the preparation of clear and accurate information plan for the future HeritageCARE institution, the practical benefits of conservation and preventive maintenance for owners and society, the construction of iterative viewers in case studies with Service Level III, collection and analysis of public opinion about HeritageCARE activities.

Publications:

Reports

Ramos, L.F. et al., "Requirements for the tools to be used on the HeritageCare Methodology", Report of the Project Activity 1.3 (GT.1) of the HeritageCARE Project 2017

Conference proceedings

- Ramos, L.F.; Morais, M.J.; Azenha, M; Masciotta, M.G.; Pereira, E.B., Ferreira, T.; Lourenço, P.B., "Monitoring and Preventive Conservation of the Historical and Cultural Heritage: the HeritageCare Project", CREPAT 2017, Congresso da Reabilitação do Património, 29-30 June, Aveiro, Portugal (2017).
- Ramos, L.F.; Masciotta, M.G.; Morais, M.J.; Azenha, M; Pereira, E.B., Ferreira, T.; Lourenço, P.B., "HeritageCARE: the new project for the preventive conservation of built cultural heritage in the South-West Europe", Changes - International Conference on Innovative built heritage models and preventive conservation, 6-8 February, Leuven, Belgium, 2017.

Contacts:

Luis F. Ramos
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: lramos@civil.uminho.pt
URL: http://www.isise.net

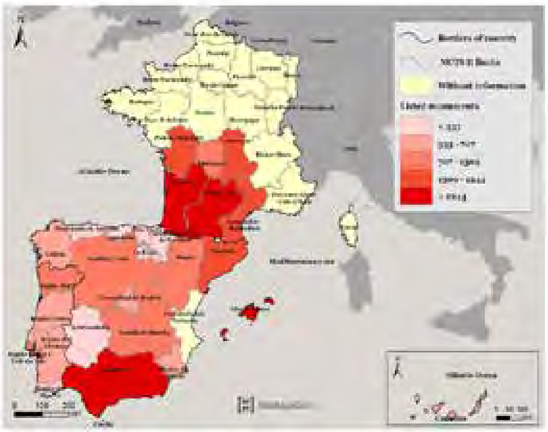


Fig. 1 Distribution of the Heritage built in the Southwest Europe

Fig. 2 Consortium of the Project

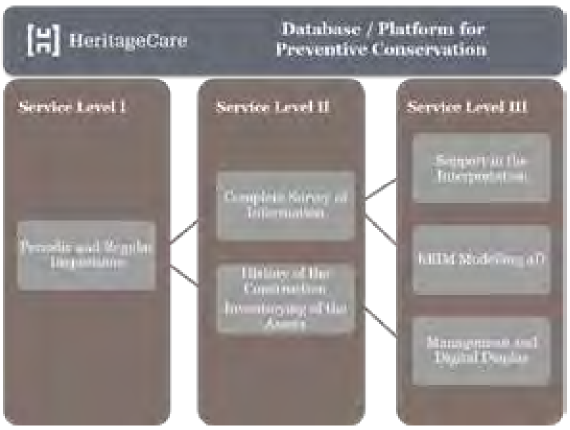


Fig. 3 Service Level of HeritageCARE

Fig. 4 Survey of the constructions systems and damage atlas

High Strength Long Span Structures | HILONG

Financing Institution(s): EC-RFCS
Promoting Institution(s): University of Coimbra, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)
Coordinator(s): Luís Simões da Silva (ISISE-UC)

Researchers and collaborators: Luís Simões da Silva (ISISE-UC); João Pedro Martins (ISISE-UC); Ashkan Shahbazian (ISISE-UC) and Trayana Tankova (ISISE-UC)

Partner Institutions: The Steel Construction Institute (SCI) (UK), Luleå University of Technology (LTU) (Sweden); University of Birmingham (UofB) (UK); Imperial College of Science, Technology & Medicine (Imperial) (UK); Sweco Structures AB (Sweco) (Sweden), S-Squared Corporation Pty Ltd (S-Squared), V&M Deutschland GmbH (V&M) (Germany)

Period: July 2012 to June 2015

Relevant facilities: Computational and laboratory equipment of Civil department of FCTUC; Computational and laboratory equipment of other partner institutions.

Objectives:
The use of high strength steel (HSS) can lead to a significant reduction in the weight of a steel structure. A lighter structure requires smaller foundations, shorter transportation and construction times, and leads to lower CO2 emissions and energy use (both directly in less materials used and also indirectly due to lower transportation costs). Although HSS have found application in machinery and automotive, they are not widely used in construction because the benefit of reduced weight struggles to outweigh the disadvantages of higher price/tonne, reduced availability and different weld procedures. The purpose of the proposed work is to investigate innovative structural arrangements, design methods and cross-sections which enable the benefit of high strength to be maximised by suppressing buckling and reducing deflection. The study will have a particular focus on long span applications such as stadia, auditoria, exhibition halls etc. The proposed programme of testing, numerical analysis and development of design guidance will be informed by close consultation with designers of long span structures throughout the project. The grades of HSS to be studied are S460 and S690.
The technical objectives of the work are:

1. To develop more cost-effective design methods which suit the specific material characteristics of HSS
2. To develop design methods for HSS prestressed cable-stayed columns and post-tensioned trusses which enable a greater proportion of the higher strength to be utilised by suppressing buckling and limiting deflection
3. To investigate the structural performance of innovative U-shaped and semi-closed polygonal crosssections which enable joints to be fabricated more easily
4. To develop comparative designs for two functionally equivalent long span structures, one using HSS and one using conventional structural steel, which demonstrate the potential savings possible using HSS in terms of weight, cost, energy and CO2 emissions
5. To prepare a series of design examples for members and joints which demonstrate the design methods developed.

Description and Methodology:
WP1 Case studies: conceptual aspects, design and evaluation - The WP aims at: identifying the range of currently existing structural solutions in order to define two case studies configurations; defining the logical range of parameters to be studied within the testing programme; validating the developments achieved in other work packages and exemplify potential practical
Applications; carrying out comparisons of the environmental impact (CO2 and energy emissions) and whole life cost of functionally equivalent long span structures made from conventional structural steel grade and HSS.

WP2 Material and section design - This WP aims at: performing full-scale tests on HSS structural material and cross-sections to address the current lack of experimental data which is restrictive for the development of design guidance; undertaking numerical modelling to extend the range of investigated parameters; developing a deformation based design method for HSS cross-sections to enable the full benefits of the material to be exploited, thus encouraging more widespread usage.

WP3 Joints - In order to design competitive and architecturally-appealing HSS trusses, it is necessary to investigate new structural details for long span trusses made of tubular, semi-closed polygonal and U-shaped profiles or their combination. The preliminary design and cost assessments of these joints will be carried out in WP1 when alternative solutions for creating more opportunities for HSS are considered.
The work proposed in this WP is: to investigate experimentally and numerically the feasibility of novel triangular space truss joints made of a combination of tubular, semi-closed polygonal and U-shaped profiles from HSS; to evaluate the ultimate load of new failure modes, and modify the preliminary design of the girders and joint details, where necessary.

WP4 Prestressed and Post-tensioned High Strength Steel Structures - This WP aims at: conducting laboratory tests on prestressed stayed HSS columns; conducting laboratory tests on post-tensioned HSS trusses; performing full-scale field measurements on long-span post-tensioned HSS trusses; supplementing the generated test data through non-linear finite element modelling; developing guidance for the design of prestressed and post-tensioned HSS components for both ULS and SLS.

WP5 Exploitation of research results - This WP is devoted to present the results of the research in an appropriate way for the intended audiences: design examples illustrating the benefits of using HSS in certain applications; proposed amendments to parts of Eurocode 3, with supporting information; a seminar, with formal presentations by researchers and practitioners and discussion.

WP6 Project Management

Publications:

Dissertations

Silva, Paulo (2015), "Controlo da Pré Tensão em cabos usando análise modal", Tese de Mestrado em Engenharia Civil, Especialidade de Mecânica Estrutural, Universidade de Coimbra

Papers

Serra, M., Shahbazian, A., Simões da Silva, L., Marques, L., Rebelo, C. and Vellasco, P, "A full scale experimental study of prestressed stayed columns", Engineering Structures, 100, 490-510 (2015)

Martins, J.P., Shahbazian, A., Simões da Silva, L., Rebelo, C., Simões, R., "Structural behaviour of prestressed stayed columns with single and double cross-arms using normal and high strength steel", Archives of Civil and Mechanical Engineering, 16, 618-633 (2016).

Conference proceedings

Serra, M., Simões da Silva L., Marques, L. and Alves, L., "Prestressed stayed columns - Compressive strength and behaviour of", in Landolfo, R. and Mazzolani, F. (eds.), Eurosteel 2014 – 7th European Conference on Steel and Composite Structures, Naples, Italy, 8-10 September 2014, (2014)

Ricardo Breda, João Pedro Martins, Ashkan Shahbazian, Luís Simões da Silva, (2015), "Estudo experimental do comportamento de colunas pré-esforçadas de elevada esbelteza". Atas do X Congresso de Construção Metálica e Mista, pp. 565 574 (II), Coimbra.

Contacts:

Luis Simões da Silva
Tel.: +351 239 797 216
Fax: +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

Fig. 1 Test Layout (WP4)

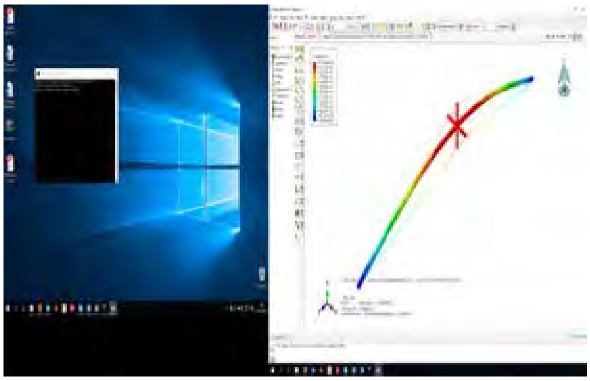


Fig. 2 Numerical simulation of a stayed column (WP4)

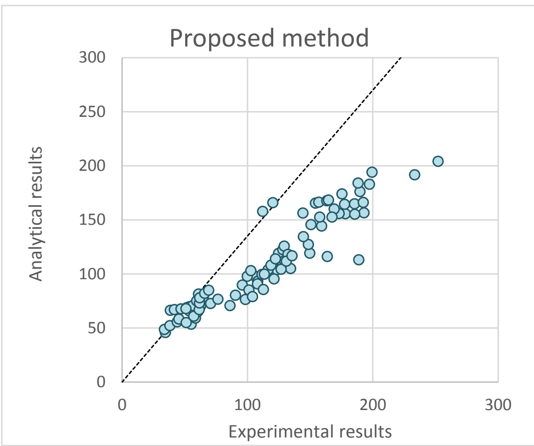


Fig. 3 Comparison of results obtained by the proposed method against results from the experimental tests (WP4)

High Strength Steel for Wind Turbines | HISTWIN+

(RFSR-CT-2014-00023)

Financing Institution(s): Research Fund for Coal and Steel – European Union (EU – RFCS)
Promoting Institution(s): TU Lullea, Sweden, Univ. Coimbra, Portugal; Univ. Aachen, Germany; Univ. Thessaloniki, Greece; European Convention for Constructional Steel Work (ECCS), Belgium; FOSTA, Germany
Coordinator(s): (Univ. Coimbra, Portugal) Luis Simões da Silva and Carlos Rebelo; (TU Lullea, Sweden) Milan Veljkovik

Researchers and collaborators: (only Univ. Coimbra, Portugal) Luis Simões da Silva, Carlos A. Silva Rebelo, Paulo Pinto, Rui Matos

Period: July 2014 to December 2015

Relevant facilities: (only Univ. Coimbra, Portugal) Structures and Structural Mechanics laboratory.

Objectives:
The HISTWIN project has been recognized as an RFCS success, http://cordis.europa.eu/coal-steelrtd/stories_en.html, due to the introduction of innovative connection details and improved design practices for Steel Wind Towers. The present proposal will make these results known to the community of designers thus facilitating the acceptance of these new concepts to the manufacturing community as well as the regulatory authorities.

Description:
In Work Package 1 "Preparation of Background Material for Workshops", an extensive collection of practical information, including a short background text and numerical examples will be prepared to show the complete structure the design process. From the load analysis to specific details of the tower design will be covered.

The objective of Work Package 2 "Public Access" is to create a "one stop shop" for the steel tower design giving easy access to literature, software and publications within the project. Links to other information relevant for the construction of steel tubular towers for the support of wind energy turbines, will be provided at the web address www.histwin.eu.

The aim of Work Package 3 "Organization of Workshops" is to disseminate the knowledge gained during the course of the HISTWIN-project to designers and practitioners. A detailed explanation of the background material, developed in WP1, and the design tools, developed in WP4, will be given.
Work Package 4 "Tools for Easy Design" has aim to create solutions easy to use in order to make the design procedure of towers for wind turbines more available for wider community of structural engineers. In addition to the development of specific software solutions to facilitate the tower design, an application for use on mobile phones will be programmed.

Publications:
Conference proceedings:
Christine Heistermann, Anh Tuan Tran, Milan Veljkovic & Carlos Rebelo (2014) "Flangeless Connections in Steel Tubular Wind Towers", International Scientific Conference and Workshop "METNET-SPb-2014" Saint-Petersburg, Russian Federation, 17-19 February 2014

Tran A.T., Veljkovic M., Rebelo C., Simoes da Silva L.., (2014) "Influence Of Geometrical Imperfections on Analyses of Door Openings in Tubular Steel Towers For Wind Turbines", Proceedings of the 7th European Conference on Steel and Composite Structures, EUROSTEEL 2014, paper 386, abstract pp., Naples, Italy.

Heistermann C., Pavlović M., Andrade P., Veljković M., Rebelo C., Simões da Silva L., (2014) "Finite Element Analysis of Lap Joints in Steel Tubular Towers", Proceedings of the 7th European Conference on Steel and Composite Structures, EUROSTEEL 2014, paper 352, abstract pp., Naples, Italy.

Matos R., Rebelo C., Simões da Silva L., Veljkovic M.., (2014) "Behavior of Pre-Stressed Bobtail® Bolts: Application in tubular wind towers", Proceedings of the 7th European Conference on Steel and Composite Structures, EUROSTEEL 2014, paper 376, abstract pp., Naples, Italy.

Matos R., Pinto P., Rebelo C., Simões da Silva L., Veljkovic M.., (2015) "Cyclic performance of single and group micropiles on loose sand", Proceedings of the: International Foundations Congress and Equipment Expo IFCEE 2015, March 17-21, San Antonio, Texas, USA.

Matos, R.; Rebelo, C. "Monitorização e avaliação do comportamento de parafusos pré-esforçados BobTail", 9º Congresso Nacional de Mecânica Experimental, Paper 110, 15-17 de Out. Aveiro, Portugal.

Journal articles:
Matos R., Pinto P., Rebelo C., Gervásio H. and Veljkovic M., "Improvement of tubular wind tower foundations using steel micropiles" (under revision in the Structure and Infrastructure Engineering, jan2015)

Matos R, Pinto P.L, Rebelo C., Veljkovic M. and Simões da Silva L. "Laboratory testing of micropiles in loose sand" (under revision in the Canadian Geotechnical Journal)

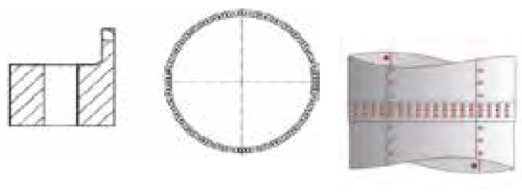
Marko Pavlović, Christine Heistermann, Milan Veljković, Daniel Pak, Markus Feldmann,Carlos Rebelo, Luis Simões da Silva, "Connections in towers for wind converters, Part I: Evaluation of down-scaled Experiments" (submitted for publication in the Journal of Constructional Steel Research)

Marko Pavlović, Christine Heistermann, Milan Veljković, Daniel Pak, Markus Feldmann,Carlos Rebelo, Luis Simões da Silva, "Connections in towers for wind converters, Part II: The friction connection behaviour" (submitted for publication in the Journal of Constructional Steel Research)

Marko Pavlović, Christine Heistermann, Milan Veljković, Daniel Pak, Markus Feldmann,Carlos Rebelo, Luis Simões da Silva, "Friction connection vs. ring flange connection in steel towers for wind converters" (submitted for publication in the Eng. Structures)

Christine Heistermann, Marko Pavlović, Milan Veljković, Daniel Pak, Markus Feldmann,Carlos Rebelo, Luis Simões da Silva, "Influence of execution tolerances for friction connectionsin circular and polygonal towers for wind converters" (submitted for publication in the Eng. Structures)

Contacts:
Carlos Rebelo
Tel.: +351 239 797 209
Fax: +351 239 797 123
Email: crebelo@dec.uc.pt
URL: http://www.isise.net



a) b)

Fig. 1 Tower segment connection. a) flange connection; b) friction connection

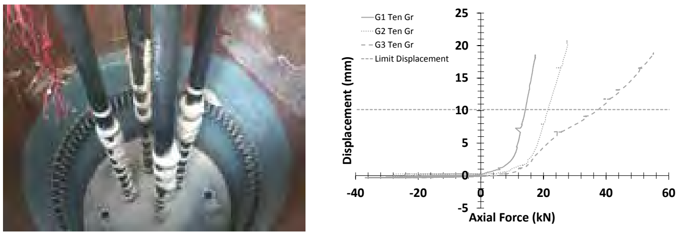


Fig. 2 Micropile experimental tests

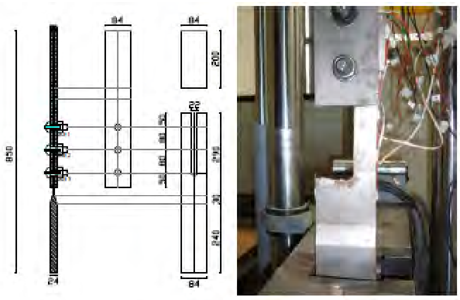


Fig. 3 Friction connection fatigue tests

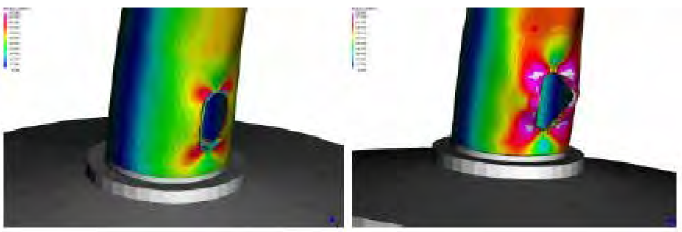


Fig. 4 Door stability

Innovative structural system based on advanced materials for lightweight and durable Offshore Wind Towers | InOlicTower

Financing Institution(s): Financed by the FCT and co-funded by FEDER through Operational Competitiveness and Internationalization Programme (POCI)
Promoting Institution(s): University of Minho (UM)
Coordinator(s): António Ventura Gouveia (Joaquim Barros in SC-UM)

Researchers and collaborators: Joaquim António Oliveira de Barros; Vítor Manuel do Couto Fernandes da Cunha; Isabel Brito Valente; Eduardo Nuno Borges Pereira; Lúcio Abel Pereira Lourenço; Fatemeh Soltanzadeh; Mohsen Ebrahimzadeh Hassanabadi

Partner Institutions: University of Minho; Institute for Sustainability and Innovation in Structural Engineering (ISISE)

Period: July 2016 to June 2019

Relevant facilities: Servo close-loop equipment's for experimental programs; FEMIX V4.0 Finite Element package; Laboratory equipment and facilities of Civil Department of UMinho.

Objectives:
This project aims to develop a wind tower made out of precast high performance fibre reinforced self-compacting concrete (FRSCC) segments (rings) assembled through the application of a hybrid system of post-tensioned strands, some of which in steel and others in carbon fibre reinforced polymeric matrix (CFRP), specially positioned in order to maximize the benefits that can be obtained from their mechanical and durability performance. This system allows the construction of towers of relative low self-weight and high stiffness, since the rings are constituted by a structural system based on the concept of ribbed shell, with the strands positioned on the ribs. The conjunction of relatively low weight and high stiffness allows the structure to have a sufficiently high natural frequency in order to present a better structural behaviour than actual solutions, as well as higher durability, lower construction time, and manufacturing and maintenance costs. The structural concept aimed to develop can also be applied to the tower foundation.

Description and Methodology:
The FRSCC precast ribbed shell rings without any ordinary reinforcement and assembled by a system of CFRP and steel post-tensioned strands located in the ribs (see Fig 1.), is totally innovative for offshore wind towers. The combination of steel and structural synthetic fibres will be explored, since high performance fibre reinforced concretes (FRC) can be developed using this hybrid fibre reinforcing concept, with excellent impact resistance and fatigue behaviour. One of the fibres has capability of retaining water, contributing to the self-healing of the micro-cracks that can occur during the service life of the structure, as long as the matrix has a relatively high percentage of pozolanic materials, like the FRSCC to be developed in this project.
The potentialities of FRSCC have been demonstrated by the structural composite research group of University of Minho. In fact it is possible to develop FRSCC with high post-cracking resistance, capable of eliminating completely the conventional reinforcement in certain applications, with economic and structural advantages, more durable and sustainable.
The post-tension system will be comprised of strands of CFRP and steel. The CFRP has higher elastic modulus, ultimate strength and fatigue resistance when compared to steel, and is immune to corrosion, therefore the CFRP reinforcement will be applied near the external surface of the ribs of the ring. However, these bars have linear elastic behaviour up to its failure. Therefore, to provide the necessary ductility to the structural system for ultimate limit states, post-tensioned steel reinforcement will be also applied in the ribs, but at the most internal part in order to increase the protection against corrosion. The percentage of post-tensioned steel strands is designed to assure the stability of the tower for service limit states even if CFRP strands fail or become inactive. The same design philosophy is adopted for the percentage of CFRP. This hybrid reinforcing system is an innovating approach in this type of structures, since the location of the strands and the post-tensioned level to be applied mobilizes the favourable benefits they can provide.

The research project is constituted by the following main tasks: 1) Characterization of the relevant properties of FRSCC; 2) Assessment of the behaviour of post-tensioned CFRP bars submitted to fatigue and maritime environment conditions; 3) A multi-physics approach for an integrated assessment of the instantaneous and long term behaviour offshore wind towers; 4) Optimization of the structural system; 5) Assessment of the structural performance of a FRSCC ribbed ring prototype by experimental tests; 6) Recommendations for the design and construction of offshore wind towers based on the developed structural and material concept.

Regarding the existing structural solutions for offshore wind towers, the material/structural solution proposed in this project is more lightweight and durable, deserves lesser maintenance costs, lower construction times and presents better structural behaviour. The structural system is based on the "LEGO" concept by assembling precast FRSCC ribbed shell rings through a hybrid system composed of CFRP and steel post-tensioned strands located along the ribs in positions and with post-tensioned levels that mobilizes effectively their mechanical and durability potentialities. The advantages do not only reside on the new structural concept but also on the used materials: FRSCC and post-tensioned CFRP and steel strands. The advantage of using FRSCC is the possibility of replacing all ordinary steel reinforcement by discrete fibres, diminishing significantly the costs related to the preparation and assembling the relatively complex reinforcing systems for this shell system, as well as the elimination of the vibration activities for the concrete. The costs maintenance due to corrosion of conventional reinforcement are also eliminated in this solution, since corrosion does not exist, even if the hybrid fibre reinforcing system includes steel fibres, as long as crack width is limited to 0.3 mm. Due to the higher compactness, better organization of the constituents, derived from an optimized composition methodology, the FRSCC will have suitable durability for the exigencies of offshore environmental conditions, and rheological properties for a perfect finishing of the ribbed rings.

The structural concept to be developed is extended to the foundation of the tower. In fact, for soil foundation at relatively small depth, the foundation will be also constituted by precast FRSCC rings assembled by post-tensioned CFRP/steel strands. The ring in contact with the soil foundation will be connected to a sealing concrete slab. To contribute to the structural stability of the tower, and considering the relatively low stress fields that occur in the core of the rings that will stay submerged, these rings will be filled with concrete made by sub products of the construction industry, especially, with recycled aggregates and fibres, and fly ash will be the predominant constituent of the binder of this concrete. For soil foundation at intermediate depth, the foundation of the tower will be constituted by a pile tripod based on the referred material/structural concept, whose top extremities will be connected by a grid to support the tower. For relatively deeper waters, the tower can be supported on floating platforms similar to the ones used in oil industry, but of smaller dimension.

The experimental and the material properties of the FRSCC will be assessed in Task 1, and the derived data will be also used for the calibration of the constitutive models to be developed in the scope of Task 3. Task 2 will be executed in parallel with task 1 since the fatigue tests with CFRP bars submitted to offshore environmental conditions requires different equipment's of those required by task 1. After having been calibrated with the data derived from task 1, and its predictive performance has been proved from the results derived from the tests with prototypes (task 5), the software will be used to execute the final optimization of the structural system and predict the life cycle behaviour considering a multi-physics approach. In Task 4 the wind tower is pre-designed in order to determine the requirements for the intervening materials and to define the best geometry for the FRSCC ribbed rings. Then parametric studies will be executed in FEMIX in order to assess the influence of the material properties, geometry of the structural components and position and level of the post-tensioned reinforcement on the structural behaviour of the tower. The experimental programs to be carried out in task 5 have the main purpose of assessing the performance of the FRSCC ribbed rings when submitted to severe loading conditions (see Fig. 2 for the test setup of the first series of tests with prototypes of FRSCC ribbed ring of ¼ scale), as well as to provide data for the assessment of the predictive model being developed in task 3. All the relevant information derived from the research activities of the previous tasks will be compiled in a document with a design guideline format, which is the main objective of the last task of the project.

Fig. 1 Schematic representation of the FRSCC ribbed ring

Contacts:
António Ventura Gouveia
Tel.: +351 232 480 500
Fax: +351 232 424 651
Email: ventura@estgv.ipv.pt
URL: http://www.isise.net

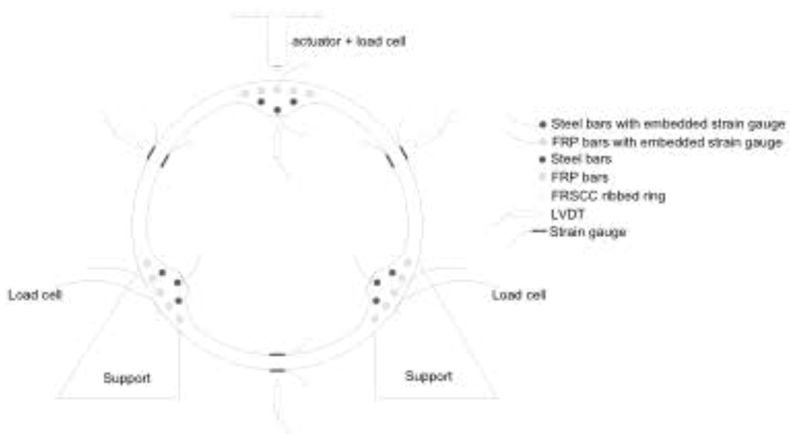


Fig. 2 Schematic test setup

Innovative material of ultra-high ductility for the rehabilitation of the built patrimony | INOTEC

Financing Institution(s): ADI (co-financed by the European Regional Development Fund (FEDER) through the Operational Program COMPETE)
Promoting Institution(s): CiviTest – Pesquisa de Novos Materiais para a Engenharia Civil, Lda.
Coordinator(s): Lúcio Lourenço (CiviTest); Joaquim Barros (ISISE-UM)

Researchers and collaborators: Lúcio Lourenço (CiviTest); Delfina Gonçalves (CiviTest); Tiago Valente (CiviTest); Inês Costa (CiviTest); Dina Pires (CiviTest); Inaldo Vasconcelos (CiviTest); Joaquim Barros (ISISE-UM); Daniel Oliveira (ISISE-UM); José Sena-Cruz (ISISE-UM); Miguel Azenha (ISISE-UM); Isabel Valente (ISISE-UM); Eduardo Pereira (ISISE-UM); António Matos (ISISE-UM); Marco Jorge (ISISE-UM); Cristina Frazão (ISISE-UM); João Almeida (ISISE-UM); Fatemeh Soltanzadeh (ISISE-UM).

Partner Institutions: University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)

Period: October 2012 to June 2015

Relevant facilities: Computational tools and equipment of ISISE-UM; Computational and laboratory equipment of both partner institutions.

Objectives:
Development of a material reinforced with a relatively high percentage of synthetic fibres (non corrodible material) with a tensile strain hardening behaviour, which means that the tensile strength is higher than the stress at crack initiation and the tensile failure occurred at strain level higher than 2%, with the formation of diffuse crack patterns. This material, designated as SHCC, was tailored to have excellent bonding to natural stones, concrete, clay and mortar bricks, and timber elements, in order to have the requisites for its use in the rehabilitation of structures made by these type of fragile materials, such is the case of masonry-based structures of reduced strength to seismic events.
Using this SHCC, it was developed a new rehabilitation technique based on the shotcrete of two outer thin SHCC layers connected with polymer fibre reinforced connectors, able of increasing significantly the in-plane and out-of-plane load carrying capacity and energy dissipation capacity of structures vulnerable to seismic events.

Description and Methodology:
The development of the SHCC was be based on the experimental characterization of the material, supported by the use of advanced numerical tools. The SHCC composition was tailored in order to present appropriate rheological, material and mechanical properties for this application. The numerical tools were developed to assist in the SHCC optimization process, in the design of the strengthening system and in the analysis of the behavior of structures. The proposed strengthening technique efficiency was appraised by performing numerical simulations and by the experimental characterization of masonry walls prototypes strengthened with outer thin layers of SHCC.

WP1 Preliminary studies: In WP1 were selected the appropriate materials for the SHCC and its application according to the shotcrete technology. The competitiveness of the reinforcement technique was assessed by performing preliminary numerical simulations of the application of thin outer thin layers of SHCC to strengthen masonry structures. The increase of the load carrying capacity and energy dissipation provided by the technique was appraised and compared with existing strengthening techniques.

WP2 Technical specifications: Considering the numerical simulations developed in WP1, the required mechanical properties of the SHCC for distinct structural reinforcement applications levels were defined.
Considering different substrate materials and environmental demands, the SHCC durability and compatibility requirements were assessed.

WP3 Acquisition and development of new knowledge and capabilities for the development of the project: A comprehensive bibliographic research regarding the main topics of the project was carried out, namely: (i) SHCC technology, rheology, mechanical and durability properties; (ii) shotcrete technology; (iii) substrate compatibility and experimental characterization; (iv) experimental characterization of cyclic behaviour of masonry prototypes reinforced with SHCC; (v) numerical simulation of composite structures adopting a nonlinear dynamic analysis.

WP4 Development: Considering the research carried out in WP2, the development of the SHCC was carried out.
The constitutive model to simulate the nonlinear material behaviour of SHCC under cyclic loading was developed and implemented in software FEMIX.

WP5 Construction of prototypes, pre-series and pilot installation: In this activity were executed samples for the mechanical, durability and substrate bond characterization of the SHCC. Additional samples were produced to assess the shrinkage and creep behaviour of the SHCC, since early ages. Prototypes of masonry walls strengthened according to the INOTEC technique were also produced.

WP6 Tests: Based on the samples and prototypes produced in WP5, tests were executed to characterize: (i) the mechanical properties of SHCC (tension, compression and bending) tests; (ii) durability and bonding of SHCC; (iii) monotonic and cyclic tests for the development of the constitutive models (WP4); (v) in-plane and out-of-plane loading tests of strengthened masonry walls prototypes; (vi) shrinkage and creep tests since early ages.

WP7 Promotion and results dissemination: The project results are held available in a website to potential users of the rehabilitation technique. A seminar was conducted in order to present the main aspects and results of this technique. It was also planned a wide dissemination of the research findings in the form of papers and participation in national and international conferences.

Publications:

Papers

- J. Almeida, E. Pereira, and J. A. O. Barros, "Assessment of overlay masonry strengthening system under in-plane monotonic and cyclic loading using the diagonal tensile test" Constr. Build. Mater., vol. 94, pp. 851–865, Sep. 2015;
- Almeida, J.A.P.P.; Bordoni, D.; Pereira, E.N.B.; Barros, J.A.O.; Aprile A. "Assessment of the properties to characterize the interface between clay brick substrate and strengthening mortar", accepted to be published in the Construction and Building Materials Journal, 2015;
- T. Valente, D. Colarusso, M. Pecce, F. Ceroni, and J. Barros, "Influence of embedded through section connectors on the behavior of a new strengthening technique for concrete structures," Key Engineering Materials, vol. 711, no. Concrete under Severe Conditions-Environment and Loading, pp. 996–1003, Sep. 2016.
- M. Colombo, T. Valente, J. A. O. Barros, A. Aprile, and L. Lourenço, "Fibre reinforced mortar application for out-of-plane strengthening of schist walls," Construction and Building Materials, vol. 121, pp. 185–197, Sep. 2016.

Dissertations

- Colombo, M. (2014), "Strengthening of schist walls elements: experimental and numerical research", Master Thesis, Dipartimento di Ingegneria, Università Degli Studi di Ferrara, Anno Accademico 2013-2014
- Bordigoni, D. (2013). "Assessment of the brick-strengthening mortar interface: experimental research and numerical modelling", Master Thesis, Dipartimento di Ingegneria, Università Degli Studi di Ferrara, Anno Accademico 2012-2013;
- Colarusso, D. (2014). "The potentialities of ductile fiber reinforced mortar and ETS connectors for strengthening of masonry walls", Master Thesis, Università Degli Studi Del Sannio, Anno Accademico 2013-2014;

Conference proceedings

- Valente, T., D. Colarusso, J. Barros, D Gonçalves, and M. Pecce. "Avaliação de Desempenho de uma Nova Técnica Para Reabilitação de Alvenaria E Betão" In CONPAT 2015 - Congresso Internacional Em Reabilitação de Construções. Lisboa, Portugal, 2015.
- Valente, Tiago, Delfina Gonçalves, Cristina Frazão, and Joaquim AO Barros. "Argamassa de Ultra-Elevada Ductilidade Para Reabilitação: Comportamento Mecânico E Durabilidade" In 5as Jornadas Portuguesas de Engenharia de Estruturas, JPEE 2014. Lisboa, Portugal, 2014;
- J. Almeida, E. Pereira, and J. Barros, "Performance assessment of overlay strengthened masonry under cyclic loading using the diagonal tensile test" in 9th International Masonry Conference, July 7, 8, 9; Guimarães, 2014, pp. 1–12;
- J. Almeida, E. Pereira, and J. Barros, "Comportamento de Painéis de alvenaria reforçados com FRCM sujeitos a ações no plano: Estudo da interface" in CONPAT2015, 8 a 10 de Setembro; Lisboa, 2015, pp. 1–8

Contacts:

Joaquim Barros
Tel.: +351 253 510 210
Fax: +351 253 510 217
Email: barros@civil.uminho.pt
URL: http://www.isise.net

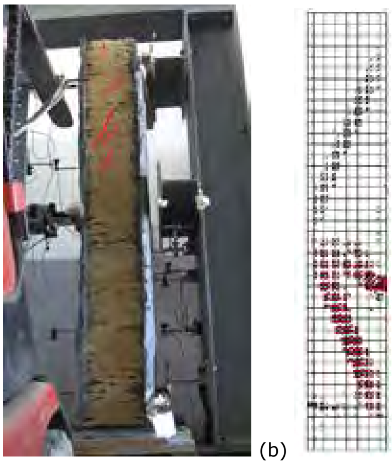

(a) (b)

Fig. 1 (a) Prototype of masonry wall strengthened with INOTEC technique after bending test (WP6); **(b)** crack pattern prediction obtained in numerical simulation (WP3)

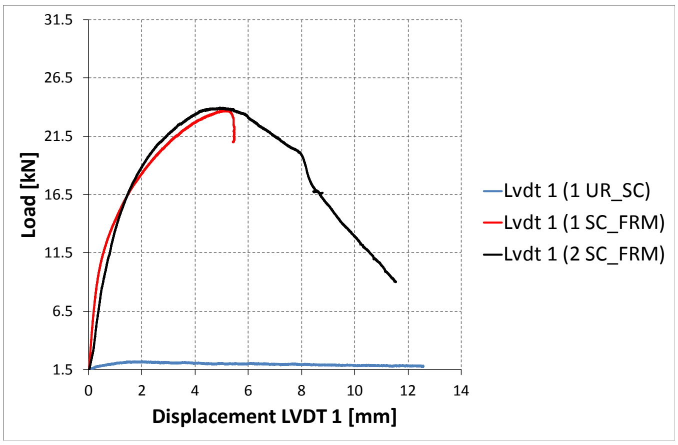


Fig. 2 Load-deflection relationship of three prototypes obtained in bending test results of masonry walls strengthened with INOTEC technique (UR_SC – unreinforced; SC_FRM – reinforced)

Development of a new reinforcing system and evaluation of the existing models for composite slabs | INOV-LAMI

Financing Institution(s): European Union (Portugal 2020)
Promoting Institution(s): University of Coimbra and O Feliz Metalomecânica SA
Coordinator(s): Rui Simões (ISISE-UC)

Researchers and collaborators: Rui Simões (ISISE-UC); Miguel Pereira (ISISE-UC). Coordinators from partner institutions: José Manuel Silva (O Feliz).

Partner Institutions: University of Coimbra (UC) (Portugal); O Feliz Metalomecânica SA (Portugal)
Period: January 2016 to December 2018

Relevant facilities: Computational and laboratory equipment of Civil Engineering Department of FCTUC; Producing equipment of O Feliz Metalomecânica SA.

Objectives:
In steel and composite buildings, the floors are usually constituted by composite slabs with steel sheeting. In general, the design of composite slabs with current spans is governed by the longitudinal shear resistance, so not taking advantage of the high bending capacity, in particular for slabs under sagging bending. The resistance to longitudinal shear can be increased through the use of reinforcement systems, such as end anchorage devices.
Based on preliminary studies performed in the University of Coimbra, it was verified that it is possible to increase the resistance of slabs reinforced with end anchorage devices (Fonseca, Marques and Simões, 2015). Additionally, it was verified that the design model for shear resistance prescribed in Eurocode 4, as it does not consider adequately the steel sheeting contribution, tends to conduct to an overdesign of composite slabs.
The main goal of the research project is the optimization of the performance of composite slabs, in order to get more economical and consequently more sustainable solutions. To meet this objective, it is intended to: (i) develop and prove the effectiveness of new reinforcement systems (in particular innovative end anchorage devices) which allow increase the longitudinal shear resistance, (ii) calibrate design equations to predict the resistance of proposed reinforcement systems, (iii) improve the design analytical models available to predict the shear resistance, (iv) development and proof the performance of a new profiled steel sheet, with 120 mm height, to be used in floors with embedded beams and (v) update the design tables and software for design of composite slabs produced by the promoter company, including the results of the present project.
The project encompasses analytical, numerical studies and an extensive experimental program. The study is applicable to conventional composite slabs and to composite slabs with deep steel sheeting.

Description and Methodology:
The main objective of the current project is to improve the behaviour of composite slabs with profiled steel sheet. So it's necessary to propose and develop new types of reinforcing systems to optimize the behaviour of this kind of structural elements, so as evaluate and discuss the existing analytical models to determine their resistance. The experimental approach is the main activity of this project because that's what will allow the development and validation of those new reinforcing systems.

This project is mainly developed on laboratory of structures and materials of Department of Civil Engineering in University of Coimbra. The steel sheets needed for experimental tests are produced on O Feliz Metalomecânica SA installations.

The project is defined for 10 different activities described bellow:

WP1 State of the art: Identification of the several existing types of (i) composite slabs, (ii) steel sheet profiles, (iii) reinforcing systems. Identification of the design methodologies specified on Eurocode 4.

WP2 Critical evaluation and proposal of new reinforcing systems for longitudinal shear: Evaluation of the efficacy on existing reinforcing systems against the longitudinal shear failure mode. Prediction of the resistance achieved with the implementation of reinforcing systems like end anchorage devices. Proposal of new types of reinforcing systems.

WP3 Critical evaluation and improvement of the analytical models to define vertical shear resistance of composite slabs: Critical reflexion about the existing analytical models to determine the vertical shear resistance in composite slabs. Proposal of a new approach to determine the vertical shear resistance for composite slabs.

WP4 Development of a new steel sheet profile with high height (120 mm): Development of a new steel sheet profile, with 120 mm of height.

WP5 Perform of standard tests to evaluate the longitudinal shear parameters according with the specifications of Eurocode 4: Determination of the longitudinal shear resistance parameters – m, k and $\tau_{u,Rd}$– needed for the evaluation of composite slabs resistance with the steel sheet profiles adopted, according with the Eurocode 4 specifications.

WP6 Experimental approach to evaluate the efficacy of the reinforcing systems previously proposed: Experimental approach to prove the efficacy of those reinforcing systems previously proposed. Calibration of analytical models to define de achieved resistance for each kind of reinforcing system created and tested.

WP7 Experimental approach to evaluate and define a new analytical model for the vertical shear resistance of composite slabs: Evaluation of the existing approach to determine the vertical shear resistance on composite slabs and calibration of a new analytical model to determine the real resistance to vertical shear.

WP8 Numerical approach for complementary parametric studies: The specimens experimentally tested are numerically calibrated using the software ABAQUS to perform the results achieved in laboratory. After that, several models will be developed to perform a parametric study to develop an analytical approach to simulate the resistance achieved with the new reinforcing system.

WP9 Development of a dynamic software to define the preliminary design tables for composite slabs with the available steel sheet profiles and considering the reinforcing systems previously developed: Development of an application/software to determine the resistance of composite slabs according with the specifications of Eurocode 4 and with the analytical models previously calibrated.

WP10 Conclusions and recommendations: Summary of all the conclusions obtained with the developed work. According with the achieved results, proposal of new analytical models to evaluate the resistance for composite slabs.

References:

Fonseca, A., Marques, B. e Simões, R. (2015). *Improvement of the behavior of composite slabs: A new type of end anchorage*. Steel and Composite Structures, Vol. 19, No. 6 (2015) 1381-1402.

Publications:

Dissertations

Agreira, C., Desenvolvimento de um novo produto: chapa perfilada de altura elevada, Master Thesis, July 2016

Contacts:

Rui Simões
Email: rads@dec.uc.pt

Miguel Pereira
Email : mpereira@uc.pt

Fig. 1 Experimental test (Fonseca, Marques and Simões, 2015)

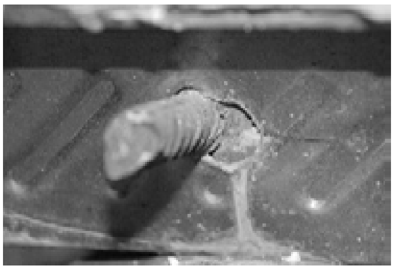


Fig. 2 Anchorage end system (Fonseca, Marques and Simões, 2015)

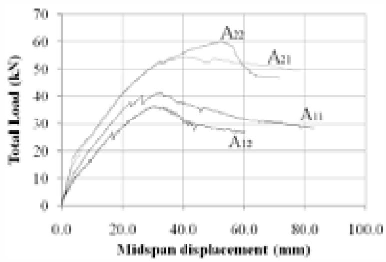


Fig. 3 Experimental results (Fonseca, Marques and Simões, 2015)

Fig. 4 Exemple of a specimen

Fig. 5 Experimental test

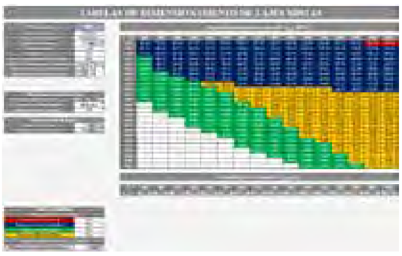


Fig. 6 Dynamic table developed for preliminary design

Innovative systems for earthquake resistant masonry enclosures in RC buildings | INSYSME

Financing Institution(s): European Commission
Promoting Institution(s): University of Padova
Coordinator(s): Paulo Lourenço

Researchers and collaborators: Paulo Lourenço, Graça Vasconcelos, Luis Miguel Silva

Partner Institutions: Ruredil S.p.A., SDA-engineering GmbH, Tiles and Bricks Europe (TBE), Andil Assolaterizi, CTCV, APICER, TUKDER, Ziegel, Vavouliotis – Gounaris - Mitakis S.A., SCI H.I. Struct S.R.L., University of Kassel, University of Pavia, National Technical University of Athens, University of Minho, Midle Esat Technical University

Period: October 2013 to September 2016

Relevant facilities: Laboratory equipment and facilities of Civil Department of UMinho.

Objectives:
The project aims at developing innovative systems for a wide range of masonry enclosures, by improving their overall technological performances and in particular those related to the earthquake behaviour. The project also aims at developing sound design rules, in order to update national and European standards and to make engineering design easier and more reliable. To reach these goals, the project is structured into two main steps, in a three-year time. In the first step, new construction systems for enclosure walls will be developed, and their technical and economic feasibility will be assessed performing parallel experimental and numerical studies. The progress towards successful completion of this phase will constitute a milestone for the subsequent project prosecution. In the subsequent step, on the basis of the obtained experimental and numerical results, design methods for this kind of elements will be developed, and the proposed solutions will be completely validated by demonstrations of design and construction of prototype walls in real buildings. Procedures for quality assessment through on-site testing, software for design and guidelines for end-users, will ensure full usability of the developed knowledge and technologies.

Description:
Infill masonry panels, if properly distributed and considered in the seismic design of structures, can have a beneficial effect. They increase the stiffness of the structure, result in reduced displacement demands, and contribute to the dissipation capacity of the structure, offering significant extra shear resistance to the earthquake. Hence, for existing rc buildings, constructed before the advent of current seismic codes, severe damage or even collapse can be attributed to poor original design or deficient construction detailing. In some other cases, damage and collapse of rc buildings is caused due to improper consideration or neglecting of the influence of infill walls on the surrounding rc elements. One cause of adverse effects is associated with the infills leaving a short portion of the column clear. In addition, the irregular arrangement of infill walls along the height of the building causes an abrupt change of the building stiffness, resulting in the possible activation of soft-storey mechanisms. Moreover, the asymmetric distribution of the infill masonry walls on the building plan can introduce torsional effects, and hence, induce large displacements of rc columns.
The principal objective of the project is thus to develop optimized masonry enclosure solutions for enhanced earthquake resistance, respecting local materials and construction practice, and considering the various levels of seismic input and environmental requirements related to the different countries. Possible types of innovative masonry enclosure systems to be developed, with reference to materials and construction details, may be divided in three major groups: (i) systems built of conventional components, following original design methods, (ii) systems built of conventional components and applying sophisticated enhancement techniques (e.g. through application of reinforcement, connectors/fasteners, joints, angles, shelves), following original design methods, and (iii) systems built of innovative components (such as clay masonry units of particular shape, sliding mortar, various steel components), following original design methods.
In Portugal two distinct solutions for earthquake resistant masonry infills walls have been developed, both characterized by having a monolithic connection between the masonry wall and the frame (Fig. 1). The idea was (1) to use tongue and groove masonry units with vertical reinforcement properly attached to the top and bottom rc beams and (2) use vertical perforated unit with an internal shape aiming at having improved thermal performance. In this system horizontal reinforcement should be used at the bed joints and steel connectors were also designed to improve the out-of-plane behaviour of the masonry infill. Besides an extensive experimental characterization of materials, an experimental campaign was designed and executed on the in-plane static cyclic in-plane and out-of-plane tests. Combined tests by imposed a previous in-plane damage was also carried out. From these tests it was possible to assess the in-plane and out-of-plane behaviour of masonry infills and define different damage limit states and corresponding lateral drifts. In addition, detailed finite element modelling and macro-modelling were also carried out to describe the in-plane (strut model) and out-of-

plane (macro-elements) behaviour of rc frames with brick infills. Finally, construction design guidelines were derived for the construction and seismic design of brick infill walls.

Publications:

Conference proceedings

Silva, L., Vasconcelos, G. Lourenço, P.B. Innovative systems for earthquake resistant masonry enclosures in rc buildings – Insysme preliminary work at 2 university of Minho, 6th International Conference on Mechanics and Materials in Design, 26-30 July, Azores, 2015.

Silva L., Vasconcelos G., Lourenço P.B., Akhoundi F. Experimental evaluation of a constructive system for earthquake resisting masonry enclosure walls, 16th International Brick and Block Masonry- Trends, Innovations and Challenges, Modena, da Porto & Valluzzi (Eds), Taylor and Francis Group, 26-30 June, Padova, Italy, Paper165, pp.1333-1340, 2016. http://hdl.handle.net/1822/44322.

Silva L., Martins A., Vasconcelos G., Lourenço P.B., Paredes de alvenaria de fachada: Soluções e sugestões de melhoria de desempenho, Seminário Reabilitação de Fachadas, Vasconcelos&Lourenço (eds), pp. 51-74, 2016

Journals

Vasconcelos, G., Lourenço, P.B. Soluções para paredes de alvenaria de enchimento com comportamento melhorado à acção sísmica, Construção Magazine, nº 64, pp. 52-53, 2014.

Lourenço, P.B., Vasconcelos, G., João Leite, Paulo Pereira, Lessons learned from the testing of masonry infilled RC frames and proposal of new solutions, Mauerwerk – European Journal of Masonry, 20 (2), 99-123, 2016. DOI: 10.1002/dama.201500672.

Contacts:

Paulo Lourenço
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: pbl@civil.uminho.pt
URL: http://www.isise.net

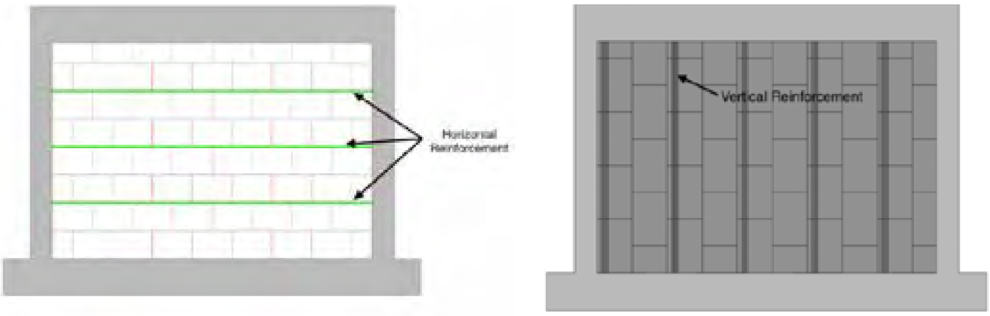


Fig. 1 Overview of the solution for masonry infills walls developed

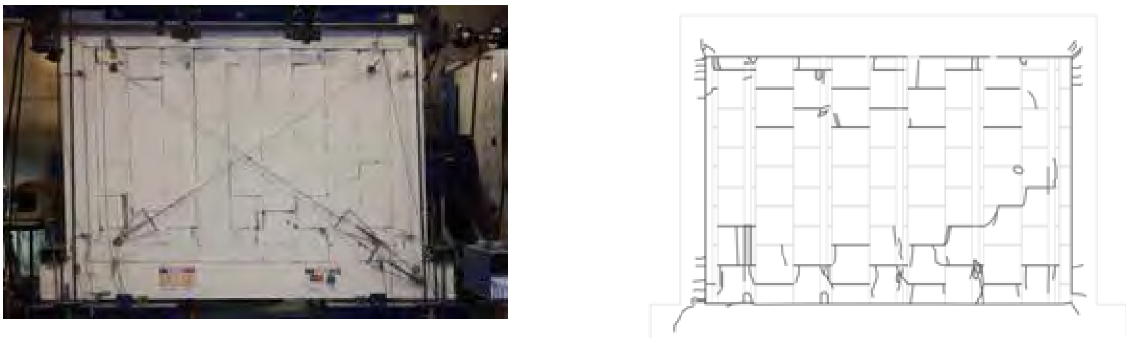
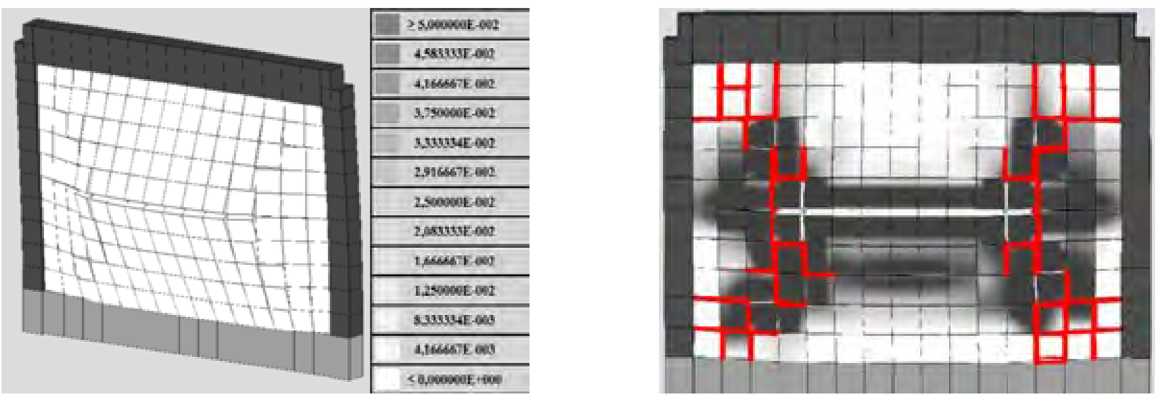


Fig. 2 Crack patterns of system 1 after cyclic in-plane test



(a) (b)

Fig. 3 Macro-model of the unreinforced prototype. deformed mesh (a); collapse mechanism (b).

A comprehensive multi-physics and multi-scale approach to the combined effects of applied loads and thermal/shrinkage deformations in reinforced concrete structures | IntegraCrete

Financing Institution(s): FCT (POCI-01-0145-FEDER-016841)
Promoting Institution(s): University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)
Coordinator(s): Miguel Azenha (ISISE-UM)

Researchers and collaborators: Rui Faria (FEUP), José Sena Cruz (ISISE-UM), Vitor Cunha (ISISE-UM), José Granja (ISISE-UM), Carlos Filipe Sousa (FEUP), Mário Pimentel (FEUP), Hadi Mazaheripour (FEUP), Behzad Zahabizadeh (ISISE-UM), José Gomes (ISISE-UM).

Partner Institutions: University of Porto, CONSTRUCT

Period: July 2016 to June 2019

Relevant facilities: Computational equipment and laboratory facilities of the DEC-UM-ISISE.

Objectives:
Even though reinforced concrete (RC) is one of the most used man-made materials in the world, and adequate models exist for the prediction and design of the ultimate capacity of RC structures, the prediction of service life behaviour is still not mature enough for actual design purposes, leading to inadequate service life behaviour even when regulatory prescriptions for design are strictly followed. This inadequate behaviour is mostly felt to the general public by the appearance of cracks with large width (>0.3mm), which usually end up causing severe reductions in the lifespan of RC structures, while enforcing costly repair/maintenance operations.

After an initial dormant period, the mechanical properties of concrete evolve significantly towards their final values along time. However, the process of hydration is exothermic, frequently resulting in relevant temperature variations of concrete (increases/decreases), which in turn cause volumetric deformations. Furthermore, the internal water consumption on behalf of cement hydration, together with progressive drying because of water evaporation from the concrete surface, lead to the desiccation of the pore structure, which results in contraction of the material. Any restraint to such deformations is bound to cause tensile stresses. Together with all the above phenomena, RC structures are loaded by their self-weight and external loads. The most challenging point in the prediction of service life behaviour is the adequate description of the intricate interactions that take place between self-imposed deformations (thermal and shrinkage related), viscoelasticity and the effects of applied loads in the process of crack development. These interactions are not taken into account by current regulations, and there are no integrative scientific research studies that take a systematic approach to this issue, leaving many questions unanswered.

The main purpose of this research proposal is precisely to close the research gap identified above through a comprehensive program that incorporates extensive experimental characterization, real-scale testing with monitoring of relevant data and their corresponding simulation with multi-scale and multi-physics approaches. The central innovation of this research project is the pioneering capacity of the team to integrate knowledge and research experience in both the experimental and numerical simulation fields, paving the way to an unprecedented set of integrative innovations ranging from the microstructural characterization and modelling to the real-scale testing, modelling and validation. This has never been done by a single team, and thus very solid and original outcomes are expectable. The improved predictions of cracking and service life behaviour, and resulting design recommendations, are bound to cause significant impact on new structures and processes of strengthening with cement-based materials that will have improved cracking performance and thus increased maintenance-free lifespan.

Description and Methodology:

The plan/methods is divided into seven main tasks:

T1 – State of the art update and initial dissemination

T2 – Bridging scales of analysis: from micro to macro

T3 – New insights into experimental characterization

T4 – Setting up of long term experimental framework

T5 – Deployment and conduction of the long term experimental framework

T6 – Integrated modelling

T7 – Documentation and dissemination

Publications:

Papers

D. Simavorian, J. de Brito, L. Castro, M. Azenha (2017) "Analysis of the effect of shoring on the behaviour of reinforced concrete slabs" Construction and Building Materials, Elsevier, 143, 473–489, http://dx.doi.org/10.1016/j.conbuildmat.2017.03.096

M. Azenha, L. Leitão, J.L. Granja, C. de Sousa, R. Faria, J.A.O. Barros (2017) "Experimental validation of a framework for hygro-mechanical simulation of self-induced stresses in concrete" Cement and Concrete Composites, Elsevier, 80, 41-54 http://dx.doi.org/10.1016/j.cemconcomp.2017.02.008

R. Faria, L. Leitão, L. Teixeira, M. Azenha, D. Cusson (2017) "A structural experimental technique to characterize the viscoelastic behavior of concrete under restrained deformations" Strain, Wiley, Volume 53, Issue 1, February 2017 http://dx.doi.org/10.1111/str.12216

C. Sousa, L. Leitão, R. Faria, M. Azenha (2017) "A formulation to reduce mesh dependency in FE analyses of RC structures under imposed deformations" Engineering Structures, Elsevier, Volume 132, 1 February 2017, Pages 443–455 http://dx.doi.org/10.1016/j.engstruct.2016.11.040

P. Silva, T. Valente, M. Azenha, J. Sena-Cruz, J.A.O. Barros (2017) "Viscoelastic response of an epoxy adhesive for construction since its early ages: Experiments and modelling", Composites Part B: Engineering, Elsevier. http://dx.doi.org/10.1016/j.compositesb.2016.10.047

M. Velay-Lizancos, I. Martinez-Lage, M. Azenha, P. Vásquez-Burgo (2016) "Influence of temperature in the evolution of compressive strength and in its correlations with UPV in eco-concretes with recycled materials", Construction and Building Materials, Elsevier. Volume 124, 15 October 2016, Pages 276–286. http://dx.doi.org/10.1016/j.conbuildmat.2016.07.104

Book

M. Azenha, J. Granja (2017). Seminar: Design of reinforcement for RC elements under the combined effect of applied loads and restrained shrinkage. E-book of presentations.
http://doi.org/10.5281/zenodo.800693

Contacts:

Miguel Azenha
Tel.: +351 93 840 4554
Email: miguel.azenha@civil.uminho.pt
URL: http://www.isise.net

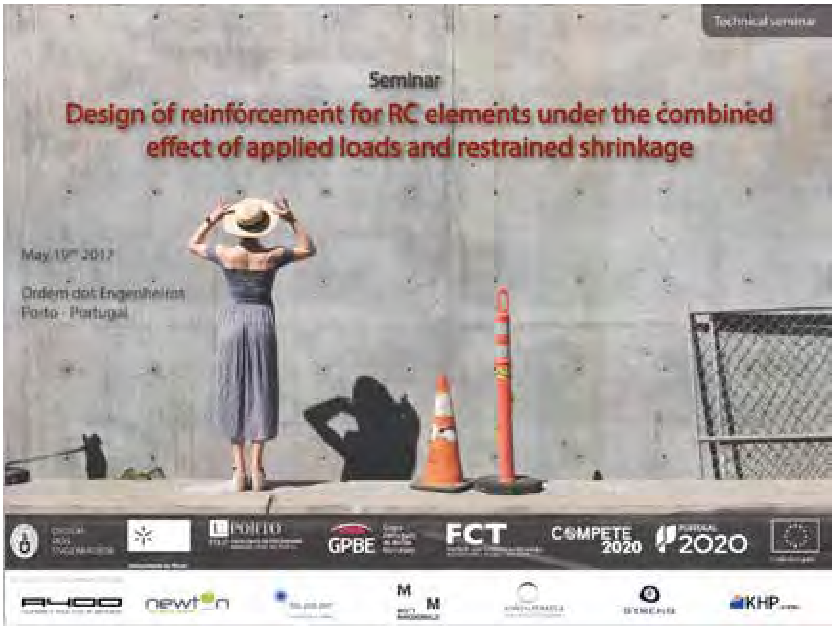


Fig. 1 E-book resulting from Task 1 of IntegraCrete

A dendrochronological survey of the structural woods of historic city centres in Portugal | INVISIBLE WOODS

Financing Institution(s): FCT/MEC, FEDER/POCI
Promoting Institution(s): University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM)
Coordinator(s): Jorge Manuel G. Branco (ISISE-UM)

Researchers and collaborators: Jorge Manuel G. Branco (ISISE-UM); Maxime Paul A. Verbist (ISISE-UM); Cristina Nabais (UC)

Partner Institutions: University of Coimbra (UC)

Period: 14 November 2016 to 13 November 2018

Relevant facilities: Laboratory equipment (UM); knowledge about the dendrochronology (UC)

Objectives:
As a science which uses tree growth rings for wood dating, the Dendrochronology was born in the Southwestern United States. Dendrochronology is the most accurate method of dating applied to (pre)-historical studies. Because many cultural objects, historic buildings and archaeological remains are made of wood, the annual resolution of growth rings provides dendrochronology with a substantial advantage over other dating techniques. Dendrochronology can also provide information about the provenance of wood, and can then contribute to the history of trade. Trees from distant geographical regions develop different ring growth patterns, conditioned by local climatic conditions. Therefore, the comparison of individual series of growth rings with reference chronologies, which reflect the average growth conditions for a given region, allows the establishment of the provenance of the wood. In addition to the dating of (pre)-historical objects and establishment of provenance, long dendrochronology is a relevant source of information for the climate reconstruction. To our knowledge, there is no sampling and dating of archaeological and historical wood in Portugal. Therefore, researchers and laboratories dedicated to dendrochronology only appeared in Portugal in the last decade. Note that the Laboratory of Dendrochronology from the University of Coimbra is one of the pioneers. The main objective of this proposal is to make a dendrochronological study of six historical centres in Portugal: Guimarães, Porto, Coimbra, Lisbon, Évora and Beja. To achieve this goal, strong interdisciplinary cooperation is essential, involving Dendrochronologists for wood dating (annual growth rings), Art Historians with their knowledge of written sources, and also Architects and Engineers for assessing the different components of timber structures in historic buildings.

Description and Methodology:
If it is more focused on the architectural and engineering part, the research Project "Invisible Woods" aims at assessing the stability and the health of existing timber structures from the selected historic buildings. This purpose will be achieved through the proposed work programme including 5 main tasks: initial analysis of timber structures, assessment of the cross-section, modelling of timber structures, assessment of timber joints, proposition of preventions and/or interventions means.

<u>Task 1: Initial analysis of timber structures</u>
The initial task will be done with the close cooperation of the two research institutions involved in the Project "Invisible Woods". In each historic centre, a selection of Buildings will be made following some established criteria such as: a selection of buildings from different centuries, the amount of accessible information for each building, the accessibility to timber structures,... This task aims at performing the inspection and diagnosis of timber roof structures from the selected buildings within the project. This phase includes the different stages of construction, and of the different Wood Species used, the survey of the cross-sections used, the identification of the significant pathologies. From the definition of a sample on a case-by-case basis, a visual classification of the elements will also be proposed in this task.

<u>Task 2: Assessment of the cross-section</u>
Old timber structures are an important part of the Architectural heritage, because they testify the evidence of former constructions. Timber structures can be featured by their geometric organization, their dimensions, their characteristics (mechanical and physical properties, biodegradability,...), and the joints linking the various structural elements. Non-Destructive Tests (e.g. Ultrasonic Pulse Velocity, Impact Penetration Test, Drilling Resistance Test) will be performed in-situ in order to characterize with reliability the current state of existing timber structures and also to assess their structural performances when exposed to biological deterioration.

<u>Task 3: Modelling of timber structures</u>
Based on the collected information from Tasks 1 and 2, the existing timber structures must be modelled in order to assess their structural safety in-situ. Through improved

knowledge about the wood mechanical properties, better and fundamental decisions will be required to achieve an adequate assessment of safety on the timber structures under investigation.

Task 4: Assessment of timber joints

Within the timber structures, the different joints linking the structural components must be investigated. The tasks then consist of studying the mechanical behaviour of joints in order to discern their local influence on the global behaviour of the whole timber structure. The presence of biological degradations inside timber joints in-situ as well as their impact on the wood mechanical properties must be taken into account in this study.

Task 5: Preventions and/or intervention

This task aims at studying and defining preventive and/or curative measures. To this end, their effects on the medium and long term behaviour of the existing timber structure must be defined.

Task 6: Writing reports:

Annual reports about the Project "Invisible Woods" are mandatory to communicate the progression of the research and the obtained results so far. At the end of the research period, a final report has to be written based on the results from the achievement of different tasks explained above.

Contacts:

Jorge Manuel G. Branco
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: jbranco@civil.uminho.pt
URL: http://www.isise.net

Acknowledgements:

This work was partly financed by FEDER funds through the Competitivity and Internationalization Operational Programme - COMPETE and by national funds through FCT – Foundation for Science and Technology within the scope of the project POCI-01-0145-FEDER-016843.

Fig.1 and 2 Analysis of the timber roof structures and assessment of the components cross-sections from the Convent of the Christ in Tomar (Task 1 and 2)

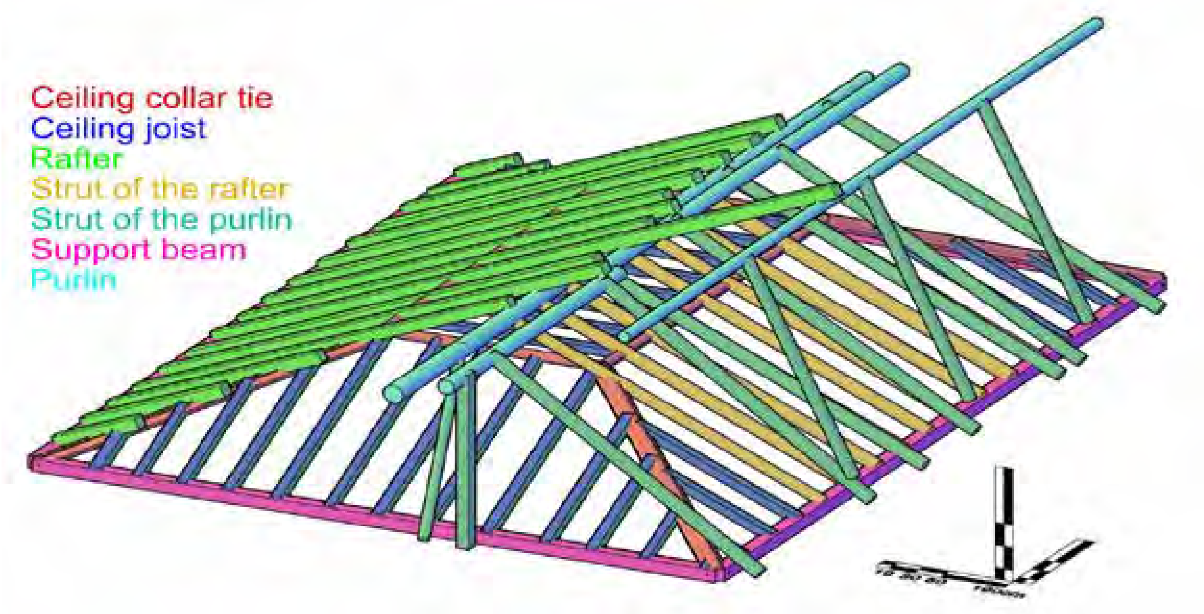


Fig. 3 Modelling the timber roof structure from the Convent of the Christ in Tomar (Task 3)

Large Valorisation on Sustainability of Steel Structures | LVS³

Financing Institution(s): EC-RFCS
Promoting Institution(s): ArcelorMittal Belval & Differdange S.A.
Coordinator(s): Olivier Vassart (ArcelorMittal)

Researchers and collaborators: Luís Simões da Silva (ISISE-UC); Helena Gervásio (ISISE-UC); Paulo Santos (ISISE-UC). Coordinators from partner institutions: O. Vassart (AM, Luxembourg); P.O Martin (CTICM, France); J.P den Hollander (Stichting Bouwen met Staal, The Netherlands); R. Siebers (Bauforumstahl, Germany); P. Elguezabal (Fundacion Tecnalia Research&Innovation, Spain); I. Talvik (Tallinna Tehnikaulikool, Estonia); M.Netusil (Ceske Vysoke Uceni Technicke V Praze, Czech Republik); L. Cascini (Universita degli studi di Napoli Federico II, Italy); V. Huet (Advanced Coatings & Construction Solutions, Belgium); P. García (Club Asturiano de la Innovacion Asociacion, Spain); B. Åstedt (Stalbyggnadsfinstitutet Stiftelser, Sweden); K. Jarmai (Miskolci Egyetem, Hungary); V. Ungreanu (Universitatea Politehnica din Timisoara, Romania); A.K. Kvedaras (Vilniaus Gedimino TechnikosUniversitetas Viesoji Istaiga, Lithuania); M. Founti (Ethnicon Metsovion Polytechnion, Greece); P. Moze (Univerza v Ljubljani, Slovenia); J.F. Demonceau (Universite de Liège, Belgium); M. Piasecki (nstytut Techniki Budowlanej, Poland)

Partner Institutions: Universidade de Coimbra (UC, Portugal); Centre Technique Industriel de la Construction Métallique (CTICM, France); Stichting Bouwen met Staal (The Netherlands); Bauforumstahl (Germany); Fundacion Tecnalia Research&Innovation (Spain); Tallinna Tehnikaulikool (Estonia); Ceske Vysoke Uceni Technicke V Praze (Czech Republik); Universita degli studi di Napoli Federico II (Italy); Advanced Coatings & Construction Solutions (Belgium); Club Asturiano de la Innovacion Asociacion (Spain); Stalbyggnadsfinstitutet Stiftelser (Sweden); Miskolci Egyetem (Hungary); Universitatea Politehnica din Timisoara (Romania); Vilniaus Gedimino TechnikosUniversitetas Viesoji Istaiga (Lithuania); Ethnicon Metsovion Polytechnion, (Greece); Univerza v Ljubljani (Slovenia); Universite de Liège (Belgium); Instytut Techniki Budowlanej (Poland)

Period: July 2013 to December 2014

Objectives:
The technical objective of this project is to disseminate the knowledge acquired in the recent years about the environmental impact assessment of steel and composite buildings. During the last decade, a lot of research projects have been funded to develop methodologies, systems and products aiming at improving the thermal efficiency as well as the global environmental footprint of steel buildings. The new standard EN15804 intended for environmental calculation of buildings takes now into account the fact that steel is a recyclable material (Module D). So the objective of this project is to summarise all this acquired knowledge into different documents (Background, Design guide, leaflet, User-friendly Software), to translate all these training and teaching support into the different European languages and finally to disseminate amongst Europe by the organisation of workshops.

Description and Methodology:
The project objectives will be achieved by following the methodology divided into 6 main Work Packages as briefly described next.

WP1 Realisation of documentation in English and software about the environmental assessment of steel and composite Buildings

1.1 Preparation of the design guide
1.2 Preparation of the background documentation
1.3 Preparation of a 6 faces leaflet summarising the key messages relating to the environmental impact of steel and composite structures
1.4 Adaptation of the AMECO software
1.5 Adaptation of the iPhone and iPad simplified calculation Software
1.6 Preparation of the PowerPoint presentations

WP2 Translation of the documentation and software interface

The different versions of the documents (background document, the design guide, leaflet and the PowerPoint presentations), prepared in the frame of WP1, will be translated in the different languages of the partners.
Moreover, the Software Interfaces will also be translated in the different languages of the partners.
In consequence, it will be possible to present them in the mother tongue to all the seminar participants.

WP3 Training for partners involved in seminars

The partners that have realised the different documents and Software (ArcelorMittal, CTICM, ULg, Univ. de Coimbra, AC&CS) acquired a deep knowledge about what is needed to be disseminated. The other partners of this project have all been chosen as experts in their countries as far as sustainability assessment of steel and composite construction is concerned. However, their level of understanding of this topic might differ.
Therefore, in order to provide high quality, professional and consistent seminars across Europe a special training for the project's partners will be organised.
The task of this WP is the organisation of an internal Workshop during which partners that have prepared the documents will present and explain the global approach as well as the Software based on the WP1 data. In this way, it will be ensured that all the seminars will provide the same harmonised information. This should happen

before the partners start with the translations in order to avoid any misunderstandings.
In order to avoid additional travel cost, the length of one of the co-ordination meetings will be extended to two days and the second day will be used for the training.

WP4 Organisation of Seminars
The main task of this project is the organisation of seminars in each of the participating countries. Each partner is responsible for the organisation of the seminar in his country. This can be organised on a University campus as well as in a conference centre. Before the event, invitations have to be prepared and distributed to the targeted people. The audience should consist of designers, architects, developers, future steel users such as students and professors. Last but not least the decision makers and authorities should be invited. The full day seminar will be organised in a central place in order to target a high attendance. During the seminar, printed documents as well as USB Keys that contain all data will be distributed.

WP5 Post dissemination activities
After the seminars, all data should be prepared for a further dissemination. A DVD or USB stick will be created with a HTML based menu that guide users through all presentations, documents and free available software that are included in all languages on it. As it will be based on HTML, the content can easily be put on internet.
A homepage will all these data's will be created and linked to a fix address to be determined (eg. www.sustianablesteel.eu)

WP6 Coordination
The co-ordination of all tasks in order that the targets as well as the fixed deadlines are reached. By this we ensure that all needed data is available in due time for the seminars. In front of this project, all involved parties have been informed about their role once the project starts. Right after the beginning of the project, a co-ordination meeting will be held, during which the tasks are again described and distributed. ArcelorMittal with its long-time experience regarding coordination of ECSC and RFCS projects, will organise this by distributing updated time and task schedules. Besides, AM can count on the help of the five partners involved in the first WP, together with AM works since several years in the frame of multiple European research projects.

Outputs:

Books

H. Gervásio, P. Santos, L. Simões Da Silva, O. Vassart, A.L. Hettinger & V. Huet, "LVS3 - Large Valorisation on Sustainability of Steel Structures: Background Document". Publication written in English and translated to 17 languages, ECCS Press, Belgium, 2014.

V. Huet, P. Santos, O. Vassart, A.L. Hettinger & H. Gervásio, "LVS3 - Large Valorisation on Sustainability of Steel Structures: Design Guide". Publication written in English and translated to 17 languages, ECCS Press, Belgium, 2014.

Software

AMECO v3.0 software for PC, available at: http://sections.arcelormittal.com
LCA calculations software for mobiles/tablets, available at:
https://itunes.apple.com/ (iPhone and iPad)
https://play.google.com/store/apps/ (Android)

Reports

O. VASSART, H. GERVÁSIO, et al., "LVS3 - Large Valorisation on Sustainability of Steel Structures". Final report of the research project RFS2-CT-2013-00016. European Commission, Directorate-General for Research and Innovation. ISBN 978-92-79-57268-5. Luxembourg: Publications Office of the European Union, 2016.

Conference proceedings

P. Santos; H. Gervásio; L. Simões Da Silva, "A Simplified Tool to Evaluate the Sustainability of Steel Buildings in Early Stages of Design", SAM9 – Society And Materials International Conference, Luxemburg city, Luxemburg, 11-12 May 2015.

Contacts:

Luis Simões da Silva
Tel.: +351 239 797 216
Fax: +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

Fig. 1 PrintScreen of the LVS3 project website

Fig. 2 PrintScreen of the software AMECO v3

Concrete Behaviour at Meso-Scale | MesoCrete

Financing Institution(s): FCT, PTDC/ECM/119214/2010
Promoting Institution(s): University of Coimbra, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)
Coordinator(s): Daniel Dias-da-Costa (ISISE-UC)

Researchers and collaborators: Daniel Dias-da-Costa (ISISE-UC), Rui Graça-e-Costa (UAlgarve), Carlos Albino (ISISE-UC), Carlos Fernandes (UC), Tiago Simões (UC), Pedro Areias (UEvora); Pedro Santos (IPLeiria), Hugo Costa (ISEC), Jonatas Valença (ISEC), Jorge Alfaiate (TULisbon), Eduardo Julio (TULisbon).

Partner Institutions: Technical University of Lisbon (Portugal)

Period: May 2012 to August 2015

Relevant facilities: Computational equipment of Civil department of FCTUC; Computational and laboratory equipment of Civil department of FCTUC and partner institution.

Objectives:
In Portugal most constructions have been erected during the second half of the XXth century using reinforced and pre-stressed concrete. This material has been dominant worldwide during this stage and still is nowadays. Many scientific breakthroughs are pushing the boundaries of concrete construction, and new mixtures with enhanced properties are being introduced every day. These advancements are arriving to construction sector at a fast pace and many of the empirical design guidelines – and even existing standards – may no longer hold. Within this scope, this project aims at contributing to the knowledge of the material behaviour both from experimental and numerical perspectives. More specifically, focus is given to the scale of the aggregates (herein designated by 'meso-scale') for understanding the role of different parameters in the mechanical behaviour of the material. The main idea was to capitalise on all scientific background of the research team to experimentally assess its behaviour and develop a robust numerical tool equipped with suitable constitutive models. The constitutive law between aggregates (and fibres) and binding paste was targeted using a combined experimental-numerical approach, with the following five tasks and goals: (1) produce different concrete mixtures, covering a wide range of properties; (2) characterise the constitutive behaviour at the scale of the aggregates; (3) model the fractured behaviour at the scale of the aggregate using the existing FEM-based software developed by the group and identify its drawbacks; (4) develop new software by taking into account the issues raised in (3); (5) deliver an integrated tool with constitutive laws, for the simulation of the behaviour of concrete.

Description and Methodology:
The project was divided in numerical and experimental tasks. All proposed work packages (WP) were specifically tailored having into account the scientific know-how of the research team on the three areas: i) concrete (WP 1, 2 and 5), ii) interfaces (WP 2, 3 and 5); and iii) numerical modelling (WP 3 and 4). For each WP, the assembled team included at least one young PhD researcher with expertise in a core area.
WP1 Mixture: The objective of this WP is to design, produce and characterise the concrete mixtures for the project to support the study of the meso-scale behaviour for a wide range of constitutive properties. Following a first study on concrete mixing technology and preliminary trials, 5 reference micro-concretes were defined for assessing the behaviour at the interface of the aggregates in the following stages of the project, as well as the mixtures for fibre-reinforced concrete needed for assessing the behaviour at the interface of the fibres. Standard tests were performed to characterise the mechanical properties of the selected mixtures, including compressive and tensile strengths and Young's modulus at different ages.
WP2 Material characterisation: This WP developed the framework, benchmarks andcarried out the material characterisation at the scale of the aggregates. This task was focused on the interface between fibres and binding paste (in the case of fibre-reinforced concrete) and aggregate-binding paste. This task was organised in 4 critical stages: i) development of image processing techniques for analysing experimental data; ii) testing and analysis of fibre-reinforced concrete; iii) design of benchmark tests for assessing the mechanical properties of the interface between aggregate and binding paste; and iv) extensive testing and analysis of all data from the benchmark tests.
WP3 Interface modelling: The objective of this task was to perform numerical simulations and identify the limitations of the existing software/approaches. The research assistant started the first numerical simulations to identify the most important parameters for the simulation of the behaviour of concrete at the scale of the aggregates. From this study, and from the literature review, the most relevant parameters were found to be: the stiffness and shape of the aggregate, the strength of binding paste (fracture energy and tensile/compressive strengths), and the properties of the interfacial transition zone (stiffness, tensile/compressive strength and fracture energy).
The many parametric studies carried out during this task allowed for the identification of the drawbacks in the existing software. The first issue was the extreme difficulty in obtaining numerical solutions due to the non-linear nature of the problem and the high number of active competing micro-cracks. For this reason, the team focused early on

the development of non-iterative algorithms. Other issues became also evident, such as the fact of the elements with built-in discontinuities being incompatible at smaller scales – which is physically wrong and produces misleading results. Furthermore, the present formulation was unable to simulate fibre-reinforced concrete. A final limitation was the fact of the software being primarily aimed at bi-dimensional problems and not handling the third-dimension.

WP4 Numerical implementation: This task had the objective of developing a framework for the simulation of the concrete behaviour overcoming the limitations found in WP 3. The task was organised into three main stages. The first stage aimed at solving the limitations in the software. The second stage included the simulation of experimental data and further developments for the simulation of the behaviour at the scale of the aggregates. The third and final stage concerned the implementation of constitutive models developed in WP 5 and the simulation of the experimental tests from WP 2. With this WP new formulations were introduced for the simulation of concrete at meso-scale with non-iterative algorithms to handle multiple sources of non-linearity and avoid convergence issues. These formulations were applied to multiple-cracks and fibre reinforced concrete, also being extended to 3D in preliminary models. The new formulations were shown to provide reliable estimates regarding crack patterns and both local and overall behaviours.

WP5 Constitutive models: This WP had the objective of providing constitutive models for the interfaces at the scale of the aggregates. This task was organised in two stages. The first stage concerned the formulation of constitutive models, whereas the second stage concerned the validation using experimental data from Task 2. The development of constitutive models applicable to the interfaces between aggregate and binding paste were developed both from theoretical and analytical perspectives, whereas its implementation was done in parallel with WP 4 and the many studies at element and mesh levels. As a result of this WP, general new models were proposed, which are applicable to different types of concrete. The purpose of this task was to use the experimental data available to assist the development and validation of the constitutive models. The first numerical models were aimed at the simulation of the fibre-reinforced concrete specimens and calibration of the constitutive law for the interface between fibre and binding paste. The models included different random distributions of fibres, which provided an envelope of failure curves and corresponding behaviour until failure. From this study, the formulation for fibre-reinforced concrete developed in WP 4 was shown to adequately capture the initial stiffness of the experimental specimens on the pre-cracking stage, as well as the peak and post-peak responses.

Selected publications: Papers

- SIMÕES, T., OCTÁVIO, C., VALENÇA, J., COSTA, H., DIAS-DA-COSTA, D., JÚLIO, E., Influence of concrete strength and steel fibre geometry on the fibre/matrix interface, Composites Part B, Elsevier, 122: 156–164, 2017.
- SIMÕES, T., COSTA, H., DIAS-DA-COSTA, D., JÚLIO, E., Influence of fibres on the mechanical behaviour of fibre reinforced concrete matrixes, Construction and Building Materials, Elsevier, 137(15): 548–556, 2017.
- DIAS-DA-COSTA, D., CARMO, R.N.F., GRAÇA-E-COSTA, R., Numerical modelling of concrete beams at serviceability conditions with a discrete crack approach and noniterative solution-finding algorithms, Structural Concrete, Wiley, 18(1): 225–236, 2017.
- DIAS-DA-COSTA, D., VALENÇA, J., JÚLIO, E., ARAÚJO, H., Crack propagation monitoring using an image deformation approach, Structural Health Monitoring, Wiley, 2016 (in press).
- OCTÁVIO, C., DIAS-DA-COSTA, D., ALFAIATE, J., JÚLIO, E., Modelling the behaviour of steel fibre reinforced concrete using a discrete strong discontinuity approach, Engineering Fracture Mechanics, Elsevier, 154: 12–23, 2016.
- GRAÇA-e-COSTA, R., ALFAIATE, J., DIAS-DA-COSTA, D., NETO, P, SLUYS, L.J., Generalisation of non-iterative methods for the modelling of structures under nonproportional loading, International Journal of Fracture, Thomas Telford, 182(1):21–38.
- DIAS-DA-COSTA, D., ALFAIATE, J., SLUYS, L.J., AREIAS, P., JÚLIO, E., An embedded formulation with conforming finite elements to capture strong discontinuities, International Journal for Numerical Methods in Engineering, Wiley, 93(2): 224-244, 2013.
- VALENÇA, J., DIAS-DA-COSTA, D., JÚLIO, E., ARAÚJO, H., COSTA, H., Automatic crack monitoring using photogrammetry and image processing, Measurement, Elsevier, 46(1): 443-441, 2013 (doi: 10.1016/j.measurement.2012.07.019).
- GRAÇA-e-COSTA, R., ALFAIATE, J., DIAS-DA-COSTA, D., SLUYS, L.J., A non-iterative approach for the modelling of quasi-brittle materials, Thomas Telford, International Journal of Fracture, 178: 281-298, 2012 (doi: 10.1007/s10704-012-9768-1).

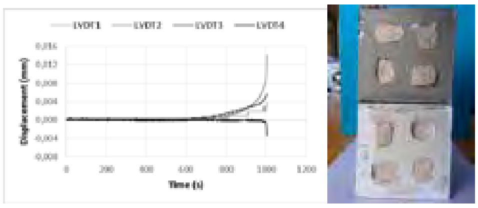


Fig. 1 Tensile tests on limestone aggregates

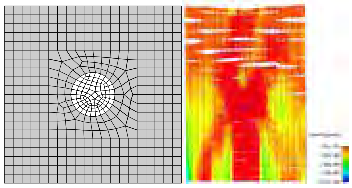


Fig. 2 Simulation at the scale of the aggregate

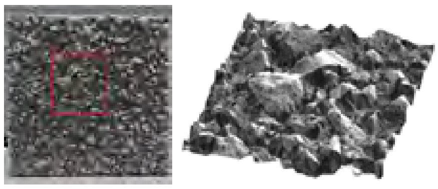


Fig. 3 Characterisation of roughness at scale of aggregates

Contacts:

Daniel Dias-da-Costa
Tel.: +351 239 797 256
Email: dias-da-costa@dec.uc.pt
URL: http://www.isise.net

Next Generation Monitoring of Coastal Systems in a Scenario of Global Change | NEXT-SEA

Financing Institution(s): NORTE2020
Promoting Institution(s): University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM), Centre for MicroEletroMechanical Systems (CMEMS), Molecular and Environmental Biology Centre (CBMA)
Coordinator(s): Luis Gonçalves (CMEMS-UM), Pedro Gomes (CBMA-UM) and Eduardo Pereira (ISISE-UM)

Researchers and collaborators: Luis Miguel Valente Goncalves, José Higino Gomes Correia, Graça Maria Henriques Minas, Paulo Mateus Mendes, Carlos Alberto Batista Silva, Carlos Manuel Gregório Santos Lima, Alexandre Manuel Teixeira Barros Ferreira Silva, Vanessa Cardoso, Eduardo Nuno Borges Pereira, Tiago Filipe da Silva Miranda, Maria Isabel Brito Valente, Bahman Ghiassi, Filipe Costa, Judite Almeida, Pedro Gomes, Maria Manuela Sansonetty Gonçalves Corte-Real, Maria João Marques Ferreira Sousa Moreira, Ronaldo Sousa

Partner Institutions: IB-S and IB-S Strategic Council, ISISE, CMEMS, CBMA.

Period: July 2016 to June 2019

Relevant facilities: IB-S laboratories, LEST laboratories, CMEMS laboratories, CBMA laboratoires.

Objectives:
The NEXT-SEA project aims at creating the foundations for future integrated management approaches for nearshore and estuarine ecosystems, as well as offshore installations, mostly by addressing the current lack of information and knowledge about the marine ecosystems and the physical variables that characterize these environments. This foundation will unlock the development of a wide range of innovative multifunctional structures and systems, aiming at the simultaneous production of energy, coastal protection, regeneration of habitats, adding value to marine resources, regularization of waves for aquatic sports and marine tourism, among others. At the same time, the optimal context for the development of new technologies for sensors and MEMS will be created, driven by the added challenges and difficulties found in the marine harsh environments. These goals are in line with the Regional Smart Specialization Strategy of North Portugal (EREI as Portuguese acronym), by contributing significantly to the consolidation of Key Enabling Technologies and to the Advanced Manufacturing Systems, which are identified as regional priorities, through the intention of developing innovative monitoring systems and biomimetic materials for future generation of marine structures and ecosystems management.

Description:
The NEXT-SEA project aims at creating This proposal aims to create the foundations for the next generation coastal systems management based on knowledge and innovation and supported by the team's expertise in the areas of electronics, materials, taxonomy, ecology, conservation and metagenomics, using the NW of Portugal as a case study. Monitoring is at the centre of this commitment. Efficient monitoring based on cutting-edge technologies (lab-on-chip, MEMs, smart materials and underwater networks together in marine electronics applications) is essential to broaden the type, frequency, temporal and spatial scales of variables and type of habitats to be monitored. This development will occur in close relation with the Biology, Electronics and Civil Engineering fields. The effective monitoring of coastal systems will provide the ideal background for future innovation in Marine Sciences combining a holistic approach. New synergies will be unlocked in order to make the transition from an antagonist relation into a sustainable evolution path based on interventions that are beneficial to both the ecosystems and the human society. Effective knowledge about the coastal systems will support not only the decision making process but also the establishment of a baseline database, that will allow to detect abiotic and biotic changes in response to global stressors in the coastal environment. This approach will enable the anticipation of environmental problems and the support of adapting strategies for communities and ecosystems, increasing its global resilience.
The following activities (A) will be implemented:

- A1 - System Specification
- A2 - Technology to sea and estuarine sensing
- A3 - System development and technology integration
- A4 - Sampling, biodiversity evaluation and ecological analysis
- A5 – Molecular Biology and Metagenomics
- A6 - Information based systems for supporting the decision-making process
- A7 - Innovation in structural systems
- A8 - Prototype Integration and tests in real scenarios
- A9 - Project coordination, dissemination and results exploitation

Activities A1 and A3 will mostly address all the issues related with the identification of processes to monitor and system specification and development for the implementation of the new monitoring systems, mostly related to the Electronics Engineering. These activities will also be fed by information generated by the other activities, which are related with the ecosystems and the engineering structures.
Activities A4 and A5 will be essentially associated with the

description and documentation of biodiversity in coastal and estuarine ecosystems, using classical and cutting edge methodologies in order to validate the newly proposed procedures and gather all the information and data necessary about the ecosystems, mostly from the perspective of Biochemistry, Molecular Biology and Environmental Sciences. Activities A6 and A7 will be mostly concerned with the creation of the information based systems that will combine the information collected and support the current and future decision-making. In addition, these activities will include the development innovative solutions for materials and structural systems for addressing all the multifunctional challenges identified in this proposal, mostly from the perspective of Materials Engineering and Advanced Manufacturing Processes.
Activity 8 will integrate all project outcomes into the real case scenario, by transversely taking from all the other activities the required information for the in situ implementation of the case studies identified within this project proposal.
Finally, Activity 9 will combine the coordination of the project and the exploitation, including financial and project results, as well as the dissemination of these to the major stakeholders, as well as the outreach activities to general society. In order to maximise its impact in the North Region, workshops and dissemination sessions will be organized, along with the publication of results in ISI journal papers and conference proceedings. A website is planned for increasing the public awareness about the main topics addressed in this project.

Conclusions:
NEXT-SEA articulates the knowledge of 4 different areas of expertise (electronics, civil engineering, environmental sciences and molecular biology) for the development of an integrated methodology to evaluate the effects of global change in coastal systems. This articulation will enable, among others, the development of new technological products for wide applications in sea monitoring (including deep sea), essential not only to document on-going changes but also to evaluate the ecological conditions to the establishment of aquaculture and energy production facilities, as well as to provide solid information for supporting management decisions. As an example, these outcomes are seen as critical for a new generation of policies in the context of erosion protection installations.
NEXT-SEA will certainly leverage the capacity of local administration authorities to take decisive action in the coastal planning domain.

Publications:
During this initial stage of the project conference papers have been published (5), as well as master thesis have been finalized (5).

Contacts:
Eduardo N.B. Pereira
Tel.: +351 253 510 487
Fax: +351 253 510 217
Email: eduardo.pereira@civil.uminho.pt
URL: http://www.isise.net

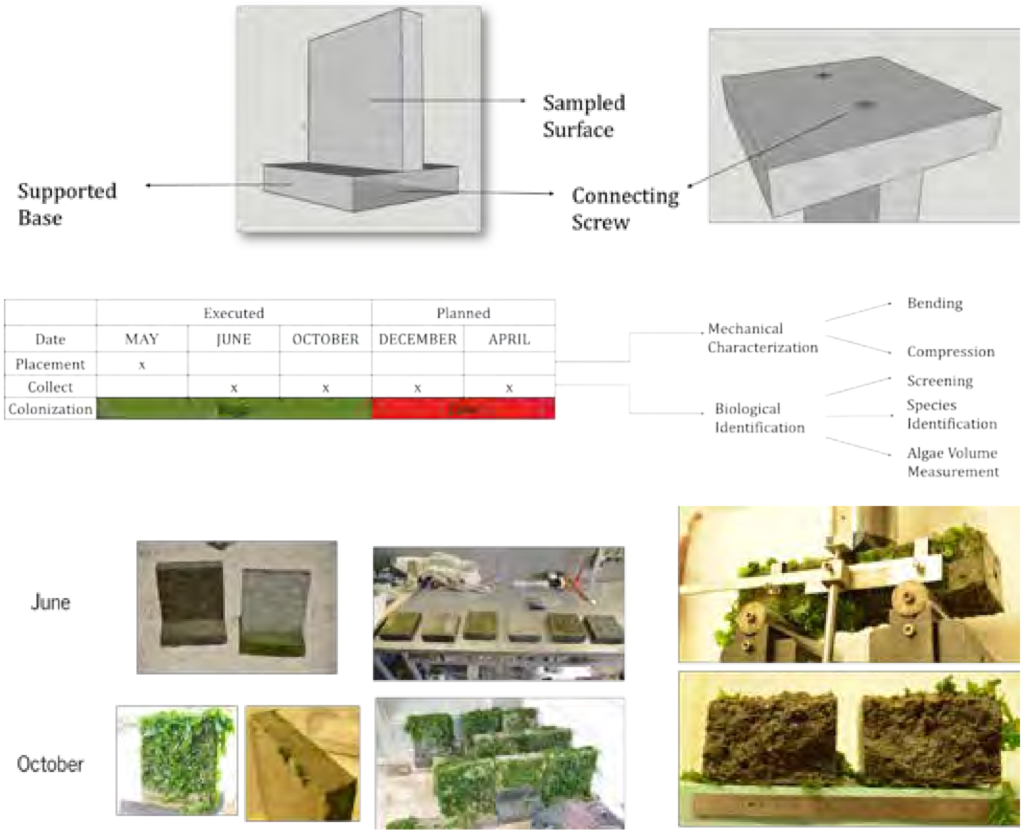


Fig. 1 Scheduling and conception of the testing systems for assessing the colonization process in artificial materials. The preliminary results of specimens submerged at the intertidal zone in the north of Portugal have shown that material and surface characteristics are very relevant to the colonization process

Optimal Use of High Strength Steel Grade Within Bridges | OPTIBRI

Financing Institution(s): RFCS
Promoting Institution(s): University of Coimbra, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)
Coordinator(s): Carlos Rebelo (ISISE-UC), Luis Simões da Silva (ISISE-UC)

Researchers and collaborators: Carlos Rebelo (ISISE-UC); Luís Simões da Silva (ISISE-UC); Helena Gervásio (ISISE-UC); Constança Rigueiro (ISISE-UC); Jorge Teixeira (ISISE-UC). Coordinators from partner institutions: • Anne-Marie Habraken (ULg;, Chantal Bouffioux (ULg); Laurent Duchêne (ULg); Ulrike Kuhlmann (USTUTT); Stephanie Breunig (USTUTT); Vahid Pourostad (Sutt); Thomas Baaten (BWI); José Pedro (GRID); Anne-Claude Vanderbecq (Industeel); Patrick Toussaint (Industeel).

Partner Institutions: University de Liege (ULg); Universität Stuttgart (USTUTT); Universidade de Coimbra (UC); Consulting Engineers, Lisbon, (GRID); Belgian Welding Institute (BWI); Industeel BE;

Period: July 2014 to June 2017

Relevant facilities: Computational and laboratory equipment of Civil Engineering department of FCTUC; Computational and laboratory equipment of other partner institutions.

Objectives:
The project aims to develop welded bridges using High Strength Steel where it is required (mainly in highly stressed web). As usually the fatigue resistance of the welded joint as well as stability issues reduce the interest of using HSS in bridges, the project studies: the optimal welding and post welding treatment in order to have a high fatigue resistance, as well as, the buckling behaviour of multiaxially stressed plates. The quantification of the interest of HSS welded bridge from the point of view of cost and environment is performed on a 20 m wide highway bridge spans 80 m. Three designs of the same bridge are compared through Life cycle environmental assessment (LCA), Life cycle cost (LCC) analysis, Life cycle performance (LCP). The first bridge design (A) is classical and uses only standard S355 steel grade when the second design (B) uses HSS S690 QL steel, however with the current Eurocode state which does not account of the steel grade in many issues. Finally the third design (C) is performed relying on the real HSS behaviour and HFMI post treated welds or welds with LTT material filler. This third design and more generic case study demonstrate the need of updating of Eurocode. The 20 m wide highway bridge spans 80 m has a large place on the market. It presents clear fatigue problems and some stability issues (need of enhanced rules for buckling of multiaxially stressed plates) that the project addresses. The research will provide a window example to inform the Civil Engineering community about the interest of using HSS within bridges. In addition a comparison between the HFMI post treated welds and welds with LTT material filler will allow a ranking of these two possibilities to increase fatigue strength of welded joints.

Description and Methodology:
- to propose solutions to solve the current drawbacks of using HSS within bridges: Eurocode modifications relying on current project results (fatigue study of HSS welds and buckling of multiaxially stressed plates);
- to quantify by LCA, LCC and LCP the interest of using HSS in bridges;
- to provide guidelines for optimal use of HSS in bridges;
- to propose a post treatment qualification procedure of HFMI post treatment for HSS welds;
- to check what is optimal (HFMI post treatment of welds or welds with LTT filler material);
- to disseminate the knowledge generated by the project.

WP1 Design of Bridges: The main aim of this WP is to provide basic design cases of HSS bridges, taking into account the structural behaviour at Ultimate Limit States (ULS), Serviceability Limit States (SLS) and fatigue loading either based on the current state of Euro codes or on the true static and fatigue behaviour of HSS steel and their welded joints (optimized either by HFMI post treatment or by the use of LTT weld material). For the sake of comparison a standard design will be also done.
In short, the following cases will be considered: Design A =a bridge design example by adopting standard steel grades, namely S355 J2/k2 or N/NL and the usual design rules as per the Eurocodes 3 and 4, parts 1 and 2. Design B = the same design example, but adopting HSS 690QT, although based on current Euro code specifications, without taking into account true HSS behaviour identified in WP2 and improvement of stability rule from WP3 Design C = the same design as design B , i.e with HSS 690QT, but with due account of true static and fatigue HSS behaviour and its welded improved joints identified in WP2 and improvement of stability rules from WP3.

WP2 Fatigue Study: To perform static and fatigue tests on material samples as well as on larger size samples with welded connections to generate experimental data on HSS S690 QL and its welds considering either the effect of HFMI post weld treatment or LTT welds; To develop, identify and validate a fatigue model of the HSS welded connections able to generate their fatigue life in a detailed manner considering the multiaxial local stress state; To develop and validate S-N curves for HSS welded connections after HFMI post weld treatment or LTT welds considering size effects; To apply the model for details of bridge design C; To apply the model for interesting details for HSS welded bridge design to provide information for general guidelines.

WP3 Buckling of Multiaxially Stressed Plates: Experimental analysis of multiaxially loaded slender steel plates subjected to buckling; Analysis of design approach according to EN 1993-1-5 on multiaxially stressed plates and comparison with test results and a numerical parametric study; Clarification of discrepancy with existing rules and development of enhanced design rules for EN 1993-1-5; Interactions with GRID about Design C based on enhanced design rules for EN 1993-1-5.

WP4 Samples Generation and Post Weld Treatment Qualification: To optimize welding procedures for small and large scale specimens; To weld small and large scale specimens for fatigue testing; To make weld simulations and specimens of bead on plate samples for characterization of the weld and the heat affected zone as an input for finite element calculation; To develop and validate the post weld treatment qualification (high frequency impact treatment) and apply it on samples.

WP5 Impact of bridge design: The main aim of this WP is to provide an appropriate methodology for the lifetime assessment of HSS bridges, from bridge construction to the end-of-life stage, taking into account structural, environmental and cost criteria. Divided in 4 steps this WP will perform researches for all the missing data related to HSS bridges then will cover systematically the difference between Design A, B and C of the studied bridge cases.

- WP 5.1 – Life cycle performance of HSS bridges:
  To estimate the life cycle performance of HSS bridges by the definition of a deterioration curve for bridge structural performance, focussing on the fatigue behaviour;
  To established an appropriate general maintenance plan for HSS bridges, in order to keep the bridge above the required condition over its life cycle.
- WP 5.2 – Life cycle environmental analysis of HSS bridges To establish the system boundaries for the life cycle analysis of HSS bridges; To collect appropriate data for the environmental analysis; To select the relevant environmental impact categories for life cycle assessment; To identify the most critical processes over the life cycle of bridges and to propose strategies for further life cycle improvement.
- WP 5.3 – Life cycle cost analysis of HSS bridges To collect appropriate data for the life cycle cost analysis; To develop a mathematical model to account for bridge deterioration and costs; To identify the most critical processes over the life cycle of bridges and to propose for improvements.
- WP 5.4 – Application to case studies To apply the developed life cycle approach to the bridges analysed in WP1 To highlight the advantages by the use of HSS in the lifetime performance of bridges.

Promotion of HSS; Publication of the main results of the project in scientific journals and conferences; Implementation of a webpage for public consultation. Organization of a European Seminar to promote the outcome of the project.
This Work Package 6 deals with the dissemination activities. The results of the research programme will be presented and discussed in important organizations and/or forums for the steel sector (e.g. European Convention for Constructional Steelwork (ECCS) and European Steel Technology Platform (ESTEP), in which the partners of the project are actively involved.

Publications:
Papers
Dissertations
Reports
Conference proceedings

- Optibri Workshop, 3 May, 2017, UStutt, Stuttgart, Germany; Design Guidelines for Optimal Use of HSS in Bridges
- C. Bouffioux, C. Canales, L. Duchêne, J.P. Ponthot and A.M. Habraken, "Fatigue crack propagation in HSS S690QL welded connections in bridges", 14th International Conference on Fracture (ICF 14), 18-23 June, 2017, Rhodes, Greece.
- Distribution of the Optibri workshop documents to the participants of the German seminar on steel structures "Stahlbaukalendertag 2017", 23 June 2017, Stuttgart, Germany, organized by USTUTT.
- José Oliveira Pedro; António Reis; Cláudio Baptista, "High Strength Steel (HSS) S690 in roadway bridges decks – Comparative study", Eurosteel 2017, The 8th European Conference on Steel and Composite Structures, 13-15 September 2017, Copenhagen, Denmark.
- Antonio Zizza, Vahid Pourostad, Ulrike Kuhlmann, "Investigations on the Buckling Behaviour of Slender Plates under Multiaxial Stress", Eurosteel 2017, The 8th European Conference on Steel and Composite Structures, 13-15 September 2017, Copenhagen, Denmark.
- Constança Rigueiro, Helena Gervásio, Jorge Teixeira, Luis Simões da Silva, Carlos Rebelo, José Oliveira Pedro, "Avaliação de Ciclo de Vida de Pontes Mistas Rodoviárias em Aço de Alta Resistência", XI CMM 2017, 23-24 November 2017, Coimbra, Portugal. https://www.cmm.pt/event/event/home/index.php?target=home&event=16&defLang=1)
- José Oliveira Pedro, Carlos Vieira, Cláudio Baptista, António Reis, Francisco Virtuoso, "Dimensionamento de Tabuleiros Rodoviários Mistos Aço-Betão utilizando o Aço de Alta Resistência S690 QL", XI CMM 2017, 23-24 November 2017, Coimbra, Portugal. https://www.cmm.pt/event/event/home/index.php?target=home&event=16&defLang=1)
- Helena Gervásio, Constança Rigueiro, Luis Simões da Silva, Carlos Rebelo, José Oliveira Pedro, "Life cycle performance of HSS bridges", IALCCE 2018 - The Sixth International Symposium on Life-Cycle Civil Engineering, 28-31 October 2018, Ghent, Belgium, http://www.ialcce2018.org/#/home.

Contacts:

Luís Simões da Silva
Tel.: +351 239 797 216 | Fax: +351 239 797 123
Email: luisss@dec.uc.pt | URL: http://www.isise.net

Optimization of forest resources in construction | OptimizedWood

Financing Institution(s): Pedrosa e Irmãos (P&I)
Promoting Institution(s): University of Coimbra (UC), Centro de Inovação e Competências da Floresta (SerQ), Polytechnic of Leiria (IPLeiria)
Coordinator(s): Alfredo Manuel Pereira Geraldes Dias (UC)

Researchers and collaborators: Nelson Manuel Gomes Pedrosa (P&I), Telmo Filipe Marques Morgado (P&I), Joel da Silva Ferreiro (P&I), Paulo Coelho (P&I), João Henrique Jorge de Oliveira Negrão (UC), Ricardo Joel Teixeira Costa (UC), Luís Manuel Cortesão Godinho (UC), Paulo Jorge Rodrigues Amado Mendes (UC), Diogo Manuel Rosa Mateus (UC), Helena Maria dos Santos Gervásio (UC), Luís Filipe Vieira Cordeiro (UC), Rafael Caldeirinha (IPLeiria), Judite Vieira (IPLeiria), Sílvia Monteiro (IPLeiria), Sandra Raquel Sousa Monteiro (SerQ), André Filipe da Silva Marques (SerQ)

Partner Institutions: BASF (Iberian) e Tisem (PT)

Period: May 2017 to December 2019
Relevant facilities: Computational and laboratory equipment of: Pedrosa e Irmãos, University of Coimbra (UC), Centro de Inovação e Competências da Floresta (SerQ) and Polytechnic of Leiria (IPLeiria)

Objectives:
The main objective of this project is to develop and validate a wood-based product for structural application with many innovative features. The product to develop will be innovative in various perspectives, such as: optimization of structural and non-structural performance of the own panel, possibility of improvement of electromagnetic shielding, more rational use of raw materials and increased value of national species of wood. The research will also include the development of connection technology between the panels themselves but also the compatibility of these with the existing building.
The reach of the objectives necessarily presupposes the use of a set of complementary methodologies related to each other such as document analysis, numerical simulation, experimental analysis and industrial production. This research proposal is based on a multidisciplinary team that has strong recognized skills in the critical areas of the project, namely: the mechanical performance of wood products and respective buildings, thermal performance, acoustic performance, electromagnetic shielding, wood product sustainability analysis and respective buildings, design and execution of solid wood structures and selection/classification and wood processing.

Description and Methodology:
The main objective of this Project is to develop a new kind of structural wood panel based on the CLT and SIP concepts (Fig. 1). The reason for this new proposal is the increasing popularity and use of CLT in structures and the desire to improve some aspects of this product. This recent wood system has many advantages in respect to traditional wood light-frame construction, namely the higher dimensional stability, strength and stiffness capacities, and furthermore the easier connections possibilities, the better thermal and acoustic insulation, improved fire behavior, among others. In this project is developed a set of innovative knowledge that produce a new system in conformity with the defined requirements in European standards. There are two essential aspects to develop this project: the capabilities and competences of the partners and the methodologies adopted. To accomplish the goals, the methodology was divided in 6 different Project Stages (PS).

PS1 Definition of materials and adhesion systems between materials
The main objectives of this stage are the identification and definition of materials (wood species, insulation materials and types of glues) and bonding techniques that can be used in the production of panels. This stage is subdivided in four tasks: definition and characterization of materials; assessment of the integrity of wood/wood adhesions; assessment of the integrity of wood/insulation adhesions; and implementation of the "gluing technical guide". The basic design of the panels to be developed consist in a set of five elementary layers (a central one in insulating material and four in wood (two on each side of the insulation material and arranged orthogonally to each other)). The evaluation of the wood/wood glue lines will follow the guidelines established in EN 16351 dedicated to the CLT and will contemplate delamination tests (Annex C of EN 16351) and shear tests (Annex D of EN 16351). The shear strength wood/insulation is evaluated following the guidelines of ASTM C273 and/or ASTM C393, and the flatwise tensile strength is evaluated according to ASTM C297.
The information of this stage is compiled in a document (gluing technical guide) reporting the materials and the gluing processes used, which will serve as a support to the PS2.

PS2 Optimization of panel configuration and industrial production
The main objectives of this stage are related to the definition of the configuration of the panels, their optimization, production and life cycle analysis. As the panel is intended to be suitable for the construction of an entire building, four specific solutions are developed:

interior wall, external wall, interior floor and exterior floor (roof). The results and guidelines defined in PS1 allow that in this stage the principal objective be the production of panels with his optimized settings. From the various typologies under analysis, a specific one (e.g., T2) is chosen. Considering this typology and the corresponding optimized configuration for each of the four panel types (e.g., interior floor), panels in prototype version is produced. Thus, for each of the four panel types, a specific configuration is evaluated.

PS3 Characterization and experimental validation of panels
This task is dedicated to the experimental evaluation of the thermal and acoustic insulation properties of the panels produced in PS2, and the comparison of the experimental and numerical results. The thermal insulation is evaluated for each of the four panel types by the "hot box" method according to ISO 12567-1. Acoustic tests shall include the evaluation of airborne sound insulation according to ISO 10140-2 (for all four panel solutions) and insulation to percussion sounds (panels with internal floor function) according to the standard ISO 10140-3. The mechanical performance of panels is too evaluated experimentally. The relevant parameters related to stiffness and strength of the panels are evaluated when loads are applied in the plane or perpendicular to the plane and according to normative procedures and, if applicable, with others that are considered relevant to the bibliographic review.

PS4 Optimization of configuration for electromagnetic barrier
This stage aims to develop and apply new techniques of electromagnetic shielding in vegetal carbon applied to the panels. In this develop are included the optimization of the production of one or several layers of panels in an industrial environment and evaluation of their effectiveness in the electromagnetic shielding factor. Firstly, the constructive requirements in terms of electromagnetic shielding for target case studies are identified (based on bibliographic and documentary analysis). The next task is the study of a new technique of adequate wood processing by carbonization to obtain electromagnetic barriers of a reduced industrial processing. Then the electromagnetic shielding technique studied using processed wood (i.e. carbon), applicable to one or two additional external layers in the panels, is implemented. Finally, electromagnetic shielding tests are carried out on all panel structures produced in a final prototype version incorporating electromagnetic barriers, in the terms defined by ASTM D4935-10, and the critical aspects in its production are identified.

PS5 Connection systems and structure prototype
The main objectives of this stage are the development of components and techniques of connection between the various panels, between them and pre-existing structures and the construction of a prototype using the developed panel solutions. This stage assembles all anterior phases and model the final product. Firstly, are defined the requirements relative to connectors between different kind of panels and others constructive elements. When defined the requirements, the connection systems are developed based on CLT and SIP systems. Then are realized the methodology present in EN 26891 and EN 12512 standards. The compatibility of the panels with other infrastructures is evaluated, as well as their use with other functions such as technical installations. It is also evaluated its capacity of rectification or personalization in the site of the work and the possibility and facility of substitution in future situations of repair / adaptation.
With the information obtained from previous phases, a real prototype is built. Due to limitations of resources and equipment, this pilot structure is quite simple and based only on construction and production conditions available in the SerQ lab. It should be possible to assess the main technical difficulties inherent in the implementation of the prototype and allow the definition of good practices for the execution of structures using the developed system. After being built, the prototype is evaluated according to ISO 140-4 and ISO 140-5 standards for evaluation of airborne sound insulation rates and ISO 140-7 for evaluation of insulation rates to percussion sounds. Thermal monitoring tests are also conducted to the prototype. The prototype is evaluated mechanically, being subjected to static and dynamic loads, horizontal and at the level of the pavements at the top.
The knowledge acquired in the last tasks is used to give a global view on the difficulties inherent in the constructive process and to evaluate the growth potential of the solution.

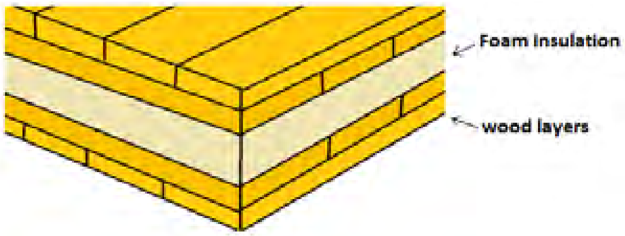


Fig. 1 Conceptual scheme of the panel to be developed

PS6 Project management and publication of results
During all the project is required a permanent coordination and management of the project as well as the technical and scientific divulgation of the products developed in the academic/scientific and professional environment. With the development of the project the deviations are constantly analyzed and the communication and coordination between the different promoters involved in the project are guaranteed. During this phase is made the conception, implementation, and management of a Website. The objective of Website is share and report the results obtained.

Contacts:
Alfredo Dias
Tel.: +351 239 797 233
Fax: +351 239 797 123
Email: Email: alfgdias@dec.uc.pt

Optimization of Steel Plated Bridges in Shape and Strength | OUTBURST

Financing Institution(s): EC-RFCS
Promoting Institution(s): University of Coimbra, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)
Coordinator(s): Luís Simões da Silva (ISISE-UC)

Researchers and collaborators: Luís Simões da Silva (ISISE-UC); João Pedro Martins (ISISE-UC); Helena Gervásio (ISISE-UC); Filip Ljubinkovic (ISISE-UC); Tiago Manco (ISISE-UC). Coordinators from partner institutions: Primoz Moze (UL); Ulrike Kuhlmann (UStutt); António Reis (GRID); Chris Hendy (ATKINS); Guenther Dorrer (MCE); Martin Pircher (ABES)

Partner Institutions: University of Ljubljana (UL) (Slovenia), University of Stuttgart (UStutt) (Germany); GRID Consulting Engineers (GRID) (Portugal); Atkins Consultants Limited (ATKINS) (UK); MCE-HG GmbH (MCE) (Austria), ABES Pircher & Partner GmbH (Austria)

Period: July 2013 to June 2016

Relevant facilities: Computational and laboratory equipment of Civil department of FCTUC; Computational and laboratory equipment of other partner institutions.

Objectives:
Curved and nonrectangular steel panels are increasingly used in the design of new bridges due to architectural and/or structural demands. This is a recent trend which has resulted from technological advances that allow the economical use of curved shapes. However, design rules and design recommendations for curved and nonrectangular plated members are still scarce and fundamental knowledge needs to be developed at various levels. The behaviour of curved and nonrectangular steel panels for the application in bridges depends on their stability behaviour and the influence of the material constitutive law. Given that the usual design approach for steel members is to derive their ultimate (design) resistance based on the elastic stability behaviour, a great deal of effort needs to be dedicated to the assessment of the buckling and post buckling behaviour of curved and nonrectangular steel panels. The main objective of this research project is to develop solid knowledge on the structural behaviour of curved and nonrectangular steel panels for optimised applications in steel and composite bridges, allowing the extended use of steel in bold and appealing architectural designs. The Structural Eurocodes do not cover the design of curved panel segments. In fact, the scope of EN 1993-1-5 is limited to flat and rectangular panels. The following objectives will be targeted:

- To extend the EN 1993-1-5 design methodology for compression, bending, shear, torsion and possible combinations of these load cases by explicitly introducing transversal or longitudinally curvature;
- To establish relevant interactions (dual flange/web role of curved cross-sections);
- To develop design rules for transverse stiffeners taking account of a possible dual flange/web role in curved panels;
- To optimize the number, shape and distribution of longitudinally stiffened panels;
- To extend plate buckling rules to plates with variable width, which are not yet covered in EN 1993-1-5, though they exist in bridges with curved shapes;
- Additionally, in view of sustainability, a life cycle approach for the sustainability assessment of curved bridges, taking into account environmental, economic and social criteria will be developed. The purpose of this approach is to enable the identification and promotion of the main characteristics of curved bridges that positively differentiate this kind of solutions in relation to standard bridges.
- Parallel to the development of new design guidance and rules it is also within the objectives of this proposal to develop software to assist designers in assessing elastic critical stresses of curved and nonrectangular panels that are needed in the design procedure.

Description and Methodology:
The two main research methods that will be used in the project are experimental and advanced numerical methods, accompanied with some analytical investigations and statistical and reliability analysis of accumulated data. The work will be distributed in 11 Work Packages (WP):

WP1 Coordination

WP2 Conceptual design review: This aims at identifying possible cross-section forms, structural systems, parameter range, fabrication issues and optimization criteria for the 3 types of curved bridges (with transversally curved panels; with longitudinally curved webs; with horizontally curved panels); identifying and promote the most relevant characteristics of curved bridges that positively differentiate this kind of solutions in relation to standard bridges.

WP3 Life cycle assessment of curved steel plated bridges: In view of sustainability, a bridge assessment should take into account different perspectives (or criteria) over its life cycle, from construction to end-of-life. This WP aims for the development of a life cycle approach for the sustainability assessment of curved bridges, taking into account environmental, economic and social criteria. The proposed life cycle analysis (LCA) will be made according to the international framework for LCA provided by ISO standards 14040:2006 and 14044:2006 and to the recently developed standards for the assessment of construction works provided by CEN/TC350. The purpose of the life cycle approach is to enable the identification and promotion of the main characteristics of curved bridges that positively differentiate this kind of solutions in relation to standard bridges.

WP4 Experimental evaluation on girders with non-rectangular panels: The design of plated structures is done by EN 1993-1-5, which provides different methods like the "effective width method", the "reduced stress method" and "Finite Element Methods of analysis". New tendencies for the bridge design lead to nonrectangular or haunched cross-sections, while design codes presume for an application of the effective width method only for rectangular panels with parallel flanges. The current design rules may be applied also for α up to 10°, but for larger angles the panel has to be checked with the higher width. This of course leads to very conservative results. This shows the need for enhanced code rules regarding nonrectangular panels for an adequate design.

WP5 Numerical simulations on girders with nonrectan-gular panels: The experimental test results will be used to validate the numerical model, which will be adopted for a subsequent parametric study in WP 4. The validation will be performed using the measured initial imperfections and material data. To validate the numerical model, the maximum resistance, the global response (load-displacement curve), initial stiffness and out-of-plane deformations will be compared.

WP6 Numerical simulations on girders with horizontally curved panels: The purpose of this WP is do develop design specifications for horizontally curved panels with the curvature radius r < a^2/t.

WP7 Experimental evaluation of curved panels: I this task, 8 test specimens will be tested in compression, composed of stiffened panels with one or two longitudinal and one or two transverse stiffeners. Additionally, two prototype bridge segments will be tested as three-point bending tests simulating the bridge behaviour near the internal support.

WP8 Numerical investigation on curved panels: The first task is to develop numerical models able to reproduce experimental results from WP7 (modelled and analysed with ABAQUS software), allowing further development in numerical parametric study and in numerical simulations on bridge sections.

WP9 Optimum design of stiffeners: The numerical model will be developed and thoroughly validated against experimental test results (WP7). The ABAQUS software tool will be used for this purpose. Geometrical and material nonlinear analysis along with measured initial imperfections and realistic boundary conditions will be used. The validated numerical model is going to be used for further parametric study in order to extend results for the whole pool of varied parameters.

WP10 Elastic buckling assessment of curved and non-rectangular panels: The aim of this WP is to develop a software tool which allows computing elastic critical buckling stresses of stiffened or unstiffened curved panels, in the presence of various support conditions and "in panel" loading systems.

WP11 Integrated behaviour of steel bridge sections and development of overall design

WP12 Preparation of design guidelines for steel bridg-es, case studies and dissemination of results

Publications:

Conference proceedings

Filip Ljubinkovic, João Pedro Martins, Helena Gervásio, Luís Simões da Silva (2017)" Cylindrically Curved Steel Panels in Bridge Design Buckling and Post-Buckling Behaviour under Shear Stresses" in (eds.), Eurosteel 2017 – 8th European Conference on Steel and Composite Structures, Copenhagen, Denmark, 8-10 September 2017, (2017).

Contacts:

Luis Simões da Silva
Tel.: +351 239 797 216
Fax: +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

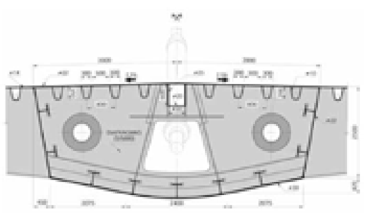


Fig. 1 Serreria Bridge - Steel box section (WP2)

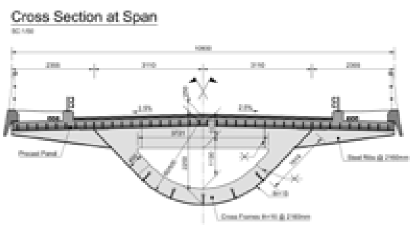


Fig. 2 Case Study 1 (WP3)

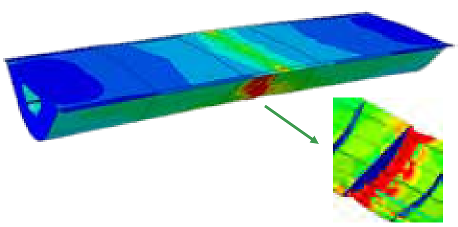


Fig. 3 Preliminary numerical model of the bridge prototype to be tested (WP7)

Systems with PCM-filled rectangular cavities for the storage of solar thermal energy for buildings | PCMs4Buildings

Financing Institution(s): FEDER funds through COMPETE 2020 - POCI and FCT: refs. POCI-01-0145-FEDER-016750 | PTDC/EMS-ENE/6079/2014.
Promoting Institution(s): Association for the Development of Industrial Aerodynamics (ADAI)
Coordinator(s): José Joaquim da Costa (ADAI-LAETA, UC)

Researchers and collaborators: Paulo Santos (ISISE-UC); Nelson Soares (ADAI-LAETA, ISISE-UC); Margarida Gonçalves (ADAI-LAETA, ISISE-UC); José Joaquim da Costa (ADAI-LAETA, UC); Adélio Manuel Rodrigues Gaspar (ADAI-LAETA, UC); António Manuel Gameiro Lopes (ADAI-LAETA, UC); Pedro Nuno Neves Lopes Simões (CIEPQPF-UC); Luísa Maria Rocha Durães (CIEPQPF-UC); Telma Matias (CIEPQPF-UC)

Partner Institutions: Association for the Development of Industrial Aerodynamics (ADAI) (Portugal); University of Coimbra (UC) (Portugal)

Period: June 2016 to May 2019

Relevant facilities: Guarded Hot Box apparatus - Civil Engineering Department of FCTUC; Computational and laboratory equipment of other partner institutions and/or research units.

Objectives:
The main goal of this project is to develop a combined experimental/CFD methodology for the parametric analysis of the thermal behaviour of new TES systems with rectangular cavities filled with different kinds of PCMs: free-form and microencapsulated PCMs. These TES systems are intended to be used to improve the energy performance of buildings by reducing the energy demand for heating and cooling, and by taking advantage of solar thermal energy. The problems to be studied lie in the mainstream area of the: () characterization of the heat transfer through rectangular cavities filled with PCMs; () characterization of the main thermophysical properties of PCMs; () CFD simulations considering solid-liquid phase-change processes; () experimental evaluation of the overall transient heat transfer through both small- and full-scale, non-homogeneous TES building structures. The particular goals are: () to evaluate alternative methods for the thermophysical characterization of PCMs; () to develop a CFD methodology for the detailed parametric analysis of the thermal behaviour of TES systems with rectangular cavities filled with different kinds of PCMs; () to develop an experimental methodology to provide a large set of benchmarking results for numerical validation purposes and for the assessment of the thermal performance of some prototypes; () to define full-scale prototypes to be numerically and experimentally optimized and to be used in the design of new TES systems for buildings.

Description and Methodology:
PCMs4Buildings is a challenging project involving researchers from different scientific backgrounds, namely civil, mechanical and chemical engineering and two institutions, the Association for the Development of Industrial Aerodynamics (ADAI) and the University of Coimbra (UC). It also involves three research units, the Associate Laboratory of Energy, Transports and Aeronautics (LAETA), the Institute for Sustainability and Innovation in Structural Engineering (ISISE) and the Chemical Process Engineering and Forest Products Research Centre (CIEPQPF).

The research plan is composed by 6 main tasks:
1. thermophysical characterization of PCMs;
2. numerical modelling and CFD evaluation;
3. tests in the small-scale experimental setup;
4. tests in the Guarded Hot Box Apparatus;
5. definition of full-scale prototypes;
6. technical seminar and workshop.

TASK 1 refers to the evaluation of alternative methods for the thermophysical characterization of PCMs. TASK 2 involves the numerical modelling of the heat transfer with solid-liquid phase change and the development of a CFD methodology for a detailed parametric analysis of the thermal behaviour of TES systems. TASK 3 involves developing an experimental methodology to provide benchmarking data for numerical validation purposes considering an existing setup designed to measure the transient heat transfer with phase-change through small-scale TES units. TASK 4 involves adapting the existing Guarded Hot Box Apparatus to evaluate the thermal performance of full-scale prototypes in a transient mode and to provide experimental data for validating more complex CFD models. TASK 5 involves the design of full-scale prototypes to be numerically and experimentally optimized. TASK 6 involves organizing a technical seminar and a final workshop to disclose the achieved results.

Publications:

Papers
Soares, N., Santos, P., Gervásio, H., Costa, J.J., Simões da Silva, L. "Energy efficiency and thermal performance of lightweight steel-framed (LSF) construction: A review", Renewable and Sustainable Energy Reviews 78 (2017) 194-209.

DOI:10.1016/j.rser.2017.04.066.
URL: http://hdl.handle.net/10316/42016

Soares, N., Reinhart, C.F., Hajiah, A. "Simulation-based analysis of the use of PCM-wallboards to reduce cooling energy demand and peak-loads in low-rise residential heavyweight buildings in Kuwait", Building Simulation 10(4) (2017) 481-495.
DOI:10.1007/s12273-017-0347-2.
URL: http://hdl.handle.net/10316/42004

Soares, N., Bastos, J., Pereira, L.D., Soares, A., Amaral, A.R., Asadi, E., Rodrigues, E., Lamas, F.B., Monteiro, H., Lopes, M.A.R., Gaspar, A.R. "A review on current advances in the energy and environmental performance of buildings towards a more sustainable built environment", Renewable and Sustainable Energy Reviews 77 (2017) 845-860.
DOI: 10.1016/j.rser.2017.04.027.
URL: http://hdl.handle.net/10316/42014

Dissertations

Rodrigues, R., Estudo numérico de um sistema com PCMs microencapsulados para o revestimento de fachadas verticais exteriores, Master Thesis in Mechanical Engineering, University of Coimbra, Portugal, September 2016.
URL: http://hdl.handle.net/10316/36731

Antunes, P., Estudo numérico de unidades de armazenamento de energia térmica com materiais de mudança de fase para a termorregulação de painéis fotovoltaicos, Master Thesis in Mechanical Engineering, University of Coimbra, Portugal, September 2016.
URL: http://hdl.handle.net/10316/36988

Conference proceedings

Soares, N., Antunes, P., Costa, J.J., "Effective heat capacity method to simulate heat difusion problems with phase change", Energy for Sustainability International Conference 2017 - Designing Cities & Communities for the Future, Funchal, Portugal, 8-10 February 2017.
URL: http://hdl.handle.net/10316/42003

Soares, N., Antunes, P., Gaspar, A.R., Costa, J.J., "Thermal management of photovoltaics with thermal energy storage units filled with microencapsulated PCMs", Energy for Sustainability International Conference 2017 - Designing Cities & Communities for the Future, Funchal, Portugal, 8-10 February 2017.
URL: http://hdl.handle.net/10316/42002

Soares, N., Gaspar, A.R., Santos, P., Lopes, A.G., Durães, L., Simões, P.N., Costa, J.J., "Kick-off presentation of the project "PCMs4Buildings" - Systems with PCM-filled rectangular cavities for the storage of solar thermal energy for buildings", CINCOS'S 16 International Congress of Innovation on Sustainable Construction - NEW CHALLENGES FOR THE HABITAT VALUE CHAIN, Lisbon, Portugal, 3-4 November 2016, pp. 235-247.
URL: http://hdl.handle.net/10316/42000

Soares, N., Gaspar, A.R., Santos, P., Costa, J.J., "Small thermal energy storage units filled with microencapsulated PCMs for building applications", CINCOS'S 16 International Congress of Innovation on Sustainable Construction - NEW CHALLENGES FOR THE HABITAT VALUE CHAIN, Lisbon, Portugal, 3-4 November 2016, pp. 225-234.
URL: http://hdl.handle.net/10316/42009

Soares, N., Gaspar, A.R., Santos, P., Reinhart, C.F., Costa, J.J., "Thermal energy storage with phase change materials (PCMs) for the improvement of the energy performance of buildings", Poster in: 2016 MIT Portugal annual conference: 10 years engineering a better future, University of Minho, Campus of Gualtar, Braga, Portugal, 30 June 2016.
URL: http://hdl.handle.net/10316/42010

Contacts:

José Joaquim da Costa
Tel.: +351 239 790 732
Fax: +351 239 790 701
Email: jose.costa@dem.uc.pt
URL: http://www.adai.pt/pcms4buildings

Performance of reinforced concrete structures strengthened in flexural with an innovative system using prestressed NSM CFRP laminates | PRELAMI

Financing Institution(s): FCT
Promoting Institution(s): University of Minho (UM)
Coordinator(s): Salvador Dias
Researchers and collaborators: Joaquim Barros, José Sena-Cruz, Vincenzo Bianco, Gláucia Dalfré, Inês Costa, Mohammad Ali Rezazadeh, Mohammad Reza Hosseini
Partner Institutions: University of Minho (UM), Clever Reinforcement iberica - Materiais de Construção Lda (S&P)
Period: April 2011 to September 2014
Relevant facilities: Servo close-loop equipments for experimental programs; FEMIX V4.0 Finite Element package

Objectives:
In the present research project it is assessed the performance of Reinforced Concrete (RC) structures (beams and slabs) strengthened in flexure using an innovative system with Carbon Fibre Reinforced Polymer (CFRP) laminates. This system is based on the application of CFRP laminates with a certain prestress into thin slits open on the concrete cover of the structural elements to strengthen. The present project intends to develop a strengthening system, economically and technically viable, that assures the optimal use of durable and high strength materials (CFRP) in order to significantly improve the overall performance of the strengthened RC structures.

Description:

Existing studies confirm that among the strengthening techniques with passive CFRP materials, Near Surface Mounted (NSM), based on the installation of CFRP laminates into thin slits opened on the concrete cover of the elements to be strengthened, is the most effective. However, adopting a better use of the high performance of the CFRP, it is still possible to innovate the NSM technique in order to improve the performance of strengthened RC structures. Exploratory numerical and experimental work carried out by the research group that is part of this project concluded that between the phase of the concrete crack initiation and yielding of the steel longitudinal reinforcement, the effectiveness of existing NSM technique can be extraordinarily increased if CFRP laminates are applied with a certain prestress level. The prestress applied to the CFRP can also be used to recover part of the deformation of the structure, leading to closure of existing cracks, with consequent benefits in terms of durability and structural integrity. The prestress can also contribute to increase the shear capacity of the RC elements.

In the first part of the project it was created the strengthening system that includes the development of the devices to apply the NSM prestress technique (Figure 1).

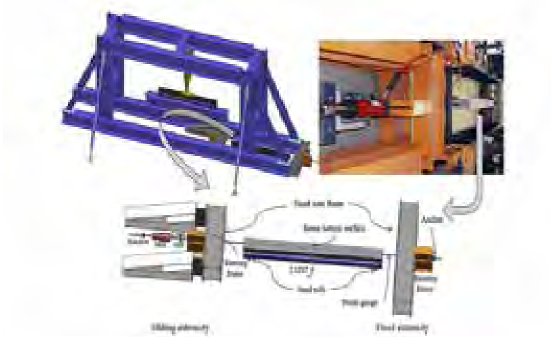


Fig. 1 Prestress system

The loss of prestress in the CFRP is too dependent on the creep behaviour of the adhesive due to the mechanism formed of micro struts and ties in the stress transference between laminate and surrounding concrete through the adhesive. Therefore a special attention was given in the creep behaviour of the adhesives (Figure 2).

Fig. 2 Creep table

The assessment of the NSM CFRP-adhesive-concrete bond was performed in the early age of the epoxy adhesive in terms of the time optimization in the process of the laminates stress transfer to the surroundings. The prestressing transfer length was defined as well as the evaluation of the prestress losses (Figure 3).

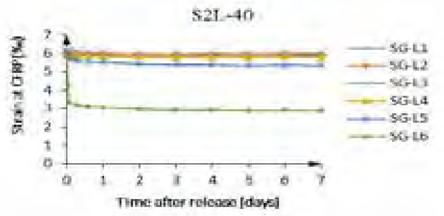


Fig. 3 CFRP strains vs. time after releasing the prestressed load in the S2L-40 slab (40% of prestressed)

The project investigated the experimental behaviour of RC structures (beams and slabs) flexural strengthened with the developed innovative NSM system (Figures 4 and 5). The prestress level, the concrete quality, the percentage of longitudinal steel reinforcement and the level of damage in the structure prior to the strengthening are parameters that were assessed. Due to the susceptibility of the long-term behaviour of adhesives and the concrete-adhesive and adhesive-laminate interfaces to the fatigue loads, and since the technique to develop is quite appropriated for RC bridge decks, where fatigue is an important load case, flexural fatigue tests were be carried out in order to evaluate the influence of the cyclic load, the amplitude and the average load applied to the RC elements, in terms of the effectiveness of the technique.

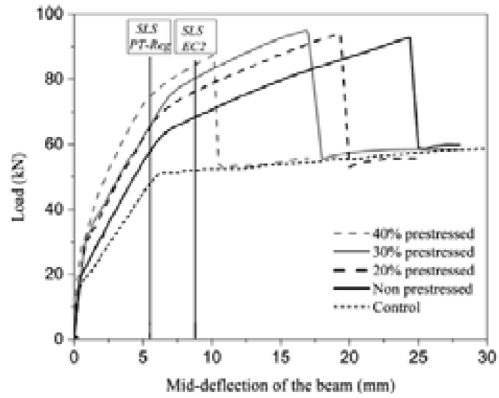
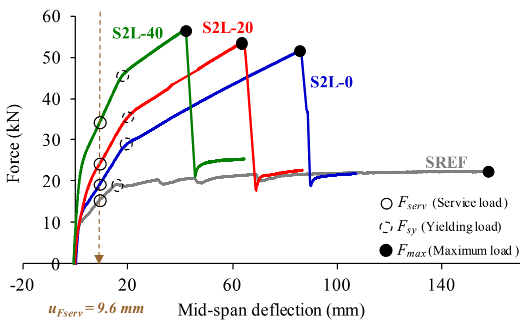


Fig. 4 Force mid-span deflection of RC beams (Control beam without CFRP; beams with NSM CFRP laminate with different level of prestress: 0%, 20%, 30% and 40%)

(a)



(b)

Fig. 5 (a) Four point bending test in RC slabs, and (b) Force mid-span deflection of RC slabs (Reference slab without CFRP (SREF); slabs with NSM CFRP laminates with different level of prestress: 0% (S2L-0), 20% (S2L-20) and 40% (S2L-40))

Based on the experimental results obtained in the project and the results of numerical studies, application of rules and design of the strengthening system with prestressed NSM CFRP laminates were done.

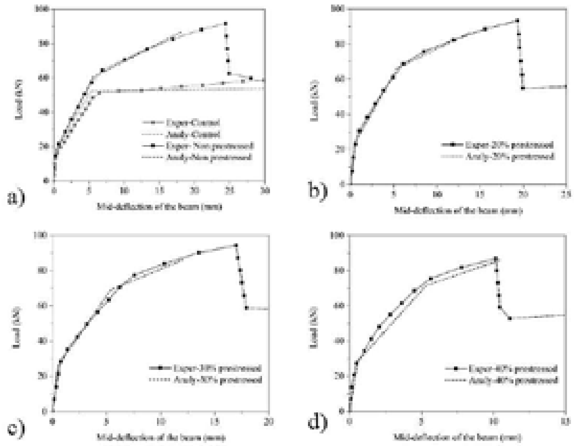


Fig. 6 Analytical prediction of tested beams: (a) control and non-prestressed, (b) 20% prestressed, (c) 30% prestressed, and (d) 40% prestressed

Experimental and numerical research were also done in the Prelami project for the evaluation of the performance of a NSM hybrid flexural strengthening technique that combines non-prestressed and prestressed CFRP laminates in the same application (Figure 7) in order to provide a good balance in terms of load carrying and ultimate displacement capacity to the strengthened elements.

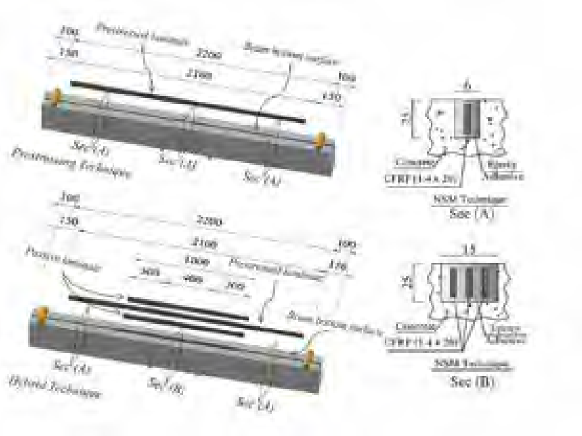


Fig. 7 CFRP reinforcement details of hybrid and prestressing NSM techniques (dimensions in mm)

Publications:

Books: 1
International journals (ISI): 12
International conference: 7
National journal: 1
National conference: 4
Reports: 3
PhD Theses: 3

Contacts:

Salvador Dias
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: sdias@civil.uminho.pt
URL: http://www.isise.net

Pre-fabricated thin panels using advanced materials for structural rehabilitation | PREPAM

Financing Institution(s): Financed by the FCT
Promoting Institution(s): University of Minho (UM)
Coordinator(s): Joaquim A. O. Barros

Researchers and collaborators: Joaquim A.O. Barros; Eduardo N.B. Pereira, J.M. Sena-Cruz, M. Isabel B. Valente, Miguel A.D. Azenha, Salvador J.E. Dias, Vitor M.C.F. Cunha, Lúcio A.P. Lourenço, Hadi Baghi, Rajendra K. Varma, Esmaeel Esmaeeli

Partner Institutions: University of Minho; Institute for Sustainability and Innovation in Structural Engineering (ISISE)
Period: 01 March 2011 to 28 February 2014

Relevant facilities: Servo close-loop equipment's for experimental programs; FEMIX V4.0 Finite Element package; Laboratory equipment and facilities of Civil Department of UMinho.

Objectives:
This project aims to: i) develop a high effective and cost competitive strengthening technique that can increase effectively the flexural and the shear strengthening of reinforced concrete (RC) frames, as well as the energy dissipation capacity of this type of structural elements; ii) develop guidelines for the design and execution of this technique; iii) formation of two young scientists, one dedicated to the use of strain hardening cement composites reinforced with fiber reinforced polymer (FRP) systems, herein designated by hybrid composite plates (HCP), for the shear strengthening of RC beams, and the other for the flexural strengthening of RC beams and energy absorption capacity of RC frames.

1. The use of HCPs for the shear strengthening of RC beams

Hybride Composite Plate (HCP) is used to increase the shear strength of reinforced concrete (RC) beams. HCP is a thin plate of Strain Hardening Cementitious Composite (SHCC) reinforced with CFRP laminates (Fig. 1). Due to the excellent bond conditions between SHCC and CFRP laminates, these reinforcements provide the necessary tensile strength capacity to the HCP, while the high post-cracking tensile deformability and resistance of SHCC avoids the occurrence of premature fracture failure of this cement composite in the stress transfer process between these two materials when the HCP is crossed by a shear crack.

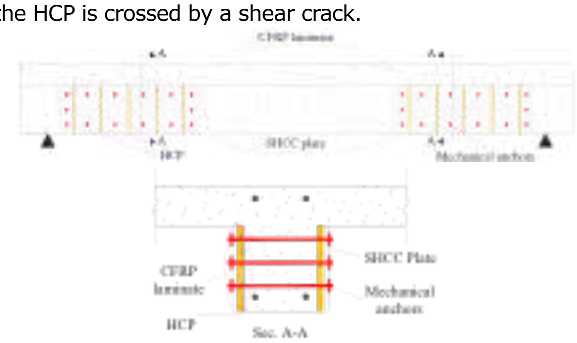


Fig. 1 Schematic representation of Hybrid Composite Plates (HCPs) for shear strengthening of reinforced concrete beams

The behaviour of the RC beams strengthened with HCPs is assessed by three point bending test as shown in Fig. 2. The HCPs are capable of increasing not only the load carrying and deflection capacity, but also the post-peak resisting load, with favorable effects in terms of energy absorption capacity (Fig. 2). The shear strengthening contribution of the HCPs is limited by the tensile strength of the concrete of the strengthened beams. Mechanical anchors prevent a premature debonding of the HCPs and a certain concrete confinement is introduced in the zone of the beam to be strengthened, resulting favorable effects in terms of shear strengthening.

Advanced numerical simulations were carried out for deep understanding of the shear strengthening mechanisms provided by HCP panels. A design-based analytical formulation was developed to predict the shear strengthening contribution of HCP panels.

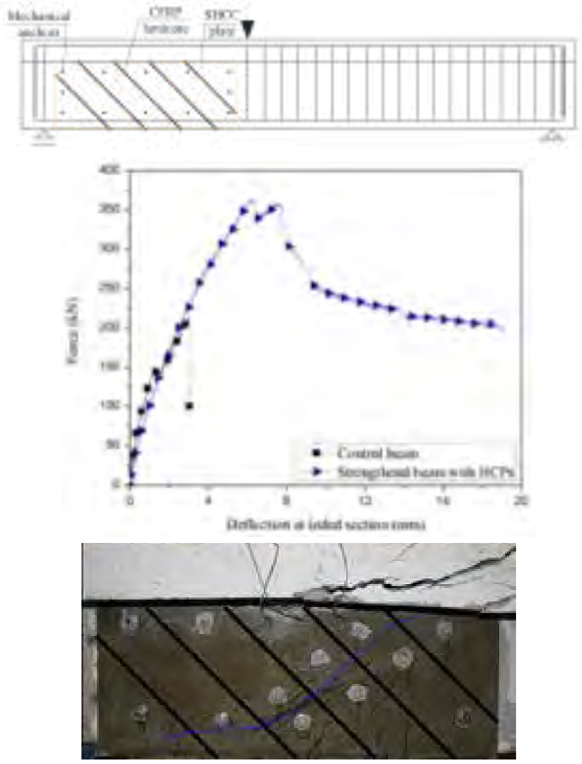


Fig. 2 Experimental test (three point bending, load deflection, and crack patterns)

2. HCPs for the flexural strengthening of RC beams and energy dissipation performance of Beam-Column joints

2.1 Flexural Strengthening of RC beams

The HCP panels were also used for the flexural strengthening of RC beams. The experimental program schematically represented in Fig. 3 was carried out.

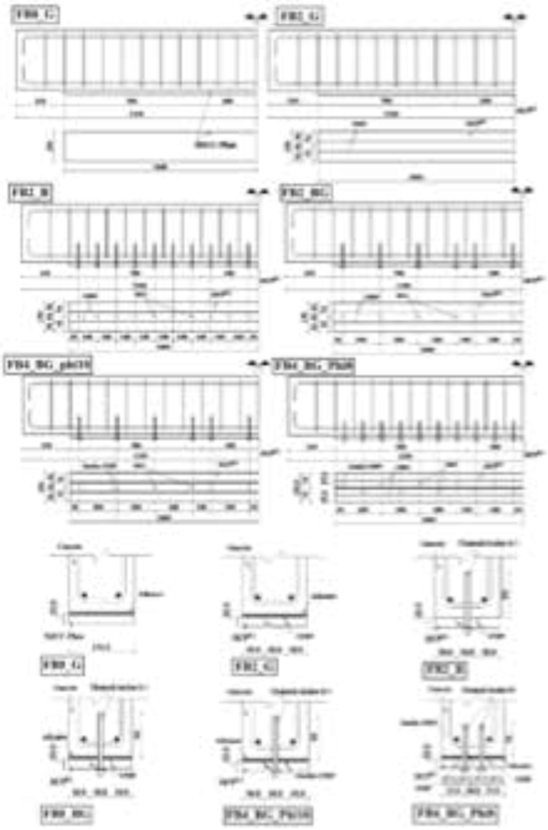


Fig. 3 Experimental program for assessing the flexural strengthening effectiveness of HCP panels for RC beams

From the results was verified:

- In comparison with the results of the reference beam, all of the adopted strengthening schemes resulted in a superior response in terms of load carrying capacity.
- A satisfactory lower bound of 3.6 for deflection ductility at a 153% increase in the ultimate load was preserved.
- Combining epoxy adhesive with chemical anchors for attaching HCP(L) to the beam's soffit was demonstrated to be an effective technique for exploiting strengthening potential of the HCP(L).
- A staggered configuration of the anchors should be adopted for avoiding premature failure of HCP(L).

An analytical model was developed to predict the contribution of the HCP(L) panels for the flexural strengthening of RC beams.

2.2 Energy dissipation performance

The effectiveness of the technique based on using HCP panels for repairing severely damaged interior RC beam-column joints of real scale was assessed experimentally. The technique was explored by using two possible technologies for the production of the HCP panels: cast in place; prefabricated and then fixed to the concrete substrate by using epoxy adhesive and chemical anchors. Fig. 4 demonstrates the effectiveness of this technique in terms of restoring, and even exceeding, the load carrying capacity and energy dissipation performance of virgin prototypes. This technique was also very effective is preserving the secant stiffness (Fig. 4d).

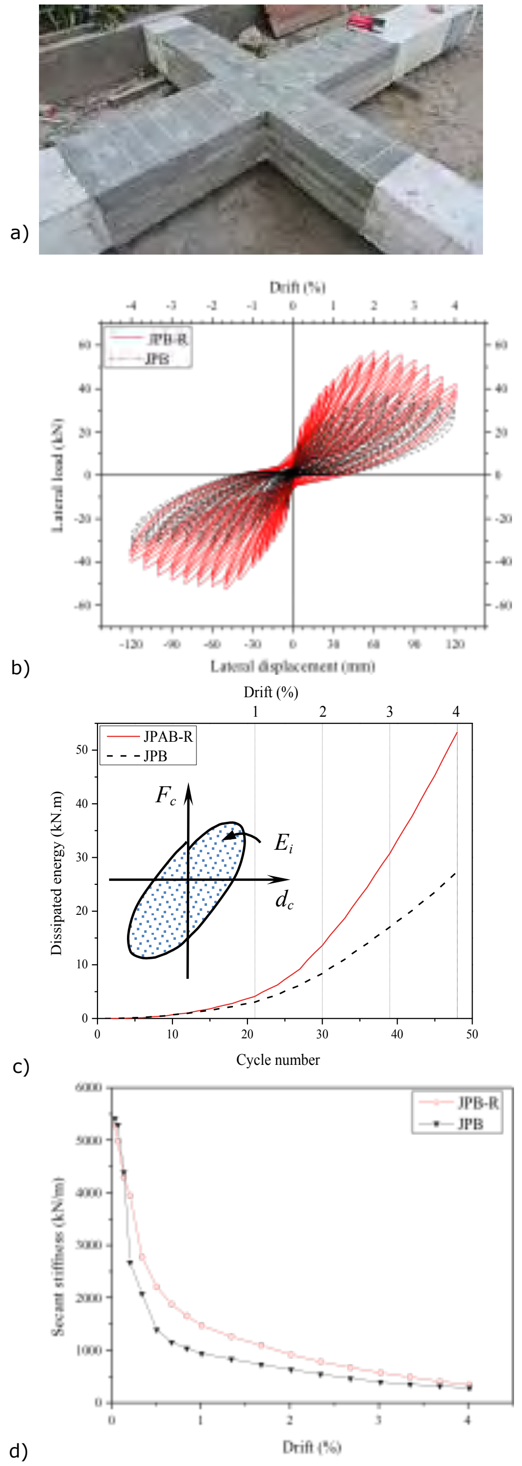


Fig. 4 a) Prototype after repaired; b) Load versus lateral displacement, and c) dissipation energy performance; d) stiffness degradation (JPB: virgin prototype; JPAB-R: repaired prototype)

3. Publications

13 ISI International journals; 5 International Conferences; 1 National Conferences

Contacts:

Joaquim A.O. Barros ; Tel.: +351 253510210/747
Email: barros@civil.uminho.pt | URL: http://www.isise.net

PROLONGING LIFE TIME OF OLD STEEL AND STEEL-CONCRETE BRIDGES | PROLIFE

Financing Institution(s): Research Fund for Coal and Steel - European Union (EU - RFCS)
Promoting Institution(s): Luleå University of Technology, Universidade de Coimbra, ArcelorMittal Belval & Differ. SA, Ramböll Sverige AB, Schimetta Consult Ziviltech, Alessio Pipinato & Partners, Movares Nederland BV
Coordinator(s): Luleå University of Technology

Researchers and collaborators: Carlos Rebelo, Helena Gervasio, Luis Simões da Silva, Peter Collin, Karin Habermehl-Cwirzen, Robert Hällmark, Victor Vestman, Roman Geier, Stoyan Ivanov, Mark van den Burg, Arjen Steenbrink, Bert Hesselink, Ruurd Gelderblom, Edurne Nunez Moreno, Mike Tibolt, Alessio Pipinato

Partner Institutions: Institute for Sustainability and Innovation in Structural Engineering (ISISE)

Period: 07/2015 to 06/2018

Relevant facilities: Laboratory for testing of materials and structures, DEC-UC

Objectives:
The main aim of this project is to assess the fatigue resistance of injected bolts and compare to standard bolted connections. Experimental tests are developed in order to understand if this injected bolts technology is suitable to replace existing rivets or connections new-old steel.

Description:
In the second half of the 19^{th} and turn of the 20^{th} century, an exponential growth of metallic constructions occurred throughout the world due to the streamlining of the production process of ferrous materials. Metallic bridges built in this historical period are a paradigmatic example of civil engineering structures that have been subjected to a constant increasing traffic levels, not only in terms of vehicle gross weight but also in terms of their frequencies. Consequently, innovative methods of maintenance and rehabilitation must be studied aiming to prolong their service life.
Fatigue was not a concern at the time that these structures were design once there was only a rough understanding on this phenomenon. Therefore, fatigue damage is one of the most common evidences of structural degradation. In Figure 1 is illustrated an example of a typical fatigue crack found in structural elements of Eiffel bridge, in Viana do Castelo.
Repairing and strengthening operations in old riveted construction have been implemented using injection bolts. ECCS Publication no. 79 states: "Since 1970 it has been standard practice in The Netherlands to repair old railway bridges and road bridges in this way. […] No failures with injection bolts have been reported.". It may preserve null sleep, as the original rivet. However, this technology has been essentially studied with quasi-static or creep test. Very few studies can be found in literature concerning the fatigue characterization of resin-injected bolted connections.
Fatigue problems in structural elements are not easily understandable once several parameters, which are not always independent, command the structural response to cyclic loading. Therefore, experimental campaigns are usually performed to overcome this problem and establish a reliable prediction of fatigue behaviour. The typical way to represent fatigue damage for materials, mechanical components or structural details is to use S-N curves. These curves relate stress amplitude to the number of cycles to failure. The treatment of fatigue life in structural details is described by design rules, such as, EN 1993-1-9 (EC3-1-9), BS 5400 and AASHTO.
On this experimental program is intended to assess fatigue resistance of bolted connections when using injection bolts in comparison to non-injection bolts. A total of 48 specimens will be tested varying the type of connections (single and double lap), type of bolt (injected and non-injected) and stress range (high, medium and low). Specimens will connect new steel (S355) and old steel obtained from structural elements of Eiffel bridge in order to reproduce as close as possible the real situation of strengthening techniques. Table 1 summarizes the experimental program details.
Both types of steel plates were manufactured respecting the geometry presented in Figure 2. The resulting thickness of the plates extracted from Eiffel bridge vary between 6 and 8 mm, according to the availability of the element's thickness.
Since steel plates were machined with two normalized holes of 26 mm in diameter, each test specimens includes two M24 bolts. Furthermore, in order to obtain a good performance of the connection under cyclic loading, high strength bolts class 10.9 will be used. They will be tightened using the torque method considering the procedure described in EN 1090.
As shown in Figure 3, connections with injection bolts are characterized by filling the gap between the plates and the bolt with a structural resin. The filling process is usually carried out through an injection hole in the bolt's head. Regarding washer preparation, a groove should be machined in the bottom washer (under the nut) in order to enable the air to escape while the top washer (under the bolt's head) must be prepared to ensure a smooth passage and uniform resin distribution. Several experimental studies performed in resin-injected bolted connections have made use of epoxy resins, since they

can provide a cold curing, a suitable viscosity for injection and acceptable mechanical properties. More recently, a new epoxy based resin was introduced in the market, with a commercial name Sikadur®-52, and it is characterized by its high strength properties. It is a two-part epoxy resin as shows Figure 4 (a), which should be mixed in defined quantities leading to a homogeneous injection liquid – see Figure 4 (b) and (c). As well as for the measurement of the necessary quantities of each component syringes were used, the obtained final product will be injected in the specimen using syringes. Specimens with resin-injected bolts will be subjected to a cure time of 7 days, which resulted near maximum strength properties.

Specimens will be tested on a WALTERBAI Multipurpose Sevohydraulic Universal Testing Machine rated to 600 kN. All fatigue tests will be carried out under load control with a stress R-Ratio equal to 0.1. The test frequency is 5 Hz.

Contacts:
Carlos Rebelo
Tel.: +351 239 797 209
Fax: +351 239 797 123
Email: crebelo@dec.uc.pt
URL: http://www.isise.net

(a)  (b) 

Fig. 1 (a) Eiffel Bridge in Viana do Castelo; (b) Fatigue crack found in a structural element of the same bridge

Fig. 2 Portela Bridge in Coimbra

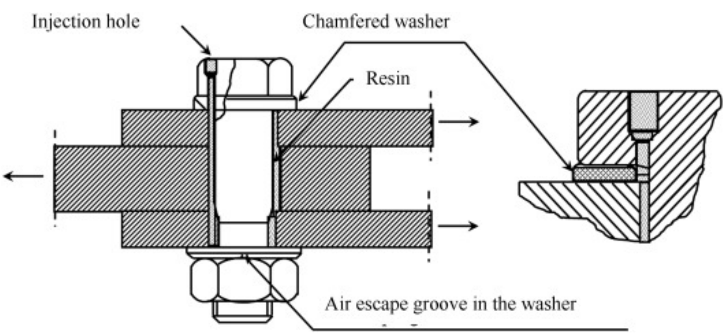


Fig. 3 Injection bolt configuration

Probabilistic Assessment of Existing Timber Structures | ProTimber

Financing Institution(s): Fundação para a Ciência e a Tecnologia (FCT)
Promoting Institution(s): National Laboratory for Civil Engineering (LNEC)
Coordinator(s): José Saporiti Machado (LNEC)

Researchers and collaborators: José S. Machado (LNEC); Ana Maria Martins Alves; Paulo B. Lourenço (ISISE-UM); Jorge M. Branco (ISISE-UM); José Carlos Carvalho Rodrigues (ISA/ULisboa); Lina Maria Ribeiro Nunes (LNEC); Teresa Maria Gonçalves Quilhó Marques dos Santos (ISA/ULisboa); José Campos e Matos (ISISE-UM); Hélder S. Sousa (ISISE-UM)

Partner Institutions: University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM); Instituto Superior de Agronomia (ISA/ULisboa)

Period: June 2016 to May 2019

Relevant facilities: Computational and laboratory equipment of the promoting institution and partner institutions.

Objectives:
ProTimber project aims to support the application of probabilistic models based on non and semi-destructive testing methods (including visual strength grading) for the assessment of existing timber structures (historic or not). The use of probabilistic models is particularly interesting given the necessity: to account for the high variability associated with the physical and mechanical properties of wood elements and to the behavior of joints; the need to combine qualitative and quantitative data; and the need to take into account the high level of uncertainty associated to the predictive models.
The project is divided six tasks. The first three tasks committed to the optimization of assessment tools and development of probabilistic models for predicting the mechanical behaviour of the members (solid timber and glued laminated timber) and joints (dowel and traditional). The fourth and fifth task is dedicated to study methods to assess service conditions effects (load-history and decay) on mechanical properties. The sixth task is committed to develop a probabilistic structural assessment model using the information obtained from the previous four tasks (resistance characteristics of the structure's components).

Description and Methodology:
Only by developing reliable assessment tools the economical sphere of sustainability is reached for a particular construction solution. At the moment in Portugal investment is increasingly being redirected from new to the rehabilitation of existing structures. To support this investment reliable evaluation methods and structural analysis models need to be available. In line with this need and regarding timber structures the project tackles four main issues:
1) How to obtain reliable predictions about the resistance variables associated with timber structural elements (solid timber and GLT).
2) How to proceed with the probabilistic assessment of structural joints.
3) How to evaluate, in a reliable way, the effect of load history and decay.
4) How to incorporate this information in a coherent manner in order to promote a true probabilistic assessment of timber structures.

TASK 1: Probabilistic assessment of solid timber
The task is divided in three sub-tasks. The first sub-task will be carried out using the data base of experimental results already available. This data includes the results of the application of a series of NDT and SDT methods for clear wood properties and knots effect on those properties. The second sub-task deals with the effect of cracks on the behaviour of structural timber members. For that purpose an exploratory study will be carried out to evaluate the use of visual characteristics combine with information from Acoustic Emission to validate the decision about the crack stability and integrity state of the element. The third sub-task will use the information gathered to model timber elements as a heterogeneous material composed of clear wood zones and knots zones.

TASK 2: Probabilistic assessment of GLT
The second task will extend the application of probabilistic prediction models from solid timber to GLT. Two random variables will be taken into consideration: properties of lamellas; and of finger-joints. The properties of the lamellas will be predicted using the information already gathered in task 1 for solid timber elements.

TASK 3: Probabilistic assessment of timber joints
The third task will develop a probabilistic model for the structural performance of both intact and damaged timber joints. This model is then be incorporated in a reliability analysis of the structure. Timber dowel joints and traditional (carpentry) joints will be addressed. An experimental campaign will include tests on laboratory in which damage will be introduced in the joints while AE will monitor its evolution.

TASK 4: Decay assessment and modeling
Regarding decay the objective is to obtain reliable data about the existence of decay, its extension and probable evolution in time. This information is included in a probabilistic model allowing predict the short and long-term impact of decay

in the structural reliability analysis. A novel SDT method will be developed based on assessing the internal cohesion of the superficial layer of wood. The purpose is to define a threshold of superficial cohesion strength.

TASK 5: Load-history assessment and modelling

Load history effect on timber members will be address by studying possible NDT method (modification of the chemical structure of cellulose) in the assessment of stress-level. Also knowledge that a structure shows no signals of deterioration after certain a number of years in service should be taken into account. This acknowledgment is proposed to be followed by applying the concept of conditional reliability given a service history.

TASK 6: Reliability-based assessment model

A reliability-based methodology will be defined incorporating the results of NDT and SDT as well as the effects of deterioration on the evaluation of material, elements and connections performance. The definition of a reliability assessment framework will allow the calibration of partial safety factors for a semi-probabilistic approach, based on partial safety factors. Simplified rules for estimating the design properties of materials, elements and connections considering the results of NDT and SDT will be proposed.

Publications:

Papers in international journals:

– Sousa HS, Neves LC (submitted) Reliability based design of interventions in deteriorated timber structures.
– Sousa HS, Prieto-Castrillo F, Matos JC, Branco JM, Lourenço PB (submitted) Combination of expert decision and learned based Bayesian Networks for multi-scale mechanical analysis of timber elements.

International conference proceedings:

– Sousa HS, Ribeiro S, Matos JC, Branco JM, Lourenço PB (2017) Uncertainty of Visual Inspection on the Reliability Analysis of Timber Elements. In: 39th IABSE Symposium. Sept. 21-23, Vancouver, Canada.
– Sousa HS, Branco JM, Machado JS, Lourenço PB (2017) Properties of timber elements by regression analysis considering multicollinearity of non-destructive test results. In: SHATIS2017. Sept. 20-22, Istanbul, Turkey.

Contacts:

José Saporiti Machado
Núcleo de Estruturas de Madeira, LNEC
Tel.: +351 218 443 299
Email: saporiti@lnec.pt

Jorge M .Branco
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: jbranco@civil.uminho.pt
URL: http://www.isise.net

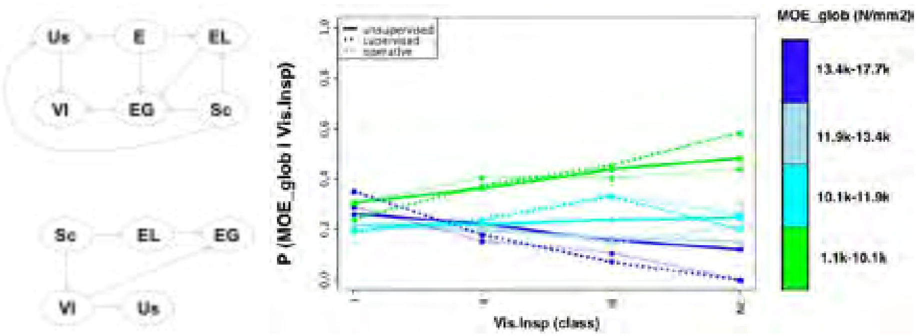


Fig. 1 Bayesian networks for inference on timber mechanical properties (Task 1, 6)

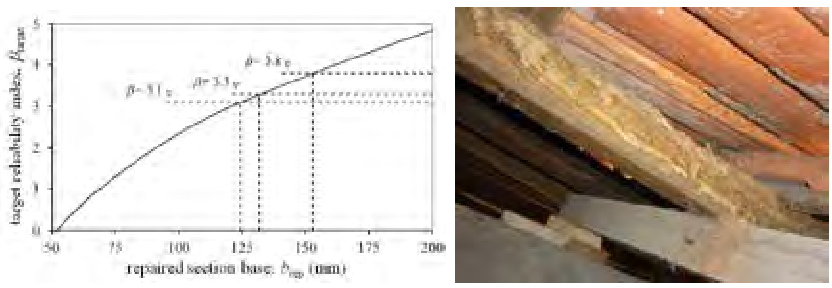


Fig. 2 Reliability performance for different interventions on existing decayed elements (Task 4, 5)

Fig. 3 Experimental campaign using acoustic emission for crack evolution assessment (Task 2, 3)

Promotion of new Eurocode rules for structural stainless steel | PUREST

Financing Institution(s): RFCS-AM
Promoting Institution(s): The Steel Construction Institute LBG (SCI) (United Kingdom)
Coordinator(s): Nancy Baddoo (SCI); Luís Simões da Silva (ISISE-Coordinator)

Researchers and collaborators: Aldina Santiago (ISISE-UC); Joel Cunha (ISISE-UC)

Partner Institutions: Universitat Politecnica de Catalunya (UPC) (Spain); Universitaet Duisburg-Essen (UDE) (Germany); Katholieke Universiteit Leuven (KU Leuven) (Belgium); Centro Sviluppo Materiali SPA (Italy); Stalbyggnadsinstitutet Stiftelser (SBI) (Sweden); Teräsrakenneyhdistys ry (Finland); Imperial College of Science Technology and Medicine (United Kingdom); Ceske Vysoke Uceni Technicke V Praze (Czech Republic); Politechnika Rzeszowska Im Ignacego Lukasiewicza (PRZ) (Poland); OneSource (Portugal)

Period: July 2016 to December 2017

Relevant facilities: Computational equipment of Civil department of FCTUC; Computational and laboratory equipment of other partner institutions.

Objectives:
The aim of this project is to disseminate technical knowledge on the structural performance of stainless steels arising from European research projects over the past 10 years. To achieve this goal, the following activities will be developed throughout the project: Publish the Fourth Edition of the Design Manual for Structural Stainless Steel; Translate the Design Manual from English into 9 languages; Develop software and apps in accordance with the Eurocode rules for stainless steel; National seminars and recorded seminars; develop a collection of teaching resources and publish articles in national engineering journals.

Description and Methodology:
The project will develop a comprehensive package of design guidance and tools which will share and promote recently developed information and knowledge on structural stainless steel. This valorisation of these research results will give constructions practitioners the confidence they need to specify the material for structural applications, it will have also an impact on the growth of markets and new applications for structural stainless steel and it will support research and innovation in the steel sector.

WP1 Design Manual for Structural Stainless Steel – Fourth Edition
The first objective of WP1 is to review and finalise the Recommendations and update and extend the Commentary of the Design Manual for Structural Stainless Steel to cover recent research and development activities. The second objective is to update the existing design examples in the design manual so they are consistent with the rules in the amendment to EN 1993-1-4. Finally, to complement the design manual will be created a set of four new design examples.

WP2 Translations, Printing and Online Dissemination
The fourth edition of the Design Manual will be prepared in English and then translated into 9 other languages (French, German, Spanish, Swedish, Finnish, Italian, Czech, Polish and Portuguese). Each partner will be in charge to print copies of the Design Manual and prepare an online platform where the Design Manual can be downloaded.
Another objective in this work package is to publish an article about structural stainless steel in a mainstream construction industry magazine or professional journal.

WP3 Online design software and apps
The stainless steel application will follow the same architecture and structure as the application available for carbon steel (ECCS EC3 Steel Member Calculator).
The the first step is to create the technical specifications of the app, following by the release of the beta edition for testing, after a thorough testing and fine tuning the next step is the public launch of the stainless steel design application. This application will provide and easy and quick access to stainless steel profiles and calculate the resistance of these profiles as columns, beams and beam-columns according the EN 1993-1-4.

WP4 Seminars, recorded webinars and student resources
To reach wider audience seminars will be held by each partner, because seminars are a key point of contact between architects, engineers, building owners and academics. To avoid duplication of effort and ensure consistent, high quality seminar materials, one partner will be responsible for preparing generic set of presentations. Another objective is to create a webinar, this webinar will provide a quick and easy way to learn about stainless steel, it will be suitable for young as well as experienced engineers.

WP5 Project Coordination
The main goal of this WP is to ensure the proper management and coordination of the project, this

implies proper communication between partners to achieve the objectives in time and on budget. Another objective is to prepare at least 3 face-to-face meetings and regular conference calls or online meetings, and finally to prepare the technical reports required by the RFCS.

Contacts:
Luis Simões da Silva
Tel.: +351 239 797 216
Fax: +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

Fig. 1 icon of the application (WP3)

Fig. 2 Splash screen of the application (WP3)

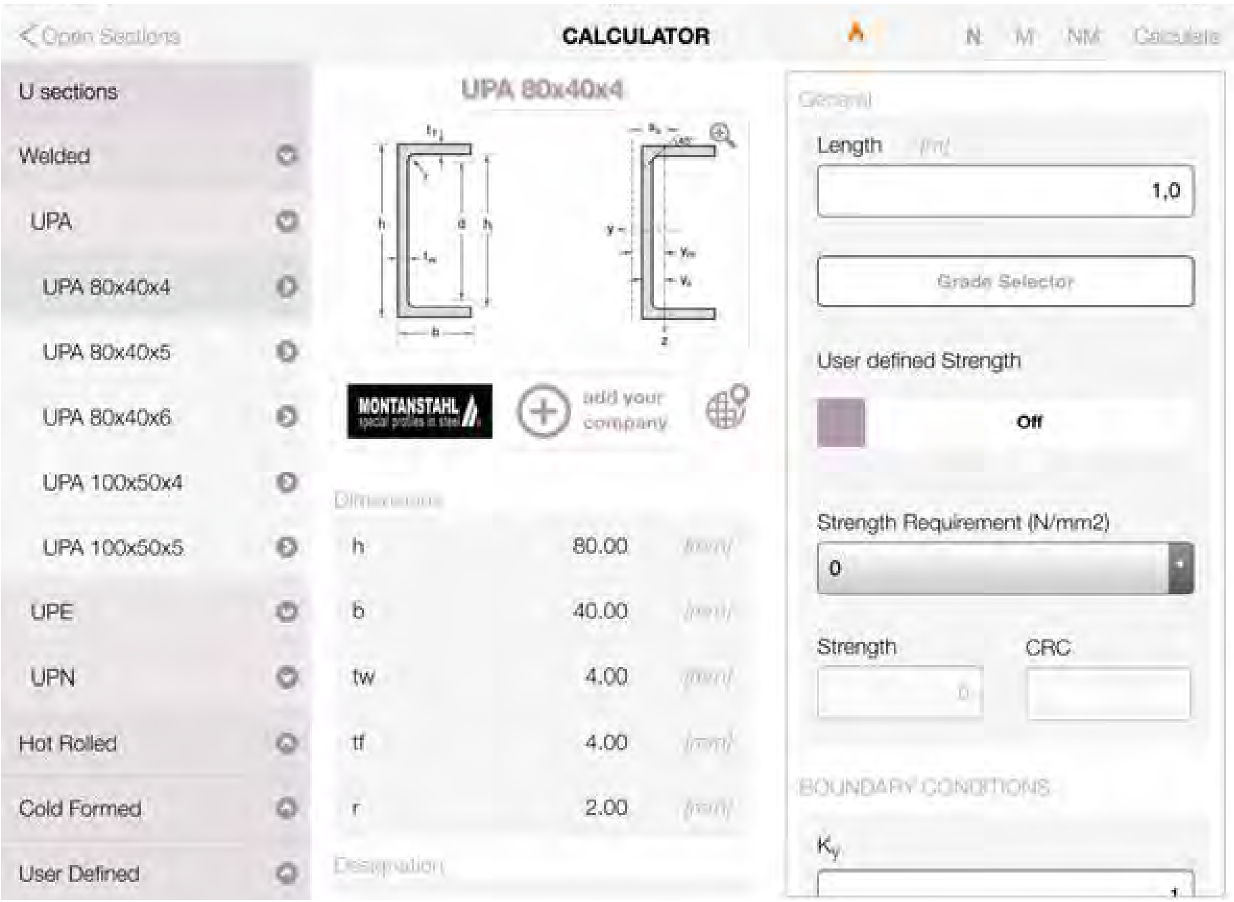


Fig. 3 Calculation interface of the application (WP3)

Rehabilitation of Building Floors with Lightweight High Performance GFRP Sandwich Panels | REHABGFRP

Financing Institution(s): FCT
Promoting Institution(s): University of Lisbon | Instituto Superior Técnico, University of Minho | Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM)
Coordinator(s): Fernando António Baptista Branco (IST-UL) and Joaquim A. O. Barros (ISISE-UM)

Researchers and collaborators: Fernando A B Branco (IST-UL); João Ramôa Correia (IST-UL); Mário Garrido (IST-UL); Joaquim A O Barros (ISISE-UM); Isabel B Valente (ISISE-UM); Mohammad Mastali (ISISE-UM)

Partner Institutions: University of Lisbon | Instituto Superior Técnico (IST-UL); University of Minho (ISISE-UM)

Period: March 2011 to February 2014

Relevant facilities: Laboratory and computational equipment of Civil Engineering department at EEUM; laboratory and computational equipment of IST.

Objectives:
Old masonry buildings usually exhibit timber-joisted floors that often need to be replaced. Rehabilitation with traditional materials introduces significant dead loads in constructions, increasing their seismic vulnerability, and poses constructive problems associated to transport, elevation and placement operations in narrow accesses.Fiber reinforced polymer materials (FRPs), including GFRP sandwich panels, present several advantages over traditional materials, namely their high mechanical performance, lightness, insulation properties, low maintenance, durability and increasingly competitive costs. These characteristics are particularly relevant for building rehabilitation, since the use of FRPs may avoid the need of elevation devices and introduce much less dead loads.This project addressed the development of innovative sandwich panels for the replacement of degraded building floors, providing an easy solution for their rehabilitation. Prototypes of glass fibre reinforced polymer (GFRP) and hybrid GFRP-UDFRM (ultra-high ductility fiber reinforced mortar) sandwich panels were produced by an innovative vacuum infusion (VI) process and their mechanical behaviour and thermal and acoustic performances were studied.The main objectives of this project are (i) to develop and test innovative and optimized GFRP sandwich panels for the rehabilitation of degraded building floors, with several advantages over traditional solutions, in terms of structural/seismic performance, lightness, durability, ease of application and maintenance, economy and sustainability; (ii) to develop numerical models (calibrated based on tests) able to simulate the mechanical behaviour of sandwich panels with arbitrary architecture, as well as their thermal and acoustic performances, thereby constituting a robust tool for their design; (iii) to develop a user's manual, with design methods/rules and design tables, together with construction procedures, technical specifications and quality control procedures for installation.

Description and Methodology:
Task1 Project Management: The activities planned within this task were executed according to planned, namely in what concerns (i) the coordination of the different tasks, (ii) the communication strategy and (iii) the development and consolidation of the several elements and deliverables of the project (planning, progress reports, milestone reports, cost statements and budgetary overviews), (iv) the dissemination and publication of the results.

Task 2 Analytical and numerical study on the structural behavior of sandwich panels – Parametric study and panels optimization: This task aimed at developing the calculation procedures for the design of sandwich panels for building floor applications, which were based on closed-form analytical models and equations. The task was carried out in parallel by the two research teams, duly coordinated: the research team from IST studied the all-GFRP sandwich panels, while the research team from UM-ISISE developed the work related to the GFRP-ECC hybrid panels.

Task 3 - Materials development and manufacturing of the sandwich panels: Two main types of sandwich panels were developed: i) all glass-fibre reinforced polymer (GFRP) sandwich panels, and ii) GFRP-DHCC hybrid sandwich panels. The all-GFRP sandwich panels generically comprise two relatively thin GFRP face sheets sandwiching a relatively thick core made from a low density material. In the GFRP-DHCC panels, the top face sheet is replaced with ultra-high deflection fibre reinforced mortar (DHCC) layer.
The production processes were aimed at producing high quality sandwich panel prototypes. The production methods used were explained and detailed.

Task 4 - Experimental study of the structural behavior of GFRP sandwich panels: The experimental characterisation of the all-GFRP sandwich panels was divided into two separate programmes: (i) small-scale material characterisation, and (ii) large-scale flexural behaviour characterisation. The material characterisation programme was carried out in order to assess the mechanical response of the materials incorporated into the sandwich panels (GFRP laminates and core materials) and of the sandwich panel system as a whole (assembly of core and faces). The full-scale flexural testing programme was designed to assess the flexural response of the sandwich panels, including their effective flexural properties (bending and shear stiffness), their dynamic response (natural frequencies), and their behaviour up to failure (type of response, failure modes and loads).

Task 5 - Experimental study of the structural behavior of GFRP-DHCC hybrid sandwich panels: The experimental campaign was divided into three phases. The first phase consisted on testing two panels with optimized dimensions in order to assess the global behaviour of the proposed solution. The second phase consisted of a set of specimens to be tested under bending, shear, and localized loading in order to assess the behaviour of the panel for specific loading situations and stress distributions. The third phase consisted on the assessment of long term loading behaviour. The panels tested in the first phase of this task were defined to clarify the global behaviour of the proposed solution and its weak points. The span defined for these specimens was 1800 mm, and the total width and distances between ribs of these two panels were 800 mm and 400 mm, respectively. Two slabs were manufactured based on the selected dimensions, with 130 mm and 162.5 mm height.

Task 6 - Experimental and numerical study of connecting solutions for adjacent panels and for panels-supporting elements: Connection systems were designed and developed for the sandwich panel floors. These included connections between adjacent panels, or panel-to-panel connections, and connections between the floors and the vertical supporting elements, which are typically masonry walls in rehabilitation works, therefore panel-to-wall connections. A set of requirements was defined for each connection type, so as to guide the development of the connection systems.

Task 7 - Experimental and numerical analysis of the thermal behavior of GFRP and GFRP-ECC hybrid sandwich panels: The main objective of Task 7 was the determination of the thermal behaviour of the composite sandwich panels. Sandwich panels with GFRP faces and four different types of core materials were considered: (i) balsa wood; (ii) PET foam; (iii) PUR foam; and (iv) polypropylene (PP) honeycombs. Regarding the experimental work, this task essentially consisted in the determination of the thermal conductivity coefficient of each material that constitutes the sandwich panels, using both stationary and transient methods.

Task 8 - Experimental and numerical analysis of the acoustic behavior of GFRP and GFRP-ECC hybrid sandwich panels: The main aim of this task was to develop simple tools for prediction of the acoustic behaviour of sandwich panels. In order to reach this main goal, the following subtasks were performed:
- Application of standard acoustic prediction methods developed originally for heavyweight floors in order to screen the acoustic performance of GFRP sandwich panels;
- Development of numerical and more detailed methods for prediction of the acoustic behaviour of GFRP panels and comparison of predictions with other measurements of different types of lightweight floors and standard measurements of airborne and impact sound insulation.

Task 9 - Preparation of a user's manual for the design and construction of building floors rehabilitation solutions with sandwich panels: This task provided specific guidance for the particular application of composite sandwich panels in the rehabilitation of building floors. Recommendations and guidelines were provided.

Publications:

Papers

– Mastali, Mohammad, Valente, Isabel B., Barros, Joaquim A. O. (2017). *Flexural performance of innovative hybrid sandwich panels with special focus on the shear connection behavior.* Composite Structures, Volume 160, 15 January 2017, Pages 100-117, ISSN 0263-8223. http://dx.doi.org/10.1016/j.compstruct.2017.10.066
– Mastali, Mohammad, Valente, Isabel B., Barros, Joaquim A. O. (2016). *Development of innovative hybrid sandwich panel slabs: Advanced numerical simulations and parametric studies*. Composite Structures, Volume 152, 15 September 2016, Pages 362-381, ISSN 0263-8223. http://dx.doi.org/10.1016/j.compstruct.2016.05.072
– Mastali, Mohammad, Valente, Isabel B., Barros, Joaquim A. O., Gonçalves, Delfina (2015). *Development of innovative hybrid sandwich panel slabs: Experimental results*. Composite Structures, Volume 133, December 2015, Pages 476-498, ISSN 0263-8223. http://dx.doi.org/10.1016/j.compstruct.2015.07.114.

Dissertations

Mastali, M., *Development of Innovative Hybrid DHCC-GFRP Sandwich Panels*, PhD Thesis, July 2016

Conference proceedings

Mastali, M.; Valente, I. B., Barros, J. A. O. (2013). *New composite slab system for the structural rehabilitation of traditional buildings*. FRPRCS11 - 11th International Symposium on Fiber Reinforced Polymers for Reinforced Concrete Structures. Guimarães, 26-28 June 2013. (http://hdl.handle.net/1822/26125)

Contacts:

Joaquim A. O. Barros
Tel.: +351 253 510 200 | Fax: +351 253 510 217
Email: barros@civil.uminho.pt | URL: http://www.isise.net

Fig. 1 Numerical model on GFRP-DHCC sandwich panel

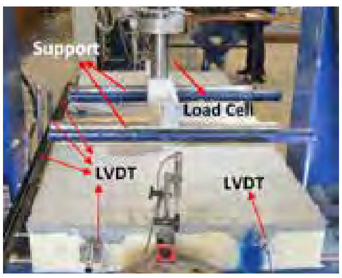


Fig. 2 Experimental Test setup

Developing Innovative Solutions for Seismic Retrofitting of Masonry Infill Walls| RetroInf

Financing Institution(s): FCT
Promoting Institution(s): University of Minho (UMinho)
Coordinator(s): Graça Vasconcelos

Researchers and collaborators: Graça Vasconcelos, Paulo Lourenço, Farhad Akhoundi, Luis Ramos, Raul Fangueiro, Fernando Cunha

Partner Institutions: Faculty of Engineering of University of Porto

Period: April 2012 to July 2015

Relevant facilities: Laboratory equipment and facilities of Civil Department of UMinho

Objectives:
The quality of the built heritage play a central role on the quality of daily human lives as they interact continuously with the built spaces, either in the work, social events and at home. In particular, the safety of the built spaces is indeed a demand of modern societies and remains a huge concern in prone seismic regions. It is known that seismic vulnerability is not exclusive of ancient masonry structures but affects also the built heritage from XX century, composed in a majority of reinforced concrete (RC) buildings, both in structural and non-structural elements. In this constructive typology, brick masonry walls represent the most traditional enclosure system and have demonstrated reasonable performance with respect to healthy indoor environment, temperature, noise, moisture, fire and durability, even if there has been some trend for improvement serviceability by purposing newly solutions. Therefore, the main goals of the research project are; (1) to develop of innovative materials and solutions for retrofitting masonry infill walls; (2) to derive sound concepts for the analysis of masonry infill walls; (3) to derive design guidelines for retrofitting masonry infills.
The major innovation in relation to past recent studies is the development of structural textile based materials that can be used both on the surface of masonry infills to improve simultaneously the in-plane and out-of-plane performance. Additionally, due to the lack of detailing on existing buildings about the connections between masonry infills and RC frames, which is a major source of vulnerability as concern the out-of-plane resistance, anchor systems to RC frames will be developed. The out-of-plane vulnerability of cavity masonry infills due the lacking of connection between the leaves should be solved by designing adequate fasteners linking the leaves. An interesting property that fibre textile based materials should have introduced is its sensing ability, enabling to record the damage extent during seismic event.

Description:
In the scope of the research project RetroInf, an innovative strengthening technique was developed based on meshes composed of braided composite rods (BCR) in which two distinct reinforcing fibres were considered, namely carbon and glass fibres. The idea is that these meshes are added to the rendering mortar working similarly to the reinforced textile mortar (TRM). The production technology considered to manufacture the reinforcing meshes was based on the braiding technique of three distinct materials, each one with different functions. This technology consists in the combination of yarns that make up the base of the braid, involving a central core responsible for the mechanical resistance (carbon or glass fibres) (Fig. 1).
The validation of the mechanical performance of the meshes to work as a retrofitting technique was based on flexural tests on small specimen of brick masonry.
Samples of masonry walls are composed of units of brick units most used in construction of masonry infill walls in Portugal. Masonry specimens with dimensions of 300mm x 200mm x 150mm (length x height x thickness) were considered. Besides the developed mashes, commercial meshes using the same type of reinforcing fibres were also considered. Ir was concluded that the developed meshes are very similar in terms of flexural resistance but present a remarkable enhanced behavior in terms on capacity of nonlinear deformation. With the developed meshes, it is possible to reach very important flexural deflections; particularly in case of meshes of braided rods have glass fibres in the reinforcing f nucleous.
The developed meshes will be also applied in reinforced concrete (RC) with masonry infilled frames, designed to represent RC frames from the eighties.
In-plane and out-of-plane tests were designed on reduced scale RC frames, being the tests under development. For the in-plane testing, an existing testing setup was updated and for the out-of-plane testing, a novel out-of-plane testing setup was designed based on airbags to better represent the out-of-plane forced induced by earthquakes. The out-of-plane testing procedure is automatic for which a software was developed (Fig. 2 and Fig. 3a). Additionally, combined tests aiming at assessing the influence of the in-plane damage on the out-of-plane performance of the masonry infill walls (resistance and deformation) are under preparation.
The nonlinear numerical analysis encompasses the definition of a numerical model, its calibration based on the experimental results and a parametric study aiming at assessing the influence of selected parameters in the in-plane and out-of-plane of RC masonry infilled frames. The non-linear behavior of the concrete and masonry was represented by a Total

Strain Crack Model based on a fixed stress-strain law concept available in the commercial. It describes the tensile and compressive behavior of the material with one stress-strain relationship in the local coordinate system that is fixed upon crack initiation. Exponential and parabolic constitutive laws were used to describe the tensile and compressive behavior of concrete and masonry infill respectively. An example of the stress distribution of the masonry infill is shown in Fig. 3b.

Publications:

Papers

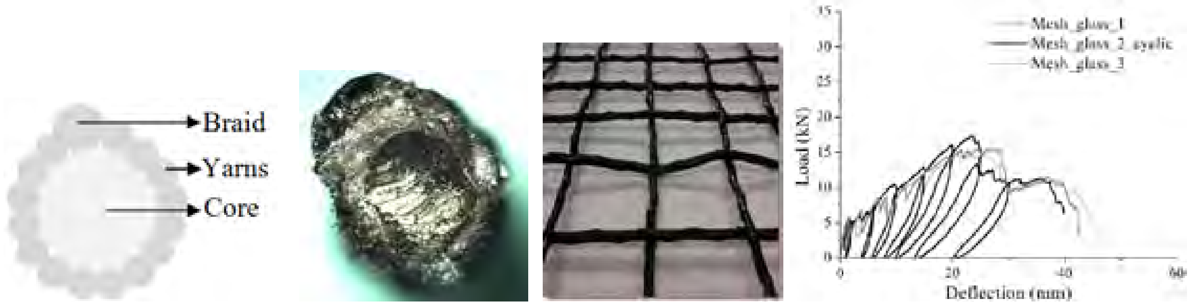
- Martins A., Vasconcelos G., Fangueiro R., Cunha F. Experimental assessment of an innovative seismic strengthening material for brick masonry infills, Composites Part B: Engineering, 80, 328-342, 2015.
- Ackoundi F., Lourenço P.B., Vasconcelos G., Numerically Based Proposals for the Stiffness and Strength of Masonry Infills with Openings in Reinforced Concrete Frame, Earthquake Engineering and Structural Dynamics, 45(6), 869-891, 2016.

Conference proceedings

- Vasconcelos, G., Mora, J., Fangueiro, R., Cunha, F., Martins, A. Flexural behaviour of brick masonry retrofitted with braided textile meshes, IRF2013 - 4th International Conference on Reliability and Failure of Mechanical Systems, Funchal, 23-27 June, 12pp., 2013.
- Martins A., Vasconcelos, G., Fangueiro, R., Cunha, F., Strengthening of masonry infill walls under out-ofplane loading with textile reinforced mortar (TRM), 9th International Masonry Conference, 07-09 uly, University of Minho, 2014. (In CdRom).
- Akhoundi F., Lourenço, P.B., Vasconcelos, G., Numerical modelling of masonry-infilled reinforced concrete frames: model calibration and parametric study, 07-09 July, University of Minho, 2014. (In CdRom).
- Martins, A., Vasconcelos, G., Fangueiro, R., Cunha, F. Caracterização experimental do comportamento de aderência de varões compósitos têxteis, 9º Congresso Nacional de Mecânica Experimental, 15-17 Out., Universidade de Aveiro, Portugal, 2014.

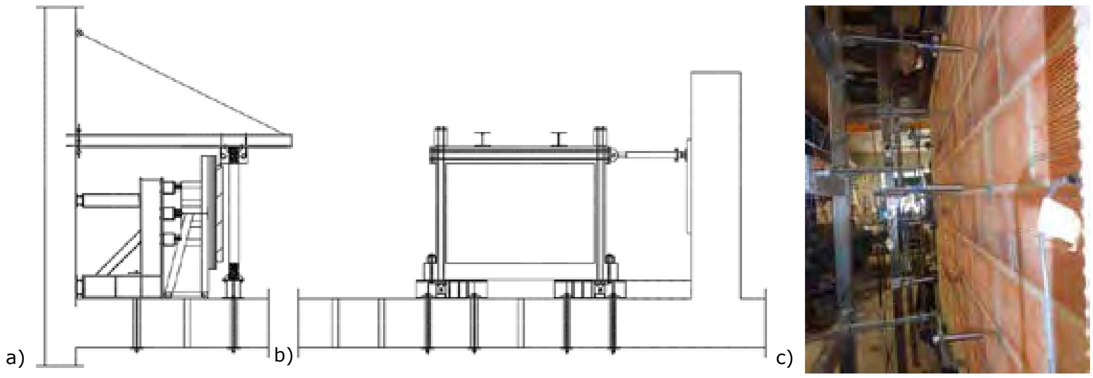
Contacts:

Graça Vasconcelos
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: graca@civil.uminho.pt
URL: http://www.isise.net



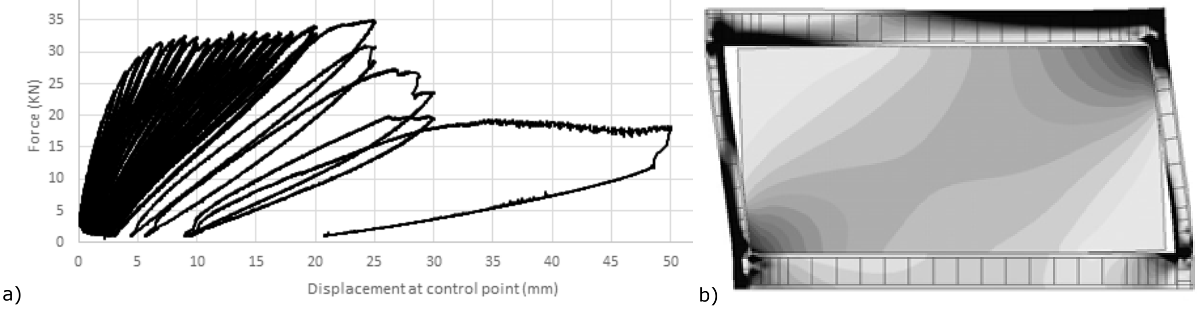
a) b) c) d)

Fig. 1 (a) Representation of the cross section of the a BCR; (b) cross section of the BCR with glass fibres; (c) developed mesh; (d) force-displacement diagram for cyclic flexural tests



a) b) c)

Fig. 2 Tests setups for cyclic tests; (a) out-of-plane testing with airbags; (b) in-plane test setup; (c) instrumentation for measuring out-of-plane deformation of the brick masonry infill wall



a) b)

Fig. 3 (a) Out-of-plane force-displacement diagrams (OOP test) on masonry infill walls; (b) in-plane numerical simulation

Seismic Protection of Earthen Construction Heritage | SafEarth

Financing Institution(s): FCT
Promoting Institution(s): University of Minho (UM), Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM)
Coordinator(s): Rui A. Silva (ISISE-UM)

Researchers and collaborators: Rui A. Silva (ISISE-UM); Daniel V. Oliveira (ISISE-UM); Nuno Mendes (ISISE-UM); Tiago Miranda (ISISE-UM); Luís Ramos (ISISE-UM); Rute Eires (CTAC); Antonio Romanazzi (ISISE-UM) Coordinators from partner institutions: Humberto Varum (CONSTRUCT-FEUP); Aníbal Costa (RISCO-UA); Alfredo Campos Costa (NESDE-LNEC)

Partner Institutions: Faculty of Engineering of the University of Porto (FEUP); University of Aveiro (UA); Nacional Laboratory of Civil Engineering (LNEC)

Period: June 2016 to May 2019

Relevant facilities: Laboratory and computational facilities of Civil Departments of UM, UA and FEUP, and shaking table of LNEC.

Objectives:
Raw earth construction still has an important presence around the World, where it constitutes one of the most ancient methods for building. Portugal presents an important heritage made of adobe and rammed earth built on regions with important seismic hazard. This fact constitutes a matter of concern, since the seismic behaviour of this heritage is not sufficiently comprehended. Furthermore, the seismic protection of adobe and rammed earth structures and of their inhabitants requires the development of compatible seismic strengthening solutions. The SafEarth project intends to respond to these needs by fulfilling the following objectives: (i) identification and assessment of the importance of building details associated with the seismic culture of adobe and rammed earth constructions; (ii) material characterisation of adobe and rammed earth; (iii) experimental characterisation of the seismic behaviour of adobe and rammed earth structures; (iv) development of numerical models for the simulation of adobe and rammed earth structures, unstrengthened and strengthened with coatings reinforced with geo-mesh; (v) development of recommendations for end-users on the safety assessment and strengthening of adobe and rammed earth structures. Finally, the results of the project are expected to provide basic tools for the correct preservation of the adobe and rammed earth built heritage from Portugal, which, in the last years, has been acquiring great value in the wellness tourism from the South of the country.

Description and Methodology:
The objectives proposed in the project will be achieved by following an integrated methodology constituted by five technical tasks, described as follows:

Task 1 Seismic culture regarding earthen buildings

The most relevant aspects of the local seismic culture of the adobe and rammed earth heritage will be established and characterised. Firstly, data available in literature and obtained from surveys developed in previous research works (SEISMIC-V and BE+EARTH) will be used to identify and establish the most relevant features, which must include geometrical, architectonical and location aspects, as well as details on failure modes and material properties of adobe masonry and rammed earth. This work will result in a database of parameters influencing the seismic performance of these structures, which will be enriched with further field surveys to be carried out in the regions of Litoral-Centro for adobe construction and Alentejo and Algarve for rammed earth.

Task2 Quasi-static testing of structural components

Under a seismic event, earthen walls are subjected both to in-plane and out-of-plane movements, which are responsible for compression, shear and bending forces. The quasi-static testing of adobe and rammed earth walls submitted to these forces is fundamental to understand their seismic behaviour. Although this approach represents a simplification of the reality (non-consideration of the dynamic effect), these tests are simpler, cheaper and less time consuming than pseudo-dynamic or dynamic tests. In a first phase, a set of quasi-static tests will be carried out both on adobe masonry and rammed earth specimens representative of Portuguese constructions from the region of Litoral-Centro and Alentejo regions, respectively. In a second phase, a set of tests with the same configuration of those aforementioned will be carried out in order to assess the strengthening capacity of geo-mesh reinforced coatings (based on earth mortars).

Task 3 Shaking table testing of structural assemblages

The dynamic testing of adobe masonry and rammed earth assemblages will be performed in this task. The assemblages will be constituted by full scale walls with representative geometry for openings and boundary conditions. In a first phase, the assemblages will be tested on the shaking table at LNEC, where the input earthquake of the shaking table will be defined with basis on the Portuguese seismic code and will take into account the regions from where each type of construction is characteristic. The dynamic tests will be performed in gradual steps proportional to the PGA. Dynamic identification tests will be performed between steps for damage assessment. In the second phase, the assemblages will be repaired with injection of mud grouts and strengthened with geo-mesh reinforced coatings.

Task4 Numerical calibration of models and parametric analysis

The numerical modelling of the adobe and rammed specimens tested in the experimental program will be performed in this Task. In a first phase, the models for the quasi-static tests will be calibrated in static analysis. In the case of the shaking table tests, numerical models for dynamic analysis will be developed and calibrated taking into account dynamic identification results and by comparing the response of the models with that of the assemblages. It should be noted that the development of these models is also expected to include the effects of the strengthening with geo-mesh reinforced coatings. In a second phase, extensive parametric analyses will be carried out on the models calibrated in the first phase.

Task 5 Guidelines for End-users

The guidelines to be developed in this task will summarize the main results of the project and make them useful for end-users (designers, architects, engineers, construction companies, bodies responsible of building maintenance, etc.). The work carried out within the project will be substantially simplified in order to fulfil the needs of end-users, by providing simple seismic safety assessment and strengthening design procedures. The guidelines will also include good practices for repair and strengthening procedures, as well as indication on intervention costs.

Publications:

Papers

Silva, R.A., Oliveira, D.V., Schueremans, L., Miranda, T., and Machado, J. "Effectiveness of the repair of unstabilised rammed earth with injection of mud grouts", Construction and Building Materials 127 (2016) 861-871

Dissertations

Barroso, C., Reforço Sísmico Inovador de Construção de Taipa, Master Thesis, December 2016 (in Portuguese)

Librici, C., Modelling of the seismic performance of a rammed earth building, Master Thesis, July 2016

Conference proceedings

Miccoli, L., Oliveira, D.V., Silva, R.A., Drougkas, A., and Fontana, P. "Numerical modelling of rammed earth under different in-plane load conditions", LEHM 2016, 7th International Conference on Building with Earth, Germany (2016)

Silva, R.A., Domíguez Martinez, O., Oliveira, D.V., Pereira, E., Soares, E. "Repair of rammed earth with mud and hydraulic lime based grouts", CNME 2016, 10º Congresso Nacional de Mecânica Experimental, Portugal (2016). (in Portuguese)

Contacts:

Rui A. Silva
Tel.: +351 253 510 200
Fax: +351 253 510 200
Email: ruisilva@civil.uminho.pt
URL: http://www.isise.net

Fig. 1 Traditional rammed earth dwelling from Alentejo (Mértola)

Fig. 2 Pull-off tests for mortar-mesh interaction

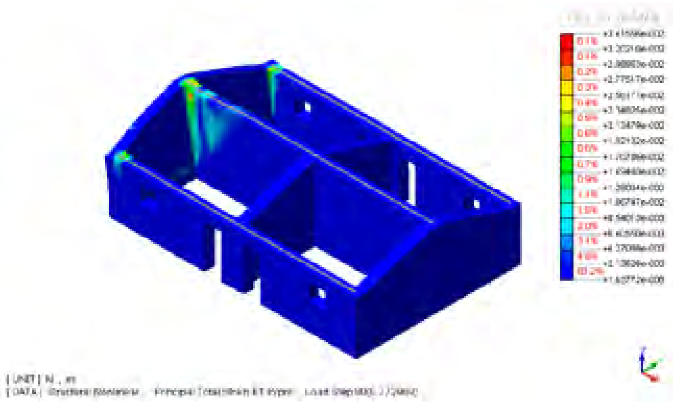


Fig. 3 Contour (maximum principle strains) from a pushover analysis on a traditional rammed earth building (loading the longitudinal direction)

Standardization of Safety Assessment Procedures across Brittle to Ductile Failure Modes | SafeBrictile

Financing Institution(s): EC-RFCS
Promoting Institution(s): University of Coimbra, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)
Coordinator(s): Luís Simões da Silva (ISISE-UC)

Researchers and collaborators: Luís Simões da Silva (ISISE-UC); Trayana Tankova (ISISE-UC); Liliana Marques (ISISE-UC). Coordinators from partner institutions: Ulrike Kuhlmann (USTUTT); Bert Snijder (TU/e); Véronique Dehan (ECCS); Louis-Gui Cajot (AMBD)

Partner Institutions: University of Stuttgart (USTUTT) (Germany); Eindhoven University of Technology (TU/e) (the Netherlands); European Convention for Structural Steelwork (ECCS) (Belgium); ArcelorMittal (AMBD) (Luxembourg)
Period: July 2013 to June 2016

Relevant facilities: Computational equipment of Civil department of FCTUC; Computational and laboratory equipment of other partner institutions.

Objectives:
The safety assessment was not consistently considered throughout the many parts of Eurocode 3, mainly due to a lack of guidance and lack of existing databanks containing information on the distribution of the relevant basic variables and steel properties.
Therefore, in SAFEBRICTILE an objective and consistent assessment procedure for the safety assessment of the various failure modes that are relevant for steel structures was developed. The unified procedure resulted in codified procedures for inclusion in the structural Eurocodes and is able to cover modes driven by plasticity, stability and fracture.
A complementary and required task to accomplish this is also carried out within this project and consists of the conceptual development and further maintenance of a European database of steel properties resulting from experimental tests.
In addition, several rules in Eurocode 3 covering the failure modes treated in the project were reassessed in order to fulfil the developed safety assessment procedures.
The results of this project will lead to major competitiveness gains: (1) faster time-cycle in the development of new design procedures able to cope with innovation; (2) increased reliability in the accuracy of new design models; (3) major savings in R&D costs by avoidance of major duplication of work.

Description and Methodology:
In a first step, the safety assessment procedure was developed by considering the option of having or not a previously established safety factor. This was carried out in accordance with Annex D of EN 1990 Basis of Design. In line with this task, a databank of test results and respective characterization of basic variables was developed. Then, considering the developed procedures, reliability assessment of design rules throughout EUROCODE 3 was performed and new rules in line with the safety requirements are developed whenever necessary.

WP1 Development of safety assessment procedure: The objective of WP1 was to provide clear and objective guidance for the efficient safety assessment of design rules for steel structures and the establishment of the corresponding partial safety factor γM^*. This is in line with the EUROCODE EN 1990 design philosophy and covers two different viewpoints: (i) the evaluation of the safety of new design procedures; (ii) the assessment of the safety level of existing design procedures. By doing this, a consistent level of safety is established throughout Eurocode 3 which has to be ensured both by existing rules and new rules.

WP2 European Database of Steel Properties (S235 to HSS S460; S550; S690): The safety assessment procedure developed in WP1 relies on the statistical distribution of certain basic input variables such as the mechanical properties of steel (yield stress; Young's modulus; etc.); cross section dimensions; geometrical and material imperfections.
The results of existing test measurements will be reported in a standard way. A comprehensive and up-dated database of sectional and material parameters for steel sections is here developed.
The European database provides results of previous experimental work as well as a consistent statistical characterization of the relevant properties for calculation of resistance.

WP3 Ductile modes driven by plasticity: Based on the results of WP1 and WP2, a consistent level of safety throughout the many parts of EUROCODE 3 is ensured concerning failure modes governed by plasticity, by adjusting existing rules if needed. This failure mode is largely depending on the yield stress. The focus was on the design rules present in EN 1993-1-1 related to cross-sectional resistance. The code rules had been developed in the past for mild steels but there still is a need to verify if the rules are also applicable to high-strength steels. Limited effort was put on the rules for single internal forces (tension, compression, bending moments, shear forces) since these rules are relatively simple. However, the focus was on combinations of internal forces since these rules are more complex. Moreover, their scope is limited to double symmetric I-shaped, circular and rectangular sections. The existing and proposed design rules were assessed to achieve a consistent safety level.

WP4 Semi-ductile modes driven by stability: In Work Package 4, the modes driven by stability were assessed. The aim of this part of the project was to contribute towards the revision of EN 1993-1-1 by achieving transparent, simple and straight-forward unified stability verification procedures. For that, focus was firstly given to the application of the safety assessment procedure to the existing stability design rules in EN 1993-1-1 thus assessing the current safety level of uniform members in compression (cl. 6.3.1), bending (cl. 6.3.2), bending and compression (cl. 6.3.3) and the general method for lateral and lateral-torsional buckling of structural components (cl. 6.3.4). Based on the results obtained the stability verifications were extended to non-uniform members. For columns and beams the rules were extended to non-members subject to arbitrary loading, for the rules for prismatic beam-columns were extended to web-tapered members.

WP5 Brittle modes driven by fracture: Considering a similar approach as in WP3 and WP4, a method for statistical validation of design rules for typically brittle failure depending on material strength using as example weld design strength of mixed connections (MCS and HSS) is developed.
Within WP5 experimental program was conducted and focused on the load bearing capacity and safety against brittle fracture on welded dual-steel connections. The typical failure is a "fracture failure" where statistical evaluation plays the decisive role. One of the main objective is then to develop design recommendations drafted for statistical evaluation of brittle failure modes based on experimental testing for design and give more detailed rules of welded dual-steel connections composed of 2 different steel grades: mild carbon steel (MCS) and high strength steel (HSS) and range of different filler metals.

WP6 Design guidance, project management and dissemination: A project management WP ensured effective communications between partners during the project. A workshop was held at the end of the project in conjunction with the *International Colloquium on Stability and Ductility of Steel Structures* – SDSS 2016. In addition, a clear guideline for the assessment and development of design rules in steel structures was prepared as outcome of WP1 being applied and further developed by WP3,4,5.

Publications:

Papers (6)
Tankova, T., Simões da Silva, L., Marques, L., Rebelo, C., and Taras, A. "Towards a standardized procedure for the safety assessment of stability design rules", Journal of Constructional Steel Research 103 (2014) 290–302

Dissertations (7)
Tankova, T., Comparative review of possible alternatives for performing safety assessment of design rules for steel structures, Master Thesis, January 2014

Reports (7)
Marques, L., Simões da Silva, L., and Rebelo, C. "Code proposal for rules for member buckling of non-uniform members", Technical Committee 8, ECCS, Document TC8-2013-11-23, Zurich, Switzerland, November 8th, 2013;

Conference proceedings (18)
Tankova, T., Marques, L.., Simões da Silva, (2016). Towards a general methodology for the stability design of steel members, Proc. International Conference on Steel and Aluminium Structure, Hong Kong, China, 7-9 December (2016).

Contacts:
Luis Simões da Silva
Tel.: +351 239 797 216
Fax: +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

Fig. 1 Workshop proceedings


Fig. 2 European database of Steel Properties

European Masters in Structural Analysis of Monuments and Historical Constructions | SAHC

Financing Institution(s): European Commission (EACEA)
Promoting Institution(s): University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM)
Coordinator(s): Paulo B. Lourenço (ISISE-UM)

Researchers and collaborators: Paulo B. Lourenço, Daniel V. Oliveira, Graça Vasconcelos, Luís F. Ramos, Jorge Branco, José Sena, Isabel Valente (only UMinho researchers listed)

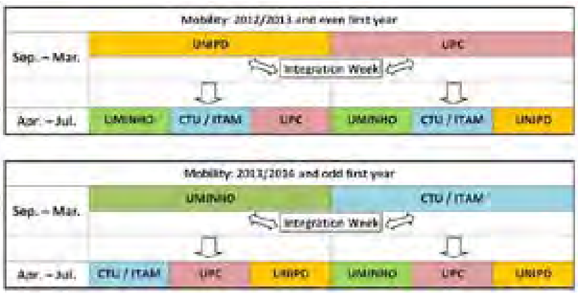
Partner Institutions: Czech Technical University (CZ), University of Padova (IT), Technical University of Catalonia (ES), Institute of Theoretical and Applied Mechanics (CZ)

Period: September 2007 to August 2017

Relevant facilities: Laboratory facilities: strong floors and reaction walls; several universal hydraulic tension-compression load frames, closed-loop servo-controlled actuators and data acquisition and control equipment; climatic chambers; diverse day-to-day laboratory equipment - Computational facilities: advanced FE numerical tools.

Objectives:
The objective of SAHC is to offer an advanced education programme on the engineering of conservation of structures, with a focus on architectural heritage. The Master combines the diversity of expertise at leading European universities in the field, offering education oriented to a multidisciplinary understanding of structural conservation through the involvement of experts from complementary fields (engineers, architects, materials scientists and others). Students face top level structural analysis knowledge in a research oriented environment, with close cooperation with the industry and a focus on problem solving.

Description:
The SAHC programme has duration of one academic year (60 ECTS credits) and is held on a rotating basis among partners. Coursework (September - March) is concentrated in two countries each year and dissertation work (April - July) is divided by all involved institutions. For 2014/2015 and even years, the coursework will be held in Italy and Spain. For 2015/2016 and odd years, the coursework will be held in Portugal and Czech Republic. Dissertation can be performed in any of the involved institutions.



The study programme is composed of eight units, with six sequential units, one unit project-based and one dissertation. The units are as follows:

- SA1: History of Construction and of Conservation
- SA2: Structural Analysis Techniques
- SA3: Seismic Behaviour and Structural Dynamics
- SA4: Inspection and Diagnosis
- SA5: Repairing and Strengthening Techniques
- SA6: Restoration and Conservation of Materials
- SA7: Integrated Project
- SA8: Dissertation

Units SA1 to SA6 are arranged as a mix of theory and application, in a context of a project-led education. Lectures are held from 9:30h to 12:30h and individual/group work is carried out at University from 14:00h to 19:00h.

The Integrated Project is s truly project-based course, includes a mini group project to solve a real engineering problem, with site visits.

The Dissertation aims at developing research and/or professional competences in the field of conservation and restoration of architectural heritage structures.

Three types of scholarships are made available. Partner Country Scholarships (25,000 Euro) are available to third-country applicants. Programme Country Scholarships (17,500 Euro) are available to students not eligible to the category A scholarship. Partner and Programme Country scholarships are directly sponsored by the European Commission, under the scope of Erasmus+ Programme. Also, a number of Consortium scholarships are planned for students from any geographical origin. These scholarships are financed by the SAHC Consortium

The degree awarded is a Master's degree, provided as a double degree from the institutions involved.

At the end of its 10th edition, the SAHC Masters Course has hosted 325 students from 65 countries, from Africa, America, Asia, Australia and Europe.

Publications:

Relevant international journal papers:

Razavizadeh, A., Ghiassi, B., Oliveira, D.V. (2014) Bond behavior of SRG-strengthened masonry units: testing and numerical modelling, Construction and Building Materials, 64, 387–397.

Manning, E., Ramos, L.F., Fernandes, F.M. (2016), Tube-Jack Testing for Irregular Masonry Walls: Regular Masonry Wall Testing, Journal of Nondestructive Evaluation, 35(3), 43.

Poletti, E., Vasconcelos, G., Branco, J.M., Koukouviki, A.M. (2016) Performance evaluation of traditional timber joints under cyclic loading and their influence on the seismic response of timber frame structures, Construction and Building Materials, 127, 321-334.

Relevant international conference papers:

Ptaszkowska, J., Oliveira, D.V. (2014) Numerical modeling of masonry vaults strengthened with transversal diaphragms, Proc. 9th International Conference on Structural Analysis of Historical Constructions, October 14-17, Mexico City, Mexico, CD-ROM, 12 pp.

Silva, R.A., Domínguez, O., Oliveira. D.V., Pereira, E., Soares, E. (2016) Assessment of the injection of grouts to repair cracks in rammed earth, Proceedings of the International RILEM Conference on Materials, Systems and Structures in Civil Engineering, Conference segment on Historical Masonry, Lyngby, Denmark, 23-32.

Lourenço, P.B., Karanikoloudis, G., Greco, F. (2016) In situ testing and modeling of cultural heritage buildings in Peru, Proceedings of the 10th International Conference on Structural Analysis of Historical Constructions, Leuven, Belgium, 365-371.

Contacts:

Paulo B. Lourenço
Tel.: +351 253 510 498
Fax: +351 253 510 217
Email: secretariat@msc-sahc.org
URL: www.msc-sahc.org

Fig. 1 Origin countries of SAHC students

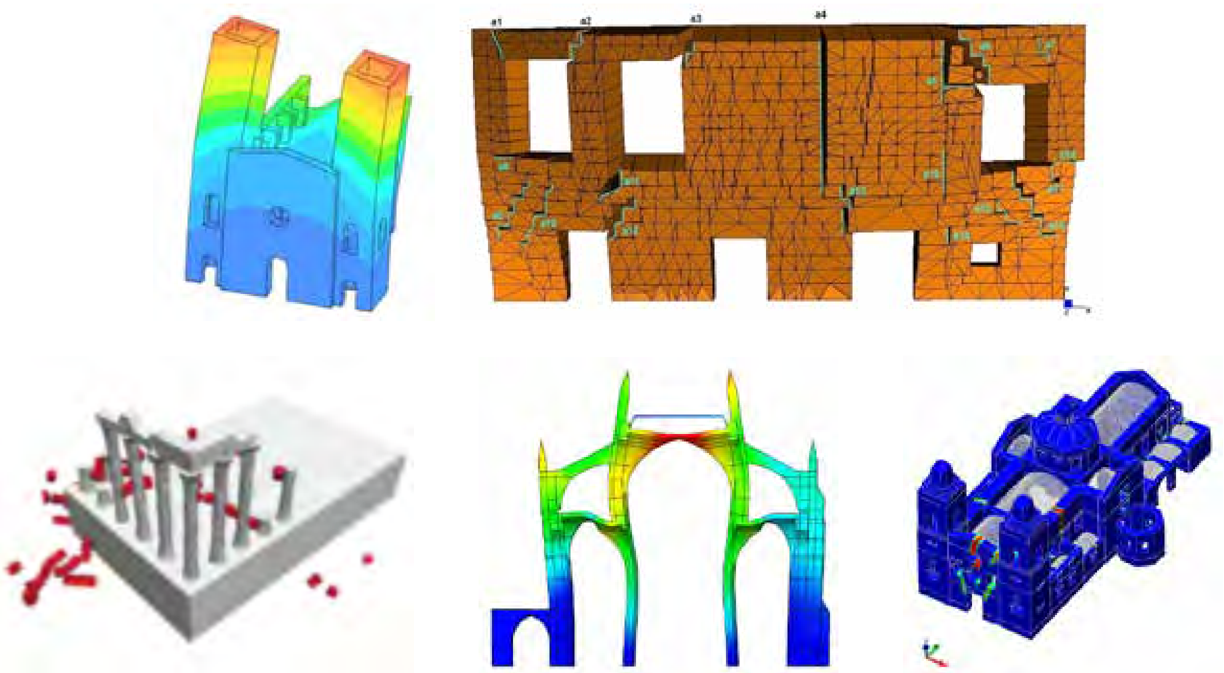


Fig. 2 Some examples of structures studied within the UMinho SAHC theses

Valorisation of Knowledge for Sustainable Steel-Composite Bridges in Built Environment | SBRI+

Financing Institution(s): RFCS
Promoting Institution(s): University of Coimbra, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)
Coordinator(s): Luís Simões da Silva (ISISE-UC), Constança Rigueiro (ISISE-UC)

Researchers and collaborators: Luís Simões da Silva (ISISE-UC); Constança Rigueiro (ISISE-UC); Jorge Teixeira (ISISE-UC; Helena Gervásio (ISISE-UC). Coordinators from partner institutions: Raffaele Landolfo (UNINA); Mariana Zimbru (UNINA);

Partner Institutions: ArcelorMittal Belval & Differdange SA (AMBD); Universität Stuttgart (USTUTT); AG Dillinger Hüttenwerke (DILL); Institut français des sciences et technologies des transports, de l'aménagement et des réseaux (IFSTTAR); Ramboll Sverige (RAMBOLL); Brisa Engenharia e Gestão (BEG); Forschungsvereinigung Stahlanwendung e.V. (FOSTA); "Politehnica" University of Timisoara (UPT); Czech Technical University in Prague (CVUT); Fundacion Tecnalia Research & Innovation (TECNALIA); The University of Naples Federico II (UNINA); Atkins Consultants Limited (ATKINS); Stichting Bouwen met Staal (BmS); BKE sp. z o.o. (BKE); Sveuciliste U Zagrebu Gradevinski Fakultet (UNIZAG GF); S. Stathopoulos - K. Farros Consulting Engineers (DOMI SA); ArcelorMittal Basque Country Research Centre AIE (AMBCR).

Period: July 2016 to June 2018

Relevant facilities: Computational and laboratory equipment of Civil Engineering department of FCTUC; Computational and laboratory equipment of other partner institutions.

Objectives:
Within the RFCS-project SBRI, a holistic approach to asses steel-composite bridges by combining Life Cycle Assessment (LCA), Life Cycle Costs (LCC) and Life Cycle Performance (LCP) was developed and applied to three representative European bridge types. This research project aims at the dissemination of the elaborated results and an extension of the methods to advanced applications and further bridge types. To reach a wide audience among bridge engineers and authorities two Design Manuals for the practical applications, including worked examples, will be prepared. In the frame of several seminars across Europe the enhanced developed software tool and the dissemination material will be spread.

Description and Methodology:

This proposal aims at the valorization, the dissemination and the extension of the developed method of SBRI for advanced applications. Whereas SBRI has been focused on the research work and the development of the holistic approach and methodology, this new proposal aims at the promotion and dissemination of the results in order to increase the acceptance of this new way of sustainable thinking especially among bridge owners and planners who are known to tend to conservatively stick to own national experiences and approaches. So a wide audience including bridge engineers and authorities should be reached, in order to assure the application of the project outcome. The transfer into practice is most likely achieved by national seminars and clearly structured design manuals issued. Finally, as the natural continuation of the experimental activities on materials and joints, pseudo-dynamic tests and/or cyclic push-over tests of a real-scale two storey will be carried out.

WP1 Design Manual I – Worked Examples
In Work Package 1 the Design Manual I will be prepared including background information on the methodology and worked examples. This will allow for an easy understanding and application of the developed methods. With integrated examples the Design Manual I will facilitate the understanding and application for practical engineers. The aim is also to enhance the SBRI software tool in view of user-friendliness in order to allow for an easy access by the users and allow them to use the multi-criteria decision analysis during comparative decision making between alternative solutions. A user manual for the SBRI software will also be prepared to alleviate the application of the software tool. Both the software and the user manual will be available for free download on various websites. (i.e. sections. arcelormittal.com, https://isise.net/, www.infosteel.com, www.constructalia.com, www.steelconstruct.com)

WP2 Design Manual II – Advanced Application
The Design Manual II will be prepared in Work Package 2 and the method developed in SBRI will be applied to innovative bridge types in order to demonstrate its general flexibility and applicability. In SBRI project only standard situations of steel concrete composite deck bridges were analyzed which will be further developed here to various innovative bridge solutions such as hot-dip galvanized corrosion protection or specially mixed structures. Whereas the case studies in SBRI were chosen as typical, but fictitious bridges, really built examples across Europe will be focused allowing considering real data and bridge situations which will then be analyzed with the approach developed in SBRI.

WP3 Recommendations and Guidelines

An additional important task for this project is the elaboration of recommendations and guidelines in Work Package 3. The gained knowledge will be summarized and extended for the advanced applications considered in WP2. Not only standard situations are therefore analyzed, but also advanced bridge situations such as other bridge types, different corrosion protections, innovative deck solutions or composite connections. This should demonstrate the generality of the method developed in SBRI and also of course allow for conclusions for further application fields. Recommendations for the practical application during bridge design work are prepared and provided. Guidelines for bridge authorities regarding agency needs are elaborated and compiled in order to support during the decision making processes.

WP4 Training for partners involved in seminars

The partners that have realized the different documents and Software (consortium of previous RFCS project SBRI) acquired a deep knowledge about what is needed to be disseminated. The new joined partners (FOSTA, BKE, UPT, CVUT, TECNALIA, UNINA, ATKINS, BmS, UNIZAG and DOMI) of this project have all been chosen as an expert in their countries as far as sustainability assessment of steel and composite bridges is concerned. However, their level of understanding of this topic might differ. Therefore, in order to provide high quality, professional and consistent seminars across Europe a special training for the project's partners will be organized.

The task of Work Package 4 will consist in the organization of an internal Workshop during which partners that have prepared the documents will present and explain the global approach as well as the Software. In this way, it will be ensured that all the seminars will provide harmonized information. This should happen before the partners start with the translations in order to avoid any misunderstandings. In order to avoid additional travel cost, the length of one of the co-ordination meetings will be extended to two days and the second day will be used for the training

WP5 Preparation of workshop materials

The different versions of the documents (Design Manual I, Design Manual II, PowerPoint presentations, SBRI software and software user manual), prepared in the frame of WP1 and WP2 in English, will be translated in the different languages of the partners (Czech, Dutch, French, German, Italian, Portuguese, Polish, Romanian, Spanish, Croatian and Greek). In consequence, it will be possible to present them in the mother tongue to all the seminar participants.

WP6 Dissemination Activities

Work Package 6 deals with the dissemination activities. The main task of this project is the organization of seminars in each of the participating countries. Each partner is responsible for the organization of the seminar in his country. This can be organized on a University campus as well as in a conference centre. Before the event, invitations have to be prepared and distributed to the targeted people. The audience should consist of designers, architects, developers, future steel users such as students and professors. Last but not least the decision makers and bridge authorities are invited. The full day seminar will be organized in a central place in order to target a high attendance. The targeted audience is between 60 and 120 participants for each workshop. During the seminar, printed documents as well as USB Keys that contain all data will be distributed. After the seminars, and further on, after the completion of the project, all data produced will be available for free download on the websites mentioned in WP1.

Moreover, the partners will ensure a wider dissemination by participation to workshops and international conferences, like "Modern Building Materials, Structures and Techniques - MBMST 2016" in Vilnius, "International Colloquium on Stability and Ductility of Steel Structures – SDSS 2016" in Timisoara, "XIIII International Conference on Metal Structures – ICMS" in Zielona Gora, IABSE-Conference 2016 in Stockholm or Eurosteel 2017 in Copenhagen. As most of the participating partners are members of different standardization groups or European Committee, the dissemination of results will be further assured.

WP7 Coordination and Management

The coordination of the global work is covered by Work Package 7. In order to achieve the overall aim of the valorization of knowledge for sustainable steel-composite bridges the interactions of the different tasks and work packages will be assured by the coordinator in order to achieve a focused dissemination work. Administrative issues as well as the communication with the European Commission will be managed in this Work Package.

The project duration is of 24 months. During this time the data are to be collected properly, analyzed and prepared in the two Design Manuals for effective dissemination activities. Within 24 months it will more effectively be possible to develop the Design Manuals for sustainable steel-composite bridges and translate them in several languages, to organize a suitable number of seminars around Europe in a high quality and to prepare the knowledge gained within the SBRI project for the use and application across Europe.

Publications:

Papers

Dissertations

Reports

Conference proceedings

Jorge Teixeira, Constança Rigueiro, Helena Gervásio e Luis Simões da Silva, "SBRI+ - Desenvolvimento de uma aplicação informática para a Análise da Sustentabilidade de Pontes Rodoviárias", Coimbra, 23- 24 Novembro – XICMM 2017.

Contacts:

Luís Simões da Silva
Tel.: +351 239 797 216
Fax: +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

Vernacular Seismic Culture in Portugal | Seismic V

Financing Institution(s): FCT
Promoting Institution(s): University of Minho (UMinho)
Coordinator(s): Paulo Lourenço (local coordinator)

Researchers and collaborators: Graça Vasconcelos, Paulo Lourenço, Javier Ortega

Partner Institutions: High School of Gallaecia (Coordinator); University of Aveiro

Period: July 2013 to October 2015

Relevant facilities: Laboratory equipment and facilities of Civil Department of UMinho.
Objectives:
This research addresses a critical gap in knowledge regarding vernacular architecture earthquake preparedness. The fact remains that Local Seismic Culture (LSC) research in vernacular architecture has had little attention by the Architecture and Engineering scientific communities. This research is based on the fact that vernacular architecture is an outstanding inheritance, from which remarkable solutions can be obtained and reinforced.
The long-term goal of SEISMIC-V is to contribute to the awareness of LSC, but also to propose recommendations to reinforce existing solutions and to avoid common errors. Thereby, it would be necessary to collect data concerning the efforts that were taken by the population in the past, and to contribute to the restoration and repair of the buildings that sustained damage from the earthquake.
The main goal of the research is to contribute to the awareness and protection of the vernacular heritage, as the need to protect this fragile heritage from natural hazards, particularly earthquakes, is evident. For that purpose and aiming at a better understanding of the seismic behavior of Portuguese vernacular constructions and traditional strengthening solutions, the proposed PhD research embraces specific and fundamental objectives:
1. Identification of materials and construction techniques on selected case studies in seismic prone Portuguese regions and its experimental in-situ characterization: 2. Development of a methodology for the seismic vulnerability assessment of vernacular architecture, calibrated with numerical parametric analyses: 3. Application of the proposed methodology on selected case studies and comparative analysis of the seismic performance of the distinct retrofitting techniques using numerical modeling; 4. Identification of common errors and proposal of strengthening solutions that reduce the seismic vulnerability of in-use vernacular architecture, so that guidelines can be accessible to main end-users and decision makers.

Description:
The work plan of the project Seismic V is divided in five technical tasks; (1) literature review; (2) definition of typical buildings representative of vernacular architecture existing in seismic prone regions in which signs of the local seismic culture can be identified based on the selection of region case studies; (3) development of a general methodology for the quantification of the seismic vulnerability of vernacular architecture; (4) numerical assessment of the addition of strengthening solutions to vernacular buildings and evaluation of the reduction of the vulnerability; (5) purpose a systematization of the strengthening solutions for vernacular buildings.
A deep literature review was carried out, namely with a deep insight of the seismic assessment vulnerability methodologies, the starting point of the practical research is the selection and analysis of typical vernacular buildings typical of seismic prone regions ana analysis of their geometry and existence of seismic resistant features. These buildings for study are defined according to the seismicity of the regions. Visual inspection, literature review and, if possible, additional experimental in-situ characterization will be used for the accomplishment of geometrical characterization of typical buildings.
A general methodology for the seismic vulnerability assessment of vernacular buildings was studied. This work was based on the methodologies used for masonry residential buildings and adjusted for the different building typologies defined in the case studies selected in the previous task. The base should be the general large scale methodologies based on earthquake damage observation and focusing on the most important parameters affecting the building seismic response that have been extensively applied in Italy and in several Portuguese historical city centers, obtaining useful and reliable results as a first level approach. The adopted methodology is based on the calculation of a vulnerability index through the evaluation of the most important parameters affecting the seismic behavior of the building based on a hybrid approach. For this, in addition to the literature review on similar methodologies, this research will focus on a series of numerical nonlinear parametric analyses to assess and calibrate the different weights of each parameter of the approach previously defined and this is considered to be relevant for the definition of the seismic vulnerability of vernacular buildings. For this same purpose, some experimental analyses are also envisaged for the evaluation of the influence of the most relevant parameters detected, such as the connections between masonry walls, namely at the corners. Notice that this is a parameter that influences the out-of-plane performance of the masonry walls and, thus, this is intended to be investigated. This experimental analysis will also complement the numerical work carried out on the strengthening solution directed to enhance the intersection of walls.
The next work will be based on the assessment of the seismic

performance of the distinct retrofitting techniques previously identified in the first task to evaluate its effectiveness in the enhancement of the seismic behavior of vernacular buildings. A detailed more complex numerical modeling of single buildings to assess their seismic vulnerability and to evaluate the efficiency of different traditional strengthening techniques was carried out. This is needed to update he seismic vulnerability methodology including retrofitting techniques for seismic performance enhancement. Finally, the results of previous tasks were essential for the fulfillment of the last main objective of the project, which consists of the proposal of strengthening solutions that reduce the seismic vulnerability of in-use vernacular architecture and the development of guidelines that could eventually be accessible to main end-users and decision makers. The identification and update of adequate retrofitting techniques for its eventual application for the preservation of the vernacular building stock was one of the main goal of this research work (Fig. 3).

Publications:

Conference proceedings

Ortega J., Vasconcelos, G., Correia M., An overview of seismic strengthening techniques traditionally applied in vernacular architecture, 07-09 July, University of Minho, 2014. (In CdRom).

Javier Ortega, Graça Vasconcelos, Mariana Correia, Hugo Rodrigues, Paulo Lourenço, Humberto Varum, Seismic vulnerability assessment parameters for Portuguese vernacular constructions through non-linear numerical analysis, 5th International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, 25-27 May, Greece, 2015.

Ortega J., Vasconcelos G., Rodrigues H., Correia M. Seismic behavior of an old masonry building in Vila Real de Santo António, Portugal, Structural Analysis of Historical Constructions: anamnesis, diagnosis, therapy, controls, Proceedings of the 10th international conference on structural analysis of historical constructions, SAHC 2016, pp. 1567-1574, 2016. http://hdl.handle.net/1822/44314

Journal papers

Ortega J., Vasconcelos G., Rodrigues H., Correia M. Traditional Seismic Strengthening Techniques for Vernacular Architecture and Local Seismic Cultures: A Literature Review, Journal of Cultural Heritage, March, 2017.

Contacts:

Paulo Lourenço
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: mendonca@arquitectura.uminho.pt
URL: http://www.isise.net

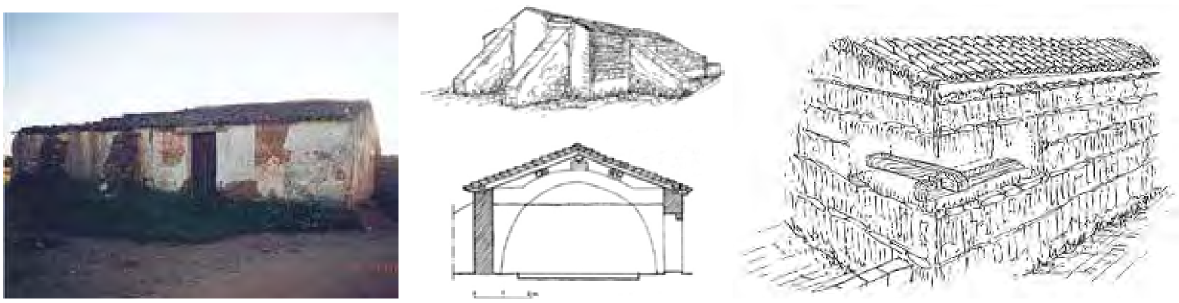


Fig. 1 Typologies of vernacular buildings in Portugal

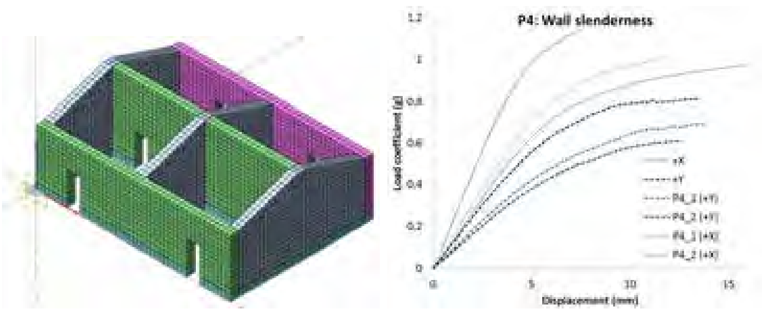


Fig. 2 Some results of the numerical parametric study

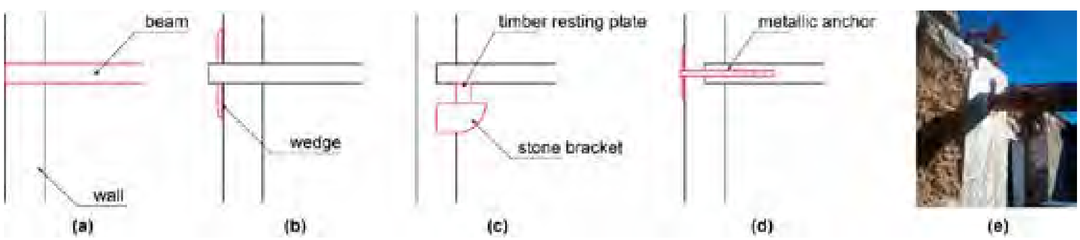


Fig. 3 Strengthening solution for floors

Steel Hybrid Onshore Wind Towers Installed with Minimal Effort | SHOWTIME

Financing Institution(s): Research Fund for Coal and Steel - European Union (EU - RFCS)
Promoting Institution(s): UNIVERSIDADE DE COIMBRA, LULEÅ UNIVERSITY OF TECHNOLOGY, RHEINISCH-WESTFÄLISCHE TECHNISCHE HOCHSCHULE AACHEN, THE UNIVERSITY OF BIRMINGHAM, SIDENOR INVESTIGACIÓN Y DESARROLLO, THE STEEL CONSTRUCTION INSTITUTE, MARTIFER ENERGIA - EQUIPAMENTOS PARA ENERGIA, FRIEDBERG PRODUKTIONSGESELLSCHAFT mbH
Coordinator(s): Carlos Rebelo (UNIVERSIDADE DE COIMBRA)

Researchers and collaborators: Carlos Rebelo, Luis Simões da Silva, Mohammad Mohammadi, Slobodanka Jovašević, Ove Lagerqvist, Efthymios Koltsakis, Markus Feldmann, Carl Richter, Charalampos Baniotopoulos, Diego Herrero, Maite Perez Alonso, Bassam Burgan, Antonia Pilpilidou, A. Matos Silva, Selcuk Güres

Partner Institutions: Institute for Sustainability and Innovation in Structural Engineering (ISISE)

Period: 07/2015 to 06/2018

Relevant facilities: Laboratory of Structures and Materials, Computing cluster

Objectives:
The main aim of this project is to introduce a new hybrid high-rise lattice/tubular tower for the onshore wind turbines with adequate erection mechanism, in compliance with EN1993-1-1 and IEC-61400-1 requirements. The supporting structure consists of the lattice structure, tubular tower and a transition piece. The aeroelastic analysis is done to obtain the aerodynamic loads. Furthermore, the iterative design process is repeated to optimize the geometry and structural properties of the supporting structure components based on the aerodynamic load convergence. The project is also intended the design of the cold form bolted cross section. Further objectives of the project are to design the full scale innovative erection process and the structure including the full life cycle assessment which is followed by downscale prototype of the tower for the erection feasibility test. Besides it would contribute to the advancement of knowledge in the field of high strength steel materials.

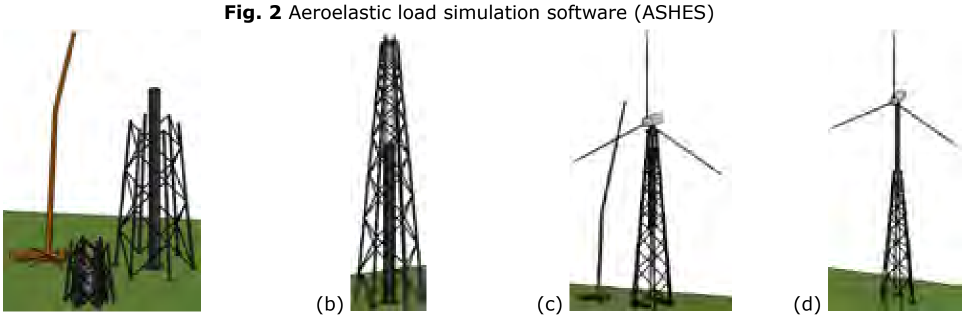
Description:
In the last 20 years, turbines have grown in size from about 0.5 MW in capacity and 60 meters in hub height to around 7 MW and 160 m hub height, although 2 to 5 MW turbines are still the most common. The mean power of the turbines installed in the ten biggest onshore wind farms in Europe commissioned or under construction in 2012 was 2.6MW. It is estimated that the average wind farm will have a turbine size of up to 10 MW by the year 2030.
Today, the onshore wind energy sector has the lowest overall cost of all renewable energy sources; it is also now competitive with conventional energy sources. The decrease in the cost of energy from wind over time has been mainly due to improvements in aerodynamic performance, materials, controls, and electronics and in the balance-of-station costs, such as installation and maintenance.
The turbine tower height determines the design of the turbine component, the foundation and the operational conditions. The wind regime that the rotor experiences is decisive in onshore installations given the influence of nearby natural obstacles, e.g. forests. The design is important, since the structural dynamic properties determine the response of the rotor and the maintenance requirements. Furthermore, the tower must fulfil other important requirements, since it allows access to the turbine nacelle and rotor and houses components of the electrical connection and the control and protection systems. Therefore, all these aspects must be taken into account when optimizing the structural form of higher towers.
The cost of the tower remains an important component of wind energy costs; its value depends on the structural solution, materials and the assembly process. Currently, the cost of the tubular steel tower represents around 15% of the capital cost of the entire megawatt-scale horizontal axis wind turbine (HAWT) installation. Its contribution to the competitiveness of wind energy was mainly achieved through the optimization of the construction process based on the use of tubular segments pre-fabricated and transported to the construction site for assembly.
Future opportunities for growth in wind energy exploitation onshore are contingent on an increase in the height of towers to support larger turbines. For steel construction, that increase leads to tubular towers with a larger diameter which cannot be transported on public roads. Therefore, the main limitation for tubular pre-fabricated towers (transportation) can be overcome only by extra work on site, comprising the assembly of full diameter sections from smaller pieces. Moreover, the installation cost exponentially increase due to the increase of the cranes. Since 1980's, companies started new wind turbine installation. In 1982, Voith and Aeolus I have been erected using pulling devices. The Growian wind turbine has been installed using hydraulic jacks in 1983. Lately, several patents were registered on different self-erecting concepts, e.g. telescoping tower, jack-up and tilt-up concept, and different climbing frames. Several concepts have additional supporting structures rather than tubular towers to facilitate the erection.

The cost estimations show that most of alternatives are economic only for high towers.
An alternative to steel tubular construction is steel lattice structures. This is also familiar technology for a range of tower types, such as for energy transmission lines. The advantages of lattice towers are well known: straightforward design and detailing (simple member and connection design and modelling, easy detailing of members and connections); good dynamic behaviour (ideal for wind turbines); economy of fabrication (lattice towers are cheaper than tubular towers due to the price of the plates, ease of fabrication and ease of protection against corrosion by galvanizing); economy of transportation (lattice angle sections are easier and lighter to transport when compared to tubular structures); simpler erection procedures (flexible scheduling with possibility of parallel working, different erection techniques are feasible); and ecological advantages (highly transparent structure, optimum ecological balance due to galvanizing and small concrete foundations required). The aim of the project is to develop an effective high-rise hybrid lattice\tubular tower with an adequate erection process. The key objectives of the project is to develop a solution that avoids this penalty by taking advantage of the well-established technology for connections between tubular segments and thereby develop a truss structure with a reduced number of joints that are also low maintenance. The application of some of the technological solutions developed in previous projects (HISTWIN, HISTWIN2, FRAMEUP, and LIFTHIGH) whose research teams included most of the partners in the present proposal, will be of great importance for the success of this project.
The project was established based on six work packages; (i) Design and optimization of the lattice\tubular tower considering practical constraints of transportation, erection and the geometry using aeroelastic load simulations, (ii) Design and simulation of the full scale and construction of the scaled prototype of the erection process, (iii) Development of very high strength steel and low-maintenance for preloaded bolts for the new type of connections in normal and aggressive environments, (iv) Design and experimental evaluation of a new cross-section for the lattice part with superior buckling resistance and easy connections, (v) Detailed design, including construction stages and steel-intensive piled foundations; life cycle assessment of best-performing case studies, including cost evaluation; design recommendations (for easy certification); and production of design rules in a format suitable for inclusion in design standards (CEN), and (vi) Coordination and management of the activities performed by partners in the project, as well as dissemination of research results in papers published at conferences and journals and in a workshop of experts.

Contacts:
Carlos Rebelo
Tel.: +351 239 797 209 | Fax: +351 239 797 123
Email: crebelo@dec.uc.pt | URL: http://www.isise.net

Fig. 1 Hybrid Tower concept with components

Fig. 2 Aeroelastic load simulation software (ASHES)



(a) (b) (c) (d)

Fig. 3 Erection mechanism's steps

Seismic Design of Multi-storey CLT buildings | SISMO 2.0

Financing Institution(s): Stora Enso Wood Products Oy Ltd
Promoting Institution(s): University of Minho (PT), Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM).
Coordinator(s): Jorge M. Branco (ISISE-UM).

Researchers and collaborators: Jorge M. Branco (ISISE-UM); Filipe T. Matos (ISISE-UM); Paulo B. Lourenço (ISISE-UM).

Partner Institutions: University of Minho (PT)

Period: November 2016 to October 2017

Relevant facilities: LEST - the Structures Laboratory of the Civil Engineering Department at University of Minho.

Objectives:
This project aims to assess the version under development of the Eurocode 8 for the seismic analysis and design of CLT buildings. Special attention is addressed to the pushover analysis provided in the new proposal for Eurocode 8. The methodology will be based on the results obtained in past researches (e.g., SOPHIE, SISMO, etc.) using experimental result obtained for elements, sub-systems and connections, applying to advanced numerical models calibrated with real scale tests made to a CLT building in a controlled laboratory environment.
The results of this project will lead to major competitiveness gains: i) definition of current standards and design; ii) experimental campaign and numerical modelling of a CLT building; iii) preparation of guidelines and recommendations for seismic design.

Description and Methodology:
As the standard apply rules very general, the options of design seismic and recommendation of CLT constructions, does not guarantee if the buildings had or not a good project. However, the aimed of this project it is the definitions of solutions and measures to implement, in the design and construction of CLT multi-storey buildings, with the special attention to the behaviour when subjected to seismic loading.

<u>Present design methodology (T1)</u>
Definition of the present design methodology and comparison to the premises of the proposal for the revision of Eurocode 8. In this task, the current design methodologies (as studied in SISMO project) will be compared to the Eurocode 8 revision proposal and indications of the main procedures for design will be provided.

<u>Result database (T2)</u>
Application of the results obtained in the SISMO project in a structured database with definition of the application, main mechanical properties and scale of each testes component.

<u>Numerical parametric analysis (T3)</u>
Definition of geometric ratios of CLT panels for the analysis of performance based on a parametric analysis through numerical modelling, based on the results of T2. Presentation of design guidelines based on the strength and stiffness performance of the CLT elements in different combinations, both in geometrical definition (architectural plans) and also accounting the use of different connectors and connection systems. The results of the parametric performance analysis will be determined by its analysis on light of the new proposal of EC8 analysed in T1.

<u>Tests on real size scale multi-storey CLT building (T4)</u>
This task comprises three main phases: i) design of a multi-storey building considering the results obtained in T3; ii) experimental tests; iii) analysis of results.
A two storey full-scale model of CLT house, with approximate dimensions of 6 m x 9 m in plan with a height of 4.9m, will be tested under quasi-static monotonic (pushover) and cyclic loading. The main objectives are to investigate 3-D system performance of CLT structure subjected to lateral loads in terms of lateral strength and deformability capacity, global behaviour of the structure, frequency response of the structure before and after each test, and performance of connectors (mainly hold-downs and brackets) and connections between CLT panels.
Lateral loads will be applied on the storeys of the buildings, inducing torsion to the building. Loading procedure, number and disposition of connectors will be varied between tests.
With this task it is intended to obtain results on: i) load-deformation response of a 3-D CLT structure subjected to lateral loads; ii) global response of the structure, focusing on the performance of CLT slabs subjected to in-plane loads, performance of parallel and perpendicular walls, and response of the structure near openings; iii) failure mechanisms and performance of connections between CLT panels and connectors.

<u>Numerical analysis of the CLT building (T5)</u>
The outcomes of the full-scale CLT house tests will be used for further analytical and numerical analyses to help the implementation of CLT as a structural system in the national standards.

Practice recommendations and improvement proposals (T6)
Preparation of some practice recommendations and improvement proposals to be used in the seismic design of CLT buildings. Those recommendations should aim to simplify the current design methodology and to comply with the new design premises.

Publications:

Papers

Jorge M. Branco, Filipe T. Matos, and Paulo B. Lourenço. "Experimental in-plane evaluation of light timber walls panels", Buildings. .

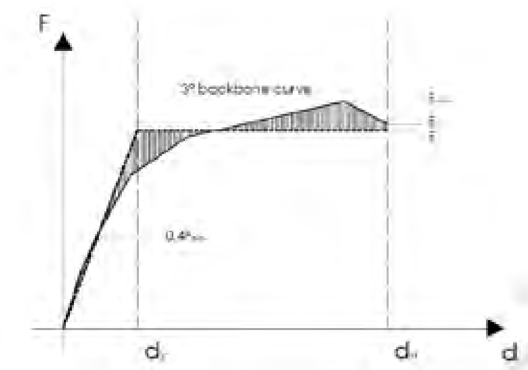


Fig. 1 Equivalent elasto plastic curve (Anexx D – New version of Eurocode8)

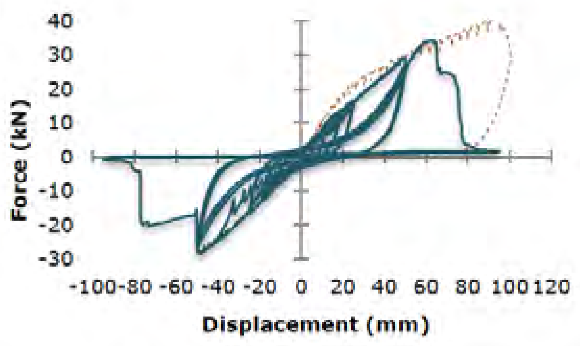


Fig. 2 Monotonic and cyclic test.

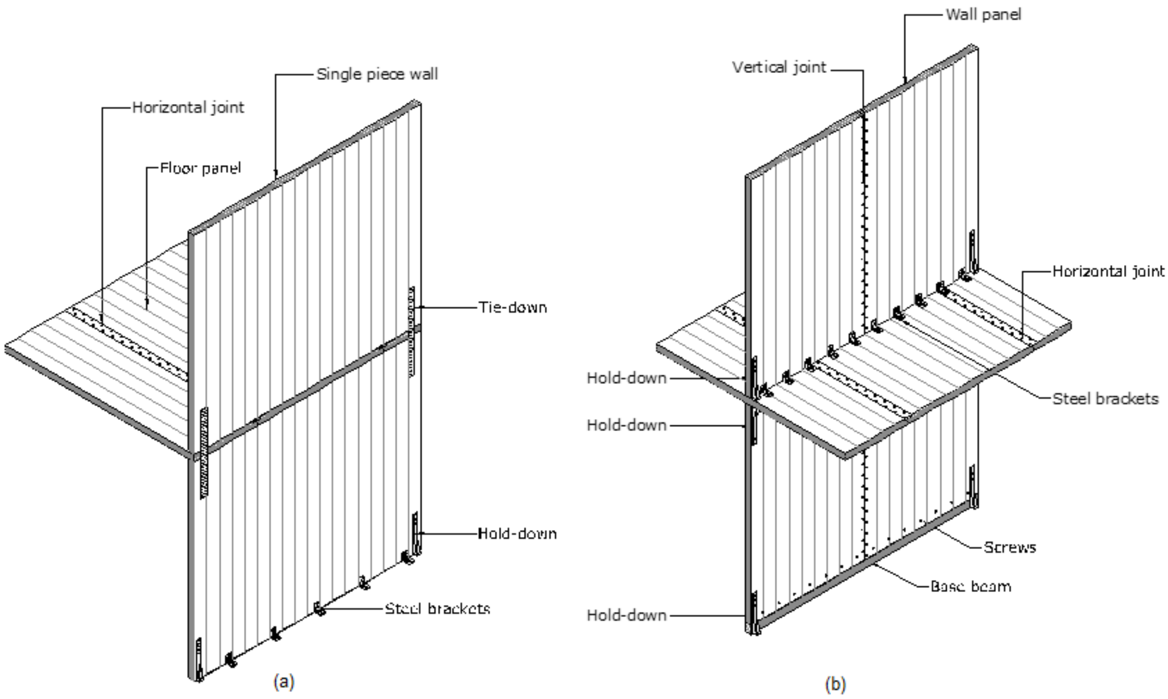


Fig. 3 Monolithic (a) and segmented (b) of Cross Laminated Timber buildings. (New version of Eurocode8)

Flat slabs for multi-storey buildings using hybrid reinforced self-compacting concrete: an innovative structural system | SlabSys-HFRC

Financing Institution(s): FCT
Promoting Institution(s): University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UM)
Coordinator(s): Vítor Manuel do Couto Fernandes da Cunha (ISISE-UM)

Researchers and collaborators: Joaquim Barros (ISISE-UM), Amin Abrishambaf (ISISE-UM), António Ventura Gouveia (ISISE-IPV), Eduardo Pereira (ISISE-UM), Lúcio Lourenço (CiviTest), Bernardo Neto (ISISE-UM)
Partner Institutions: Casais SA., CiviTest Lda.

Period: April 2012 to September 2015

Relevant facilities: Servo close-loop equipments for experimental programs; FEMIX V4.0 Finite Element package

Objectives:
This project aims to contribute for the development of a new generation of flat slabs, for multi-storey buildings, made of hybrid fibre reinforced concrete, by substituting most of the conventional reinforcement of the slab with hybrid discrete fibres, and by using concrete mixes with self-compacting ability. When compared to conventionally reinforced concrete (RC) flat slabs, the proposed structural system should have an enhanced cracking behaviour and flexural stiffness for serviceability limit states, while maintaining a flexural ductile failure mode for ultimate limit states. Also, several benefits are harvested regarding construction times and quality, labour costs, sustainability during construction, cracking behaviour, as well as increased durability. The proposed structural system has an enhanced cracking behaviour and flexural stiffness for serviceability limit states, while maintaining a flexural ductile failure mode for ultimate limit states.

Description:
In traditional techniques for executing RC flat slabs, placement of reinforcement is one of the most time consuming tasks, which involves a lot of workforce (with frequent occurrence of injuries) and equipment. The replacement of conventional rebar by discrete fibres, with significant benefits in regard to time of construction (and with a competitive price), has been made in many applications of slabs on grade with a quite good performance. Nevertheless, conventional fibre reinforced concrete, FRC, is yet seen suspiciously by the construction professionals. For this, much contributes the high coefficients of variation, CoV, of the material's mechanical strengths. The appearance and dissemination of new advanced cement matrices with self-compacting capability contributed to an increase of the confidence level on these FRC. This confidence step-up, mainly due to lower CoV pushed forward the utilization of self-compacting FRC for slabs suspended on piles (with considerable reduction of rebar). The outcome of FRC with enhanced mechanical strengths has been pushing the span limits upwards.

The main purpose of this research project is to develop a high performance reinforcing system that can be a competitive alternative to conventional RC slabs of multi-storey buildings. The studies to be conducted include the use of hybrid fibre reinforcement with high and low E-modulus fibres. The proposed system also includes the existence of embedded beams (with conventional rebar) in the alignment of the columns, in order to assure increased stiffness and ductility. This will result in a material termed as HFRSCC: Hybrid Fibre Reinforced Self-Compacting Concrete. The research tasks comprised in the project include: i) Development of a HFRSCC mixture; ii) Material characterization of HFRSCC; iii) Assessment of the structural performance of HFRSCC; iv) Quality control and establishment of parameter estimation methodology for design purposes; v) Punching shear behaviour (experimental and numerical research); vi) Construction of a full scale prototype; vii) Guide for construction and design of HFRSCC slabs.

Within structural performance of HFRSCC, punching resistance can be a concern in this structural system. In fact, punching has a brittle failure nature, and the prediction of the punching resistance is still a challenge, even in conventional concrete reinforced slabs. The difficulties on assessing the contribution of the reinforcement mechanisms of steel fibres for the flexural and shear resistance in the critical punching perimeter increase this complexity. In a first stage,
It was aimed to assess the reliability of existing analytical models for the prediction of the punching resistance of SFRC slabs. For this purpose, a comprehensive experimental campaign with SFRC slabs failing in punching was carried out. The predictive performance of analytical models available in literature was assessed. It was developed a more practical model, which is more reliable from a physical and mechanical point of views, therefore in order to accomplish the prior premises, the concepts proposed by Model Code 2010 for the characterization of the post-cracking behaviour of FRC were introduced in the developed model.

The construction and evaluation of a full or large scale prototype is one of the most important outcomes of the

present research project, as it will allow: (i) proving that the system actually works at real scale, with satisfactory performance both in terms of service
life loads (cracking and deflections) and ultimate limit state loads (load capacity and ductility); (ii) checking the feasibility of the developed analytical and numerical models, used together with the material characterization and the quality control testing; (iii) evaluating the practical feasibility of establishing simplified design guidelines. The full scale prototype will comprise a one-storey building with six columns (3 metres tall) that support two square slab bays with 5m x 5m, and embedded RC beams spanning along column support lines. Meanwhile, in an intermediate research stage, a one fourth scale prototype of an elevated steel fibre reinforced slab structural system was built (Figure 1). The elevated slab, with a length x width x thickness of 3.7x2.1x0.075 m, is supported on 12 columns of square cross section of 0.1 mm edge. The distance between columns in the X and Y directions is 1.2 m and 1.0 m, respectively. The deformational behaviour of the structural prototype was assessed under loading conditions corresponding to serviceability limit states (Figure 1h). Within the second stage of the latter task, the behaviour of this structural system under ultimate limit conditions will be also assessed.

To sum it up, the proposed structural system has an enhanced cracking behaviour and flexural stiffness for serviceability limit states, while maintaining a flexural ductile failure mode for ultimate limit states. The following objectives were attained:

i) Development of fibre reinforced concrete self-compacting mixtures with high residual strength. Mechanical and structural behaviour characterization.
ii) Assessment of the fibres' micromechanical behaviour under both monotonic and long-term conditions.
iii) Estimation of the mechanical properties variation within the structural system due to the anisometric fibre distribution.
iv) Experimental characterization of the punching shear behaviour of the developed structural system.
v) Development of analytical and numerical tools for predicting the ultimate loading capacity and deformational response.
vi) Construction and load testing of a 1/4 scale prototype to demonstrate the developed structural system and assess the structural behaviour.

Publications:
Two PhD. Thesis, one MSc. Thesis, seven articles in international ISI journals, one article in national journals, nine articles in proceedings of national and international conferences and four reports.

Contacts:
Vítor M.C.F. Cunha
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: vcunha@civil.uminho.pt
URL: http://www.isise.net

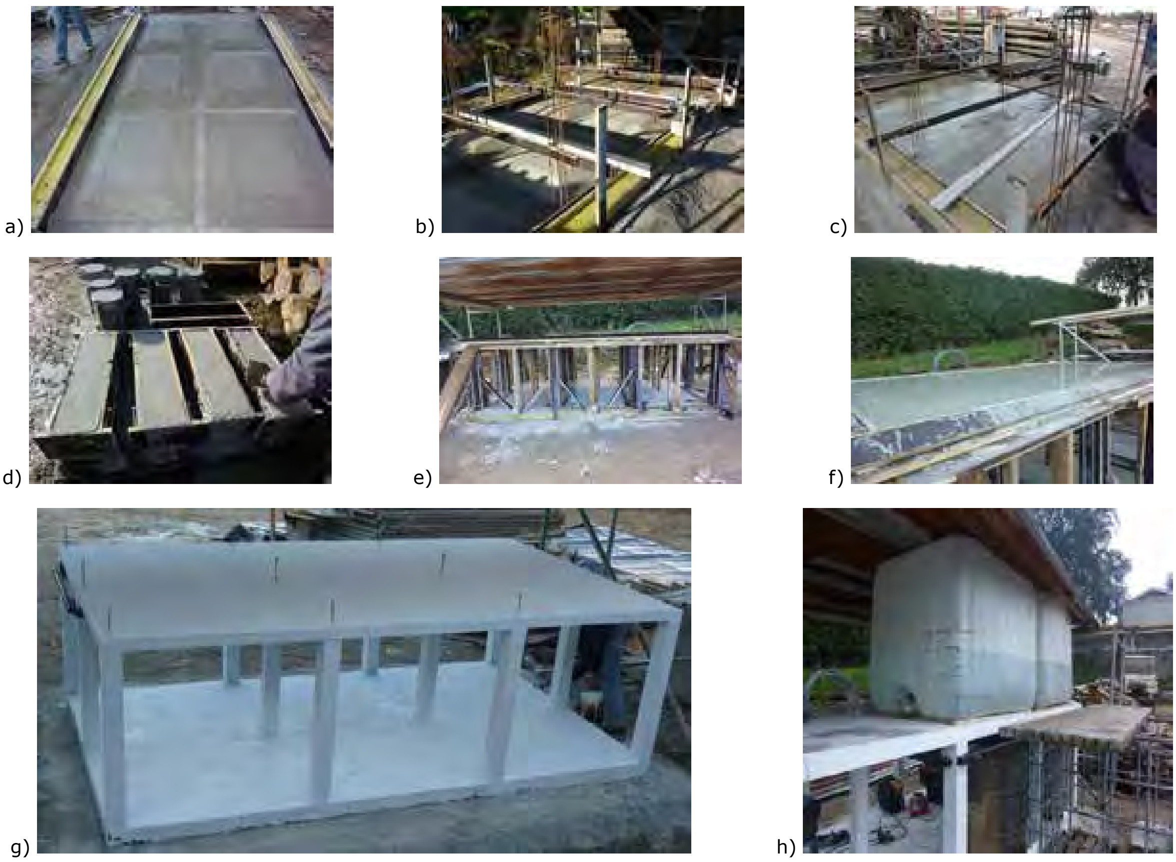


Fig. 1 The construction suspended slab prototype: (a) preparation of the foundation for the slab on grade; b) Reinforcement of the columns; c) casting the slab on grade (1st batch); d) casting the SFRSCC specimens; e) casting the columns (2nd batch); f) casting the elevated slab; g) general view of the prototype after has construction; h) Water tanks loading corresponding to the serviceability limit states

South Mediterranian Welding Center for Education, Training and Quality Control | SM Weld

Financing Institution(s): EC-ERASMUS+
Promoting Institution(s): KTH, Royal Institute of Technology
Coordinator(s): Mihai Nicolescu (KTH); Dulce Rodrigues (ISISE-UC); Hilde Garcia (ULE); Elena Scutelnicu (UDG); Tobias Rosado (EWF); Nourdine Ouali (USTHB); Salim Meziani (UFMC); Abdelwaheb Dogui (ENIM); Mohamed Belhaj (US); Steffen Keitel (GSI); Anastasios Vasiliadis (IED); George Gherman (R&G); Abdelaziz Guargouri (SOCOMININ); Ikram Makni (CCIS); Rabah Tlili (TECHNOPREST SARL); Gueridi Achour (SNVI); Heguehoug Saaden (ENSP); Abdelaziz Talbi (GERMAN)

Researchers and collaborators from UC: Altino Loureiro (CEMMPRE - UC); Albano Cavaleiro (CEMMPRE-UC); José Costa (ADAI-UC).

Partner Institutions: KTU (Sweden), University of Coimbra - UC (Portugal), University of Leon (Spain), Universitatea Dunarea de Jos din Galati-GALATI (Romania), European Welding Federation - EWF (Belgium), German Institute for Welding - GSI (Germany), Institute of Entrepreneurship Development – IED (Greece), R&G (Sweden), National Engineering School of Monastir – ENIM (Tunisia), University of Sfax – USFAX (Tunisia), University of Science and Technology Houari Boumediène – USTHB (Algery), University Frère Mentouri of Constantine – UFMC (Algeria), SOCOMINIM (Tunisia), Sfax Chamber of Commerce & Industry – CCIS (Tunisia), TECHNOPREST SARL (Tunisia), Enterprise Nationale des Véhicules Industriels – SNVI (Algeria), Entrepise Nationale de Service aus Puits/Service fabrication – ENSP (Algeria), Societe des Materiels de Gerbage et de Manutention – GERMAN (Algeria)

Period: October 2015 to October 2018

Relevant facilities: Equipment and expertise in destructive testing of welds (UC); Welding equipment and similar facilities at other partner institutions.

Objectives:
The SM Weld project will establish a Welding Centre in the participating countries – Algeria and Tunisia – to coordinate the partnerships in place and implement welding quality certification of companies. This will be achieved through a comprehensive initiative encompassing learning innovation, specialization, training and qualification through the creation of welding and joining consultancy, welding trainers and welding audit firms. The new educational and training model proposed by SM WELD aims at enhancing the employability of academic and technical personnel as well as fostering the entrepreneurial culture, thus contributing to the improvement of living standards. Another dimension is to drive the quality of the workforce while contributing to knowledge transfer, while supplying the North-African industry with highly qualified personnel. SM WELD objectives are structured for three main audiences - the Academic community, Welding Personnel and Companies who need certification in welding in compliance with ISO 3884.

Description and Methodology:
A new educational and training model is proposed by SM WELD to enhance the employability of academic and technical personnel as well as creating entrepreneurial incitements and by this contributing to the improvement of the standard of life. As the need for modernization of curricula and its adaptation to the industry requirements is apparent, the academic institutions and Ministries of Education in PCs are committed to implement the welding education programmes. Short and long term strategic decisions have been discussed and will be considered as the part of education and training curriculum development. The SM Weld will efficient manage the project implementation by organizing the partners in three clusters working in 7 work packages.

WP1 SM Weld Framework and Consolidation of the strategic goals
In this work package the main task is to formulate an integrated framework considering the strategic objectives formulated at national and regional level. The framework formalizes the liaisons among work packages and establishes guidelines for the 13 activities and defining the model for Education and Qualification of Welding Personnel in PCs.

WP2 Establishing of Master Specialization in Welding and Joining and Development of Curriculum
The curricula and Syllabus will be developed according to the methodology formulated at D1.3 and to European requirements for IWE/IWT certification. The curriculum will contain basic subjects, competence welding courses and general courses in culture and business. The curricula will be in modular form in order to be better adapted for each PC university needs. Also modernization of curricula to take into account the progress made in industry, will be possible by a modular structure.

WP3 Welding Training and Certification System
This WP will set the guidelines for the education, training, examination and qualification of welding personnel, and will prepare the training material. Industrial organizations will have an active role in the specification of the training programme and training of the staff.
Development of curricula for training for certification.

There are three routes which could be implemented, standard route, self-going route and distance learning programs. The Standard Route requires attendance at approved Training Courses designed to meet the requirements specified in curricula. The Self-going Route allows those who have gained the knowledge and who can demonstrate it, to proceed to examination without compulsory attendance at an approved Training Course. In this deliverable will be decide the levels of welding.

WP4 Quality Assurance and Control

A quality assurance plan will be created at the start of the project (M3) to ensure that an integrated quality approach is built into all project elements and activities throughout the phases of the project life cycle. The project coordinator coordinates the Quality Plan:

- Create quality goals and standards for each deliverable and activity
- Agreement from the team members on acceptable deliverable quality criteria

WP5 Dissemination and Knowledge Database

A Newsletter for Welding Centre will be available every three months. Workshops, industrial and educational seminars are carried out.

The dissemination activities will be partly focusing the academic and training levels and partly the organizational level. For the organizational level, workshops and seminars with companies will be organized about the implementation for ISO 3834 and quality procedure for welding technology. Concerning the SM Welding and Joining Center a constitutive meeting will be organized with participation of the companies, universities and governmental and other public organizations. All these activities will support the exploitation plan described in WP6. IIW/EWS contacts will be established. Stakeholder database.

WP6 Welding Centre organization

At the end of project, the WJC will initiate and control the development and implementation of academic and training programmes as well as coordinating the implementation of quality procedures according to ISO3834 in companies. Welding Centre will strive to promote the System for Education and Qualification of Welding Personnel outside the Maghreb region as part of exploitation plan.

The main costs for Welding Centre will be covered by personnel and company certification fees, membership's fees, consulting activities. Part of this amount of money will be invested in enlarging the cooperation, to develop training material and grant to students studying welding specialization. The Centre will be equipped with welding equipment, test and instrumentation for non-destructive analysis, as well as with a welding simulator.

Business Plan forms the foundation for project exploitation and exploitation plan. It is expected that employability to increase by 60% for welders in North of Africa after fully implementation of the Business and Exploitation Plan.

The WJC will represent a tangible exploitation product of partnerships University-Industry.

WP7 Project Coordination and Administration

The consortium members already have a history of cooperation in other educational joint ventures and see the SM Weld as a major opportunity to accomplish a high quality University - Industry Partnership. The management will be based on a strategic thinking to make it possible to define measurable results the project should achieve. The project will be regarded as a linked chain of measured achievements. Every partner should understand from the start of the project what the end result will look like. By engaging into active cooperation, the partners will make conceptual decisions. The Project Management Group (PMG) will consist of the contact persons from each consortium member university. The overall management of the project activities will be implemented by this group in close collaboration with other university members involved in the project. For an effective project management and efficient distribution of resources, the project work is distributed in three clusters

Contacts:
Dulce Rodrigues
Tel.: +351 239 790 748
Fax: +351 239 790 701
Email: dulce.rodrigues@dem.uc.pt
URL: http://www.isise.net

SM WELD

SUstainability-driven international/intersectoral Partnership for Education and Research on modelling next generation CONCRETE | SUPERCONCRETE

Financing Institution(s): Horizon 2020, Call H2020-MSCA-RISE-2014, Proposal number SEP-210168181
Promoting Institution(s): Universita Degli Studi di Salerno (Italy)
Coordinator(s): Enzo Martinelli (Joaquim Barros in SC-UM)

Researchers and collaborators: Joaquim A.O. Barros; J.M. Sena-Cruz, Eduardo N.B. Pereira, Miguel. A.D. Azenha, M. Isabel B. Valente, Vítor M.C.F. Cunha; Cristina M.V. Frazão

Partner Institutions: Universidade do Minho (Portugal), Technische Universiteit Delft (Germany), Fundacion Tecnalia Research & Innovation (Spain), MFPA Leipzig GmbH (Germany), University of Michigan the Regents of the University of Michigan (USA), Universidad de Buenos Aires (Argentina), UFRJ (Brazil)

Period: 01 July 2015 to 30 June 2019

Relevant facilities: FEMIX V4.0 Finite Element package; Laboratory equipment and facilities of Civil Department of UMinho.

Objectives:
SUPERCONCRETE is a cross-disciplinary international/intersectoral project addressing the formulation of theoretical models for next-generation concrete materials, characterised by a significant potential for enhancing sustainability of the construction industry. It deals with three main concrete classes (CCs) that represent the key research lines of the project: i) Low-Carbon Concrete (LCC), characterised by non-conventional constituents, often derived from recycling industrial waste or by-products; ii) High-Class Concrete (HCC), encompassing materials with enhanced performance in terms of either strength or durability; iii) Fibre-reinforced Cementicious Composites (FCC), with engineering properties by optimizing fibre reinforcement and matrix performance. Developing a comprehensive through-life models for these novel materials is the key objective of the SUPERCONCRETE project. Particularly, three transversal modelling issues are considered: i) Rheology and Early age, dealing with a multi-physics integrated approach coupling thermo-hygro-chemical phenomena occurred in the first hours after mixing; ii) Hardened state and service life, approached by constitutive modelling intended at predicting the instantaneous and long-term behaviour, for both service and ultimate limit conditions; iii) Extreme conditions, based on constitutive theories capable of simulating the response under fire and high temperature exposure. SUPERCONCRETE's final deliverables will be: i) a joint international course on sustainable concretes; 2) an underlying textbook; and 3) a web-based platform for interacting with students and practitioners.

Description and Methodology:
Recent developments in material science show the need for more sustainable production processes development (in terms of both efficiency in raw materials utilisation and reduction of green-house gas emissions) and are being reverberated by the concrete industry, which is currently one of the most resource demanding and emission producing branches of human activities. Therefore, next generation concretes do still mainly exist in research laboratories, but are on the doorstep to be introduced in practice where they can offer many new possibilities in structural engineering applications for civil buildings and infrastructure. Several classifications can be considered for such materials, but the following one will be adopted in the SUPERCONCRETE project:

- Low Carbon Concrete (LCC): environmentally-friendly concrete made by partly (to totally) replacing ordinary aggregates with recycled ones, often obtained by crushed and processed concrete debris; the use of other industrial by-products, both as filler or cement replacement, are also possible;
- High-Class Concrete (HCC): concrete meeting special combinations of performances, uniformity requirements and "possessing the following three properties: high-workability, high-strength, and/or high durability": in fact, it needs special theoretical formulations for modelling their through-life mechanical behaviour;
- Fibre-reinforced Cementitious Composites (FCC): fibre/textile reinforced cement-based matrix also presenting self-compacting features, which were considered as "the most revolutionary development in concrete construction for several decades".

Regarding the research methodology, the SUPERCONCRETE project is clearly characterised by a cross-disciplinary, multi-scale and multi-physics approach based on the competences generally required in Material Science (at different scales of observation) and Structural Engineering, in order to achieve synergistic effects from collaboration across modelling disciplines. This is the most appropriate and effective methodology to study the material behaviour of the selected concretes in the SUPERCONCRETE project. It will deepen the accuracy on multi-scale model development and enhance the understanding about physical/mechanical properties and the effects on the structural performance, through next generation models, while encompassing the through-life materials span, from constituent selection and processing up to the various relevant service-life loading conditions. Particularly, the three following stages will be addressed in the project activities: Rheology and early age phenomena; Hardened state and service life; Behaviour under extreme conditions.

The research on the aforementioned "next generation" materials and the interest for these through-life modelling issues is fundamentally driven by the objective of defining and quantifying a "Sustainability index", depending on the constituents and production procedure. Therefore, cross-cutting sustainability-related aspects are, at one time, the motivation and the final goal of the SUPERCONCRETE activities.

Therefore, the current research project aims at formulating a unified set of constitutive theories and material models capable of simulating the behaviour of the three aforementioned classes of concretes throughout their whole life cycle, starting from the reactivity analysis of constituents down to the resulting properties of the concrete mixture from the early age to their whole service life and exposure to extreme conditions.

Fig. 1 proposes a conceptual map of the activities and the planned interactions among the project participants. Three research-based WPs (namely, WP2, WP3 and WP4) can be intended as parallel investigation lines about the three "next generation" concrete materials under consideration for this project (namely, LCC, HCC and FCC). The activities belonging to these WPs can be regularly subdivided into the flowing tasks:

Task 1: Classification, definition of properties and procedures for the mechanical characterisation;

Task 2: Formulation of theoretical modelling for materials for rheology and early age phenomena;

Task 3: Formulation of theoretical modelling for materials under service life loading scenarios;

Task 4: Formulation of theoretical modelling for materials under extreme conditions.

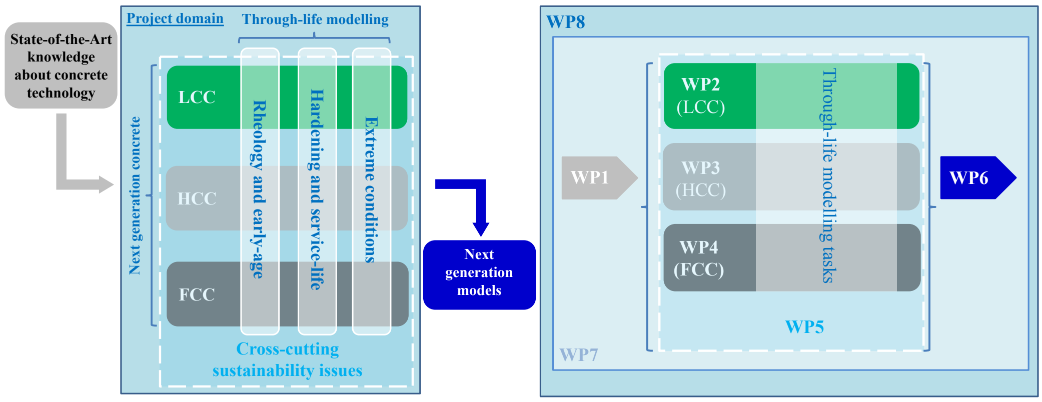


Fig. 1 Conceptual map of activities work packages and interaction among participants

Fig. 2 shows the matrix-like interaction structure between the participating organisations. Particularly, all cells of this matrix correspond to possibly common activities (and, correspondingly, a certain number of secondment months) of project participants and represent eligible secondments between the European Universities mentioned in the rows and the other institutions listed in the columns, as part of either international or intersectoral mobilities.

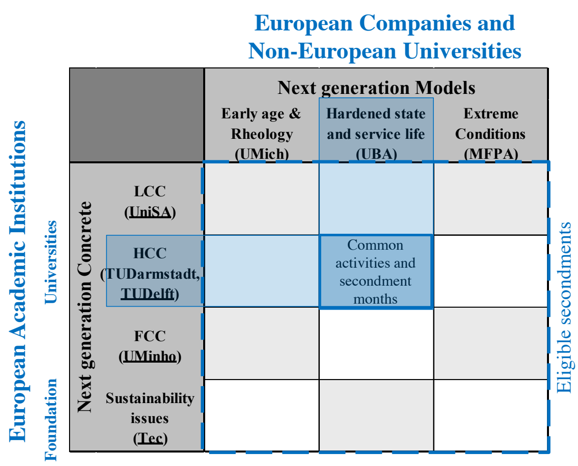


Fig. 2 Schematic matrix representation of participants' contributions and interactions

The SUPERCONCRETE project basically aims at improving the level of knowledge of the technical community in utilising advanced low carbon (LCC), high-class (HCC) and ductile fibre reinforced (FCC) concretes, as possible solutions for enhancing sustainability in the construction sector of tomorrow. Therefore, the knowledge gained in this project will be transferred to the next generation of students that will be more aware and better trained in using "next generation" theoretical models capable of predicting the physical properties and the mechanical behaviour of the aforementioned materials which will be consequently made fully available for the building industry.

The construction sector will significantly benefit from the SUPERCONCRETE project on advanced and more sustainable concretes in terms of knowledge development or by potential business development of new concrete products. The educational teaching course for sustainable solutions in industrial applications will support this by acting as a source of information and education, especially for those companies who are seeking potential environmental improvements in their human resources, also for those who want to invest in enhancing the education level of their employees.

Contacts:

Joaquim António Oliveira de Barros
Tel.: +351 253510210/747
Email: barros@civil.uminho.pt
URL: http://www.isise.net

Sustainable Infrastruture Management System| SUSTIMS

Financing Institution(s): AdI – Agencia de Inovação
Promoting Institution(s): ASCENDI, Universidade Nova de Lisboa (UNL), University of Minho (UMinho)
Coordinator(s): Ugo Berardinelli (ASCENDI), Luis Neves (UNL), Paulo Lourenço (UM)

Researchers and collaborators: U. Berardinelli (ASCENDI), A. Santos (ASCENDI), A. Ferreira (ASCENDI), A. Meireles (ASCENDI), R. Sarmento (ASCENDI), V. Corte-Real (ASCENDI), L. Neves (UNL), C. Ferreira (UNL), P. Lourenço (UM), J. Matos (UM), J. Soares (UM), R. Martins (UM), A. Correia (UM), T. Miranda (UM), M. Pinheiro (UM), P. Pereira (UM), J. Oliveira (UM), A. Moreira (UM), J. Monteiro (UM), J. Cabral (UM), J. Mendes (UM), J. Miranda (UM), P. Gonçalves (UM), T. Gomes (UM).

Partner Institutions: ASCENDI (Portugal), Universidade Nova de Lisboa (Portugal), Universidade do Minho (Portugal)

Period: September 2012 to June 2015

Relevant facilities: Computational and electronic equipment, and software of civil and electronic engineering department of University of Minho.

Objectives:
SustIMS, short name for Sustainable Infrastructure Management System, results from a collaboration project between Ascendi IGI, Universidade do Minho and the Universidade Nova de Lisboa, co-financed in the scope of the QREN, which was developed during 3 years, between the end of 2012 and 2015. The main goal of this project was to develop a road infrastructures' sustainable management platform that enabled through one single system the management of any road infrastructure. The infrastruture modules included so far are: bridges, pavements, retaining walls and slopes and telematics. The needs felt by Ascendi, as a Motorway Concessionaire, regarding the infrastructures management, are the same its counterparts feel, in Portugal or any other area of the globe, such as the fulfilment of the quality levels imposed by the respective supervisory authorities.
In this scope, one of Ascendi's main motivations for the development of this tool, was to create a technological solution that would, sustainably and in an integrated manner, support the management of road infrastructures in regard to some of its main elements – pavements, bridges, retaining walls, slopes and telematics, ensuring the fulfilment of the legal and contractual parameters in terms of quality standards, as well as applying the best maintenance strategies, thus optimizing time and resources.

Description and Methodology:

Task 1 – Develop of new knowledges for the project

Task 1.1 Predicting model for the infrastructure
This task consisted on the development of a predicting model for the different components of the rood network, namely pavements, retaining walls, slopes, telematics and bridges. In this way, Markovian models were developed.

Task 1.2. Effects of the maintenance and rehabilitation (M&R) actions
This task included the determination of the effect of maintenance and rehabilitation actions on the condition of the different elements of the infrastructure. Thus, to feed the database of the management system, a set of information was compiled.

Task 1.3. Optimization process of the M&R strategies
This task has the objective of developing a tool to optimize maintenance strategies. As with most real problems, optimizing maintenance strategies for road elements involves the consideration of multiple objectives. Therefore, the optimization problem is formulated as a multiobjective optimization problem, with the performance of the road elements and maintenance cost to represent the main objectives.

Task 2. Development phase

Task 2.1. Development of the database of the infrastructures
The primary objective of this task was the development of a database capable of adapting to any geographical or socioeconomic context, thus being open, flexible and easily scalable. In this way, the task included three distinct consecutive stages, namely: (i) Definition of the data model; (ii) Implementation of the database; (iii) Data loading.

Task 2.2. Management platform
The management platform aims to ensure the management of all the information coming from the registration of all functional modules and then implementing functionalities namely: Visual Inspections, Performance and Optimization. The Management Platform of the SustIMS solution was developed according to a SOA (service-oriented-architecture) architecture supported in 3 layers: (i) Data Layer; (ii) Business Layer; (iii) Presentation Layer.

Task 2.3. Extrinsic monitoring systems for the infrastructures
In this task, a generic Wireless Sensor Network (WSN) was developed to encompass two systems: (i) SDC (Collision Detection System), that detects the acceleration of the

security guards of the highway, allowing to automate the accident detection procedure for the concessionaire; (ii) SMMT (Wall and Slope Monitoring System), a new application of the same infrastructure created in the SDC, however, with a slightly different behaviour.

Task 2.4. Intrinsic monitoring systems for the infrastructures
This task was divided into two subtasks: (i) The first, aimed at researching and developing the interface between the Wireless Sensor Network (WSN) and its internet connection; (ii) The second, as the main objective of presentation of information collected on a web page, as well as all necessary high-level programming, such as webservices and database.

Task 3: Framework tests
Task 3.1. Laboratory tests of the management systems
This task included the validation of optimization software, performed through computational tests, considering different case studies. The results were discussed at internal meetings and faced with real scenarios. For the execution of the tests, the data related to the elements of a sub-stretch of the A29 highway, including condition states, the effects and costs of the maintenance actions applied to these elements, as well as the degradation models developed throughout this project.

Task 3.2. Laboratory tests of the management systems
Several tests were performed in laboratories, however, only those that had a significant impact were documented, given the great diversity of tests carried out throughout the project. The black point test was intended to find out the maximum coverage distance of the WSN that could be obtained at the installation site.

Task 4. Case Studies
In the scope of task 4, tests were carried out with real data on the performance models, for each module of the road network, i.e., walls and slopes, telematics, works of art and pavements, and module-to-module optimization and, subsequently, directly integrated into the management platform.

Publications:

Journal Papers

Denysiuk, R., Fernandes, J., Matos, J. C., Neves, L. C., & Berardinelli, U. (2016). A Computational Framework for Infrastructure Asset Maintenance Scheduling. Structural Engineering International, 26(2), 94-102.

Denysiuk, R., Moreira, A. V., Matos, J. C., Oliveira, J. R., & Santos, A. (2017). Two-Stage Multiobjective Optimization of Maintenance Scheduling for Pavements. Journal of Infrastructure Systems, 04017001.

Conference Papers

Roman Denysiuk, José C. Matos, Joaquim Tinoco, Tiago Miranda and António Gomes Correia. Multiobjective Optimization of Maintenance Scheduling: Application to Slopes and Retaining Walls. In: António Gomes Correia (Ed.), Advances in Transportation Geotechnics III. Volume 143 of Procedia Engineering, pages 666-673. Elsevier. DOI: 10.1016/j.proeng.2016.06.095.

Gonçalves, B., Matos, J. C., Lourenço, P. B. (2014) "Streamlining field inspections for infrastructures life-cycle management" CNME2014 9º Congresso Nacional de Mecânica Experimental, Aveiro – Portugal, 15-17 October 2014, http://hdl.handle.net/1822/30848 (oral communication – Portuguese).

Fernandes, S., Matos, J. C., Cabral, J., Corte-Real, V. (2014) "Desenvolvimento de um modelo de desempenho para equipamentos de telemática em autoestradas" JPEE 2014 5ª Jornadas Portuguesas de Engenharia de Estruturas, Lisbon – Portugal, 26-28 November 2014, http://hdl.handle.net/1822/30844 (oral communication – Portuguese).

Ferreira, C., Neves, L. C., Matos, J. C., Soares, J. M. S. (2014) "A degradation and maintenance model: Application to Portuguese Context" IABMAS 2014, 7th International Conference on Bridge Maintenance, Safety and Management, Shanghai - China, 7-11 July 2014, http://hdl.handle.net/1822/30842 (oral communication – English).

Contacts:
José Campos e Matos
Tel.: +351 253 510 200
Fax: +351 253 510 217
Email: jmatos@civil.uminho.pt
URL: http://www.isise.net

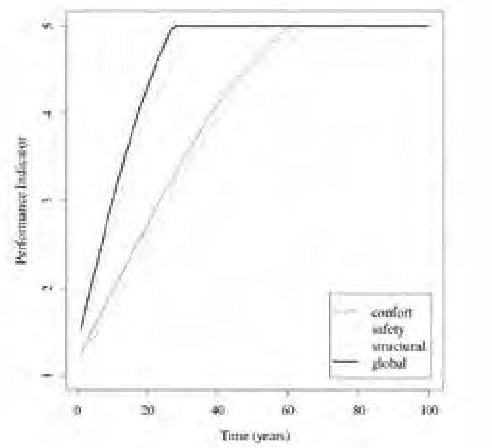


Fig. 1 Performance indicator along the time for pavements (Task 1.1)

Fig. 2 Example of a graphic with all the type of sensors (task 2.4)

Stability design of non-uniform steel members | TaperSteel

Financing Institution(s): FCT
Promoting Institution(s): University of Aveiro (UA)
Coordinator(s): Paulo Vila Real

Researchers and collaborators: Paulo Vila Real (UA); Luís Simões da Silva (ISISE-UC); Trayana Tankova (ISISE-UC); Liliana Marques (ISISE-UC); Carlos Couto (UA); Nuno Lopes (UA); João Ferreira (UA); João Pedro Martins (ISISE-UC)

Partner Institutions: Institute for Sustainability and Innovation in Structural Engineering (ISISE).

Period: April 2013 to March 2015

Relevant facilities: Computational equipment and laboratory of Civil department of FCTUC.

Objectives:
Non-uniform steel members are commonly used over prismatic members because of their structural efficiency: by optimizing cross-section utilization, significant material can be saved. EC3 provides several methodologies for the stability verification of members and frames. Regarding non-uniform members in general, with tapered cross-section, irregular distribution of restraints, non-linear axis, castellated, etc., several difficulties are noted. Not only there are yet no guidelines to overcome any of these issues, but also existing rules for these types of members are mechanically inconsistent. As a result, safety verification is conservative, not accounting for the advantages non-uniform members provide. TaperSteel deals with the stability design of non-uniform members and structural systems subject to an arbitrary loading. The buckling phenomena are properly accounted for by mechanically consistent generalized imperfections and calibrated parameters to account for the member non-uniformity. Through further implementation of results in EC3, a more economic design will be achieved. The objectives of the project are:

- Application of the safety assessment procedure to the General Method in EC3-1-1 to a range of non-uniform isolated members and frames;
- Development of a mechanical generalized slenderness model for the any stability phenomena of non-uniform isolated members;
- Properly account for the interaction between local cross-section and member bucking phenomena;
- Safety assessment of the developed rules;
- Contribution towards the revision of EC3-1-1, by achieving transparent, simple and straight-forward unified stability check procedures.

Description and Methodology:
The main objectives of this project were firstly to develop rules for stability verification for a wide range of tapered columns and beams and with this to propose a new formulation of the General Method for frames and systems. At the same time, guidelines were made for stability verification of other types of non-uniform members.

These proposals are not only analytically backed-up, but also there was numerical as well as physical tests. With the results of the experiments and the technical experience gained by literature study and from other projects, the FE-Models were validated, calibrated and verified. Afterwards parametrical studies of the typical application range gave deliverables for the development of design rules and guidelines. With this, the existing design rules in Eurocode 3 can be checked and new rules can be proposed.

To achieve the goals in a first step existing rules are evaluated and its associated problems are documented based on numerical results. This is carried out both for uniform and non-uniform members in order to achieve consistency throughout the whole project. Also, decisions will be made and unnecessary parameters can be excluded for later consideration.

<u>Design rules for tapered members</u>
The main goal was to provide a design procedure for the verification of most commonly used tapered members. Beams and Columns were considered at this level, whereas beam-columns were tackled within the General Method. The main problems concerning the verification of a tapered member are: i) Choice of buckling curve and ii) Determination of the design position. If these two parameters are known, a similar procedure to current rules for uniform members can be considered. The experimental program provided the necessary information for the definition of the initial imperfections. Geometrical imperfections and residual stresses were measured as well as failure loads, from which numerical models are calibrated. An extensive numerical study was carried out with GMNIA – Geometrically and Materially Non-linear Imperfect Analyses to provide enough data for input parameters fitting. Nevertheless, these were always backed up by analytically derived expressions for the buckling. Parallelism to Ayrton-Perry format which is adopted in clause 6.3.1 for uniform columns is hoped to be kept both for columns and beams.
In the end, new imperfection factors are delivered in form of expressions (and not constants as it is done currently) which are dependent on tapering ratio parameters and slenderness. Regarding expressions for critical cross-section positions,

two options are possible, based on further analysis of the numerical results: either an expression for that position is provided and verification is based on that; or verification is based on the smallest cross-section properties (which is well known) and a factor is applied both to the slenderness and reduction factor as it is already done for the Special Case of beams, clause 6.3.2.2 in EC3-1-1.
Linearly web-tapered members, either symmetrically or by tapering only one half of the web, will be the starting point of this study. Then, linearly tapered flanges and also nonlinear tapered webs are also considered.
Finally, the application of the interaction formulae of clause 6.3.3 is directly applied considering the developed rules for analysed buckling modes. A validation of this procedure will be made in order to evaluate its safety.

General Method in EC3-1-1

The method (clause 6.3.4 of EC3-1-1) uses a Merchant-Rankine type of empirical interaction expression in which the in-plane effects and the out-of-plane effects are analysed separately. However, no explicit derivation of this method is provided and reduction factors from clauses 6.3.1 for columns and 6.3.2 for beams are simply considered for the application of the method: at the moment, according to EC3-1-1, the reduction factor for the General Method may be taken either as a minimum or an interpolated value between the reduction factor for lateral buckling, according to clause 6.3.1 of EC3-1-1, or the reduction factor for lateral-torsional buckling, according to clause 6.3.2. One of the objectives in TaperSteel was to provide a theoretical formulation of the method in which at the end, a unique imperfection factor is chosen for the buckling mode of the member, i.e., the interpolation of the combined loading will be implicit in the provided formula. This obviously includes not only prismatic but also non-prismatic members for the calibration of such imperfection factor. Finally, within the analytical derivation procedure, the in-plane effect will be redefined, if necessary.
In the end, the proposal was compared to the application of the interaction formulae already mentioned above.

Design Guidelines for other non-uniform members / systems

Although tapered members are the focus of this project, there are many other typologies of non-uniform members and systems which have the same design logic of non-prismatic members and are also not abridged by current rules of EC3, such as:

- Nonlinear members (e.g. curved – problem with definition of imperfections);
- Non-symmetrical restraints (e.g. torsional effects – definition of buckling curve);
- Irregularly distributed restraints (e.g. definition of global imperfections);
- Other support conditions (e.g. definition of sway imperfections);
- Frames.

These typologies were also considered within TaperSteel. Through numerical and analytical derivations carried out for a wide range of non-uniform members, the main goal of this was to provide orientation for the designer to be able to easily generate adequate input parameters to apply proposed rules derived before; to model imperfections and boundary conditions in such cases where a numerical analysis is needed.
Finally, because framed systems are widely used, and many times present the characteristics that have been described (tapered columns / beams; irregular restraining systems…) a case study of an industrial hall will be carried out.

Publications:

Papers (8)

Marques, L., Simões da Silva, L., Rebelo, C. and Santiago, A. "Extension of EC3-1-1 interaction formulae for the stability verification of tapered beam-columns", Journal of Constructional Steel Research 100 (2014) 122–135

Reports (2)

Marques, L., Simões da Silva, L., and Rebelo, C. "Code proposal for rules for member buckling of non-uniform members", Technical Committee 8, ECCS, Document TC8-2013-11-23, Zurich, Switzerland, November 8th, 2013;

Conference proceedings (8)

Tankova, T., Marques, L.., Simões da Silva, (2016). Towards a general methodology for the stability design of steel members, Proc. International Conference on Steel and Aluminium Structure, Hong Kong, China, 7-9 December

Contacts:

Luis Simões da Silva
Tel.: +351 239 797 216
Fax: +351 239 797 123
Email: luisss@dec.uc.pt
URL: http://www.isise.net

Curved thin panels for structural application| UltimatePanel

Financing Institution(s): FCT
Promoting Institution(s): University of Coimbra, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)
Coordinator(s): João Pedro Martins (ISISE-UC)

Researchers and collaborators: João Pedro Martins (ISISE-UC), Luís Simões da Silva (ISISE-UC), Tiago Manco (ISISE-UC), Filip Ljubinkovic (ISISE-UC). Coordinators from partner institutions: Nuno Silvestre (IST-UL); Pedro Vellasco (UERJ)

Partner Institutions: University of Lisbon – Instituto Superior Técnico (IST-UL) (Portugal); State University of Rio de Janeiro (UERJ) (Brazil)

Period: July 2016 to June 2019

Relevant facilities: Computational and laboratory equipment of Civil department of FCTUC; Computational equipment of other partner institutions.

Objectives:
The objective of this research project is the development of advanced knowledge about the behaviour of curved panels that results in practical application rules and in a standardised FEM procedure for analysing curved panels. In fact, curved panels, either for aesthetic or structural reasons, are often used in bridge structures, ship structures, aircraft and submarines. However, curved panels are elements that have important stability issues, such as unstable post-critical paths. Additionally, existing design rules are insufficient. For example:

- European standards exclude this structural element: in EN1993-1-5 curvature is limited to b^2/(R.t)<1 (CEN, 2006)
- Other design rules are outdated: as recognized by the aerospace industry (Nemeth, 1998; Domb & Leigh, 2001)
- And, finally, the rules proposed by the naval industry, DNV-RP-C202 (DNV, 2010), are based on ancient expressions that may be outdated).

Therefore, important advances in the understanding of the structural behaviour of curved panels are still needed.
Recently, this type of structural solution has been a central theme in several research projects: the POSICOSS and COCOMAT projects (both related to the aviation and aerospace industry and with focus on the analysis of composite panels excluding normalisation). This proposal differs from others by having a transversal approach to all areas of engineering that use curved panels as structural solution

Description and Methodology:
This project is organized so that it will be possible to develop a clear design approach for curved panels. In order to achieve this goal, three action plans are implemented in parallel: i) experimental, ii) analytical and iii) numerical. After an initial review of existing standards and their design approaches (in which all identified engineering branches are going to be taken into account), the experimental tests (which will serve as a first step to assess the standards accuracy) and analytical and numerical studies (with parameterization of geometry, different materials, loading types, etc.) will be performed. The results from the numerical study will arise from benchmark models that are calibrated and validated using the experimental results. Each research team will be responsible for a plan (ISISE-UC - experimental; IST-UL - analytical; UERJ - numerical). However, despite this clear definition of responsibilities, all tasks are carried out in cooperation between research teams.
Specifically, the following steps are defined (in order to better understand the interrelation between all steps and gather a global perspective of the tasks and how leadership is organised, see attached documents tasks. pdf and timeline.pdf):

- Systematic identification and characterisation of relevant parameters (geometry, geometric initial imperfections, boundary conditions: i) simply supported edges; ii) clamped edges; iii) intermediate situations; and fundamental loading: i) uniform longitudinal compression; ii) in-plane bending; iii) circumferential compression; iv) biaxial compression; v) shear stresses; vi) out-of-plane loading and combinations). For a detailed planning of the literature revision and curved panel characterisation, see task 1;
- Evaluation of present design procedures (EN1993-1-5, EN1993-1-6, NACA design curves and DNV-RP-C202) and formulae proposed by other authors. For a detailed planning of the literature revision and curved panel characterisation, see task 1;
- Experimental programme. The experimental work will consist in nine full-scale compression tests on simply supported curved panels and on sections built-up with curved panels. The tests will be displacement controlled, with monotonously increased displacement up to collapse. A fine mesh of combinations of LVDT and extensometers will be deployed to gather as much relevant information as possible. Tests on material properties of steel and aluminium will also be performed. The main purpose of these tests is to gather information on real behaviour of curved panels

and to provide a solid basis for numerical simulations. It aims at examining the accuracy of existent design proposals and validating numerical simulations. For the sake of simplicity, all tested specimens are in steel and aluminium (built from thin plates). The experimental work will be performed at the Structures Laboratory of the Civil Engineering Department of the University of Coimbra. For a detailed planning of the experimental programme, see task 2;

– Numerical studies. An extensive numerical parametric study on curved panels under several loading conditions and boundary conditions with will be performed. For this purpose, a commercial program of finite element analysis. Specifically, LBA (linear buckling analysis), GNA (geometrically nonlinear analysis) and GMNIA (geometrically and materially nonlinear analysis with imperfections included) will be performed. LBA (also known as eigenvalue analysis) are used to predict the elastic buckling strength of an imperfection free structure. This elastic buckling strength happens by bifurcation. Since nonlinearities and imperfection free structures are an idealisation of the real imperfect structure with nonlinear responses, the elastic buckling strength is a theoretical value and its usefulness ends with the calculation of the slenderness of the structure. The postbuckling response of the cylindrically curved panel requires performing a GNA and a GMNIA. For a detailed planning of the numerical study, see task 3;

– Analytical studies. The aim of analytical studies is to develop new analytical formulations (to study the linear – elastic critical stress and nonlinear behaviour – postbuckling behaviour – of curved panels. In particular, the main objectives of this task are: i) Develop analytical formulations; ii) Understand the roots of buckling phenomena of curved panels. For a detailed planning of the analytical study, see task 4;

– Preparation of design guidance and recommendations. Design methodologies and recommendations for the optimisation of structures incorporating curved panels will follow a narrow relation to EN1993-1-5 and EN1993-1-6 design philosophy (i.e. buckling curves and effective width formulae). In addition, recommendations on how to use advanced numerical tools (FEM), on how to numerically model curved panels and how to interpret numerical results will be provided (it should be highlighted that these are identified as urgent tasks by TWG8.3 of ECCS). For a detailed planning of the preparation of design guidelines, see task 5;

– Dissemination of results. This will be done by means of attending to the most relevant national and international conferences and by offering a short course at the end of the research project.

Contacts:

João Pedro Martins
Tel.: +351 239 797 259
Fax: +351 239 797 123
Email: jpmartins@uc.pt
URL: http://www.isise.net

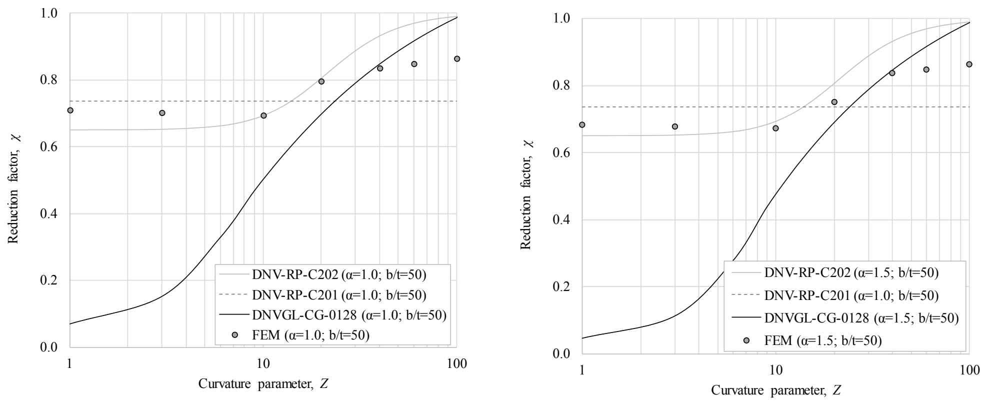


Fig. 1 Comparison of the ultimate strength to compressive loads for α ≥1 and b/t=50 and 100 (task 1)

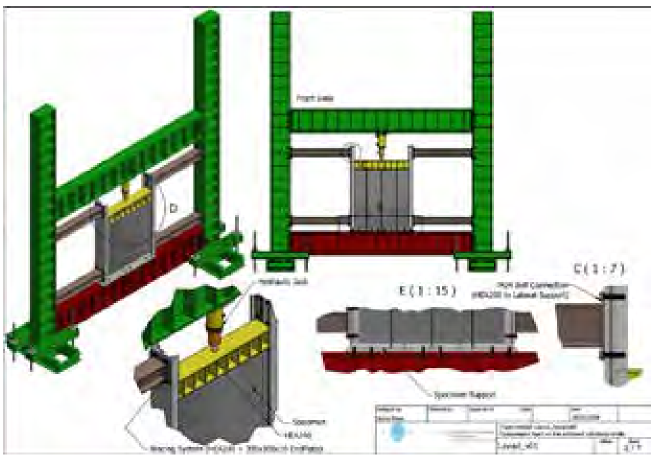


Fig. 2 Experimental layout (task 2)

Fibre reinforced concrete of enhanced properties of durability for urban furniture and infra-structures | UrbanCrete

Financing Institution(s): ADI (co-financed by the European Regional Development Fund (FEDER) through the Operational Program COMPETE)
Promoting Institution(s): University of Minho (ISISE)
Coordinator(s): Joaquim A. O. Barros

Researchers and collaborators: Joaquim A.O. Barros; J.M. Sena-Cruz, Miguel A.D. Azenha, M. Isabel B. Valente, Eduardo N.B. Pereira, Salvador J.E. Dias

Partner Institutions: FPMI Company

Period: 01 April 2013 to 31 June 2015

Relevant facilities: Servo close-loop equipment's for experimental programs; FEMIX V4.0 Finite Element package; Laboratory equipment and facilities of Civil Department of UMinho..

Objectives:
In the past few years there has been a development of high performance fibre reinforced cement based materials. This material has high flowability (self-compacting materials), excellent mechanical properties, enhanced behaviour when submitted to temperatures and is capable of withstanding high tensile strains under relatively high tensile stress with the development of micro-fissures that do not affect its durability. Since this material is reinforced with a system of synthetic fibres, without any steel elements, the corrosion phenomenon simply does not exist. This performance conjugated with the high post-cracking tensile resistance, high energy absorption capability and high fluidity of this high performance material allows the fabrication of elements of sophisticated geometry, with lower material volume of its components and much higher life cycle than the ones made by RC and FRP. This material was used in this project to develop urban furniture and infrastructures.

Description and Methodology:
In the scope of the present project some urban furniture was developed by using fiber reinforced cement composites (FRCC) of strain hardening nature. By using FRCC it is expected to demonstrate to be possible to build a new generation of relatively thin walled furniture elements do not susceptible to corrosion, since no conventional steel reinforcements are used.
This project has also dealt with infrastructures made by FRCC. In fact, fast detrimental, premature failure and thievery of steel and iron-based manhole covers have become matters that require additional investment to institutes in charge of the maintenance of highways and roads worldwide. Furthermore, numerous federal government departments and agencies in charge of infrastructures and highways have reported that factors such as flooding, heavy snowfall and turning or braking vehicles are usually not taken into account in the design and application of current manhole covers, turning them obsolete before expected and representing significant increments in the government's budget for road maintenance. In the present project, cement-based manhole covers reinforced with a glass fibre grating are studied experimentally and proposed as a sustainable and cost-effective alternative to the ones made by conventional materials.

Urban Furniture
After the development of the FRCC with rheological, mechanical and durability performance for the execution of the aimed advanced urban furniture, some real scale prototypes were designed with advanced numerical simulations (Fig. 1), produced (Fig. 2) and tested (Fig. 3). From the experimental and numerical research it was demonstrated that the developed FRCC has high potentiality for being the basic material of a new generation of lightweight, high durability, structural performance, appellative aesthetics and cost competitiveness urban furniture.

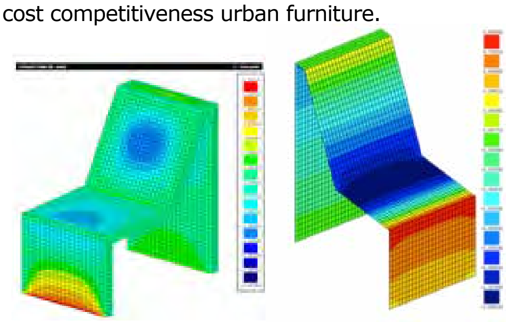


Fig. 1 Design of a FRCC chair

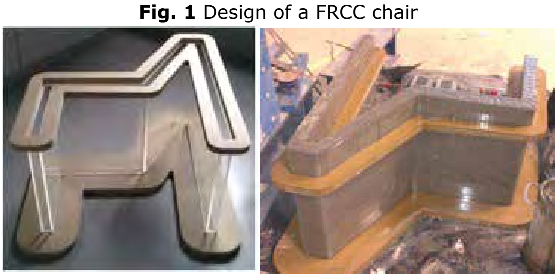


Fig. 2 Production of a FRCC chair

Fig. 3 Chair in FRCC being tested

Infrastructures

An experimental program was carried out for assessing the new material and structural concept developed for manhole covers. The experimental program is comprised of three stages, each stage as an approach that gives the trends to be adopted in the next one: The first stage (S1) consisted on the evaluation of two specimens developed with deflection hardening cementitious composite (DHCC) and reinforced with glass fibre reinforced polymer (GFRP) grating of 38x38mm of centreline open mesh, hereafter referred as G_type1 (see Fig. 4a). Based on the results obtained from S1, and aiming to assess the influence of the stiffness and compressive strength of FRC, in the Second Stage (S2) the G_type1 was also used, but the DHCC was replaced by a steel fibre reinforced self-compacting concrete (SFRSCC) for the two specimens of this stage (Fig. 4b). The results from S2 have suggested the use of GFRP grating of bigger dimensions of the centreline open mesh for ensuring a better filling of the cells of the grating with the SFRSCC. Therefore, maintaining the same type of SFRSCC adopted in S2, in the two specimens of S3 stage a GFRP grating of 50.8x50.8mm centreline open mesh (hereafter referred as G_type2) was adopted (Fig. 4c). All the specimens failed in punching shear, and the overall behaviour of the manhole covers developed and tested during the 3 stages of experimental program, S1 to S3, with exception of that related to SFRSCC110_c30_g50, in terms of load versus deflection is represented in Fig. 5.

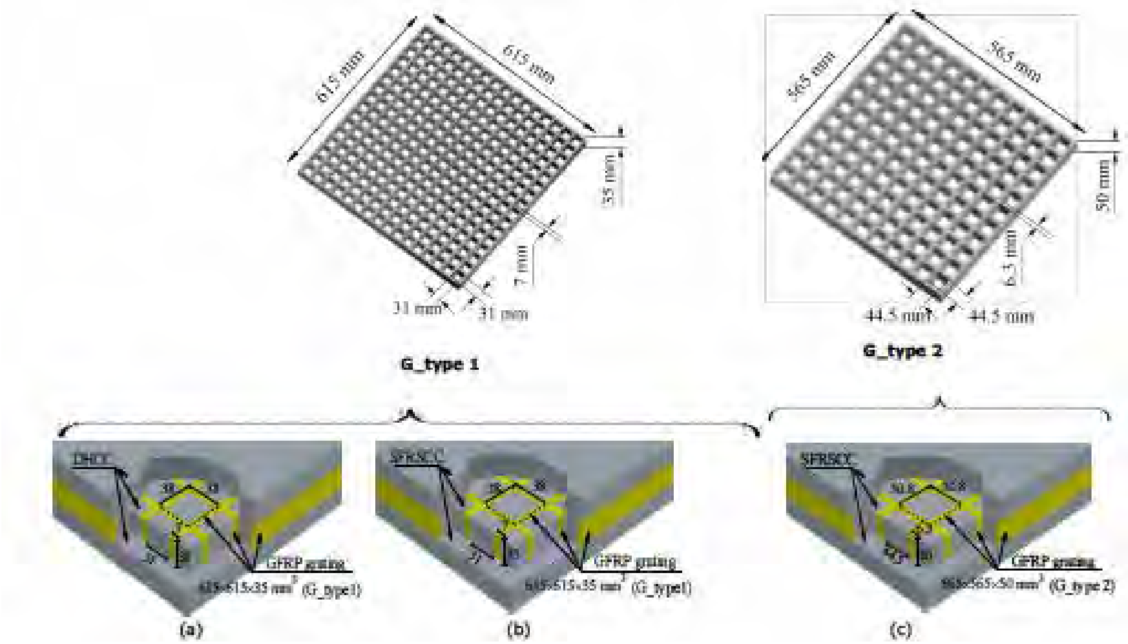


Fig. 4 Schematic representation of the geometry and disposition of the gratings on the specimens tested in stages: (a) S1; (b) S2, and (c) S3 (dimensions in mm)

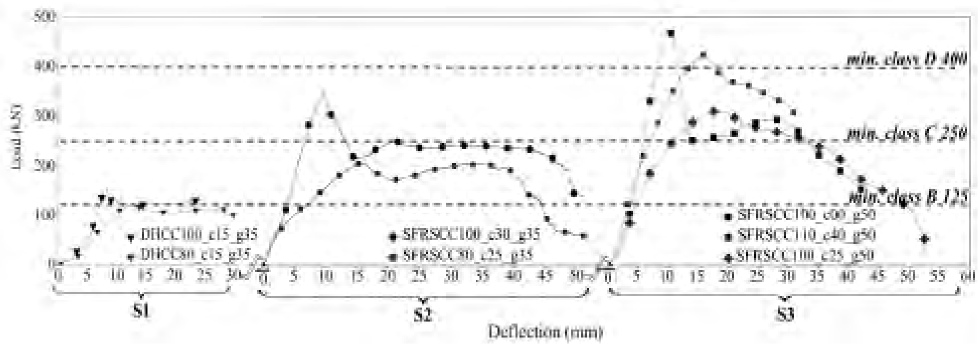


Fig. 5 Load-deflection response of the developed manhole covers in stages S1, S2, and S3.

Based on the results obtained for SFRSCC manhole covers, this study evidences the possibility of combining SFRSCC and GFRP reinforcement systems for developing cost effective, sustainable and innovative manhole covers, placed in class A15 to D400 defined in the European Standard BS EN 124:1994, to be installed in urban roads and highways areas, depending on the required load carrying capacity.

Outputs:

Publications: 5; National patent nº nº 67/2017, 2017

Contacts:

Joaquim António Oliveira de Barros
Tel.: +351 253510210/747
Email: barros@civil.uminho.pt
URL: http://www.isise.net

Innovative method for continuous monitoring of concrete viscoelastic properties since early | VisCoDyn

Financing Institution(s): FCT
Promoting Institution(s): University of Minho, Institute for Sustainability and Innovation in Structural Engineering (ISISE-UC)
Coordinator(s): Miguel Azenha (ISISE-UM)

Researchers and collaborators: Luís Ramos (ISISE-UM); José Granja (ISISE-UM); Jacinto Silva (ISISE-UM); Ricardo Oliveira (ISISE-UM).

Partner Institutions:

Period: March 2014 to February 2015

Relevant facilities: Computational equipment and laboratory facilities of the DEC-UM-ISISE.

Objectives:
Creep of reinforced concrete has been attracting a great deal of attention recently due to the long term deflections that largely overcame the design values of several bridges throughout the world, such as the well-known case of the Palau Bridge and others. The resulting serviceability problems cause very expensive repairs to be necessary.

The importance of adequate knowledge of concrete creep behavior is also recognizable in several other situations: (i) disproportionate creep deflections due to premature loading; (ii) need for adequate deflection prediction and prestress compensations during the construction of staged cantilevers; (iii) inaccuracies in the estimation of self-induced stresses in concrete at early ages.

en though the importance of concrete creep is widely recognized, the design code approaches are relatively simplified, and research efforts still struggle with experimental difficulties both at very early ages of testing (less than 72h of age) and at long term (decades). In fact, it is probably due to current experimental limitations and relatively scarce comprehensive sets of data focused on these two opposing time spans, that the existing models for creep behavior tend to exhibit limitations in such concern.

The intent is to explore the possibility of using dynamic test approaches to continuously assess viscoelastic properties of concrete, with the proposal of a new methodology termed VisCoDyn. Such innovative implementation can be achieved through the submission of a concrete specimen (e.g. a beam) to a known dynamic excitation. According to the theory of viscoelasticity, the deflection response of the beam to the known excitation allows the identification of viscoelastic parameters.

The project's Principal Investigator, Miguel Azenha, is a specialist in the field of concrete's early age behaviour, with several publications, including a patent for an innovative method for assessing concrete's elastic modulus since casting (EMM-ARM).

The project's PhD student, José Granja, is writing his PhD thesis "Continuous characterization of stiffness of cement-based materials: experimental analysis and micro-mechanics modeling" and has experience with dynamic characterization of mechanical properties since early ages.

Description and Methodology:
VisCoDyn is a project that began in March 2014 and ended in February 2015. During this 12 months, the tasks developed consisted in:

Task 1: Equipment acquisition, training and software development

Task 2: Assembly of the experimental setup and preliminary testing/tuning

Task 3: Experimental program and round-robin testing

Task 4: Analytical and numerical evaluation of creep data

Task 5: Dissemination of results and connection with industry

Publications:

Papers
J. Conceição, R. Faria, M. Azenha, F. Mamede, F. Souza (2014) "Early-age behaviour of the concrete surrounding a turbine spiral case: Monitoring and thermo-mechanical modelling" Engineering Structures, Elsevier. Volume 81, December 2014, Pages 327–340. doi:10.1016/j.engstruct.2014.10.009

J. Granja, P. Fernandes, A. Benedetti, M. Azenha, J. Sena Cruz (2015) "Monitoring the early stiffness development in epoxy adhesives for structural strengthening" International Journal of Adhesion and Adhesives, Elsevier. Volume 59, June 2015, Pages 77–85. doi:10.1016/j.ijadhadh.2015.02.005

Dissertations

"Comportamento mecânico do betão nas primeiras idades: propriedades e monitorização de deformações" MSc candidate: Andreia Daniela Silva. Research work conducted at the University of Minho. Nov 2013

Reports

R. Oliveira, M. Azenha, J. Granja, E. Guimarães (2015) "Report 1 – Equipment acquisition, training and software development". Technical report in the scope of the FCT Exploratory Project EXPL/ECM-EST/1323/2013 -"VisCoDyn – Innovative method for continuous monitoring of concrete viscoelastic properties since early age.

R. Oliveira, M. Azenha, J. Granja, E. Guimarães (2015) "Report 2 – T2 Assembly of the experimental setup and testing". Technical report in the scope of the FCT Exploratory Project EXPL/ECM-EST/1323/2013 -"VisCoDyn – Innovative method for continuous monitoring of concrete viscoelastic properties since early age.

M. Azenha, J. Granja, C. Araújo, R. Oliveira, E. Guimarães (2015) "Report 3 – T3 Experimental program and round robin testing". Technical report in the scope of the FCT Exploratory Project EXPL/ECM-EST/1323/2013 -"VisCoDyn – Innovative method for continuous monitoring of concrete viscoelastic properties since early age.

P. Silva, T. Valente, M. Azenha, R. Oliveira, J. Granja (2015) "Report 4 – T4 Analytical and numerical evaluation of creep data". Technical report in the scope of the FCT Exploratory Project EXPL/ECM-EST/1323/2013 -"VisCoDyn – Innovative method for continuous monitoring of concrete viscoelastic properties since early age.

Conference proceedings

M. Azenha, A. Silva, J. Granja (2014) "Metodologia para medição contínua do coeficiente de dilatação térmica do betão desde as primeiras idades" Jornadas Portuguesas de Engenharia de Estruturas, Lisboa, Novembro de 2014.

J. Granja, M. Azenha, J. Carvalho, N. Carvalho (2014) "Monitorização contínua das propriedades mecânicas do betão nas primeiras idades para apoio ao faseamento construtivo" Jornadas Portuguesas de Engenharia de Estruturas, Lisboa, Novembro de 2014

M. Azenha, R. Oliveira, J. Granja (2014) "Monitorização contínua das propriedades viscoelásticas do betão desde as primeiras idades: um novo método baseado em ações dinâmicas" Jornadas Portuguesas de Engenharia de Estruturas, Lisboa, Novembro de 2014

M. Azenha, J. Granja, R. Oliveira (2015) "Innovative method for continuous monitoring of concrete viscoelastic properties since early ages: concept and pilot experiments" CONCREEP10 – Mechanics and Physics of Creep, Shrinkage and Durability of concrete and concrete structures, Vienna, Austria, September 21-23, 2015.

Contacts:
Miguel Azenha
Tel.: +351 93 840 4554
Email: miguel.azenha@civil.uminho.pt
URL: http://www.isise.net

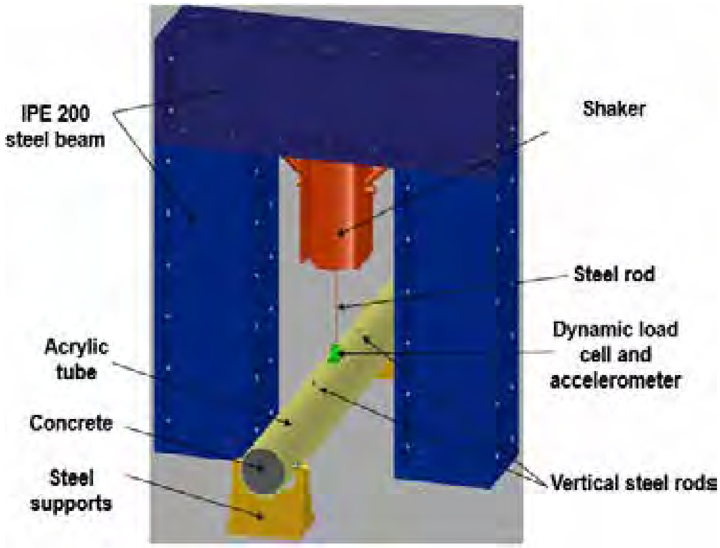
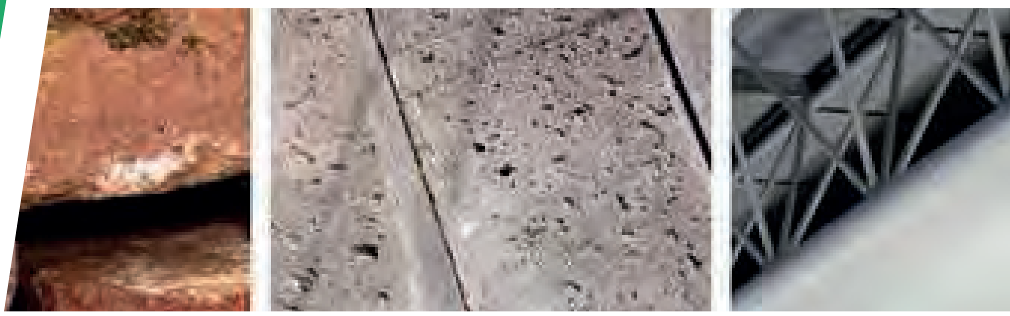


Fig. 1 Experimental setup of VisCoDyn

PHD THESES



isise Institute for Sustainability and Innovation in Structural Engineering

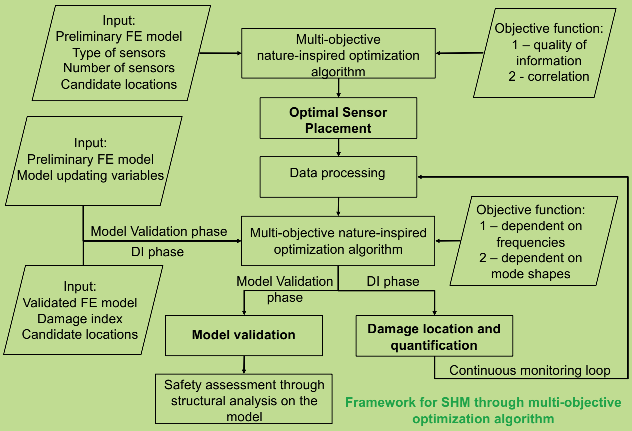
Alberto Barontini

Supervisors: Luís Ramos/ Paulo Amado Mendes

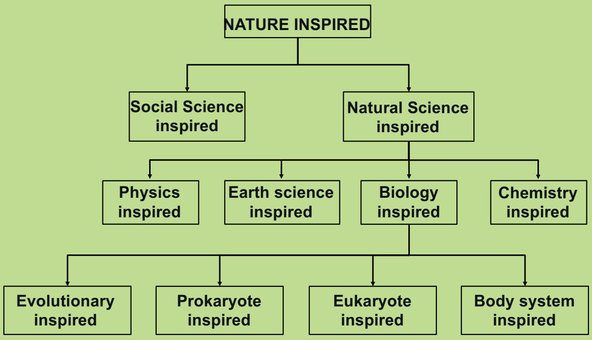
BIO-INSPIRED STRUCTURAL HEALTH MONITORING SYSTEMS FOR CIVIL ENGINEERING STRUCTURES

❑ MOTIVATIONS OF THE WORK

- **Damage**: detrimental change intentionally or unintentionally occurred to a structural system
- **Consequences**: relevant economic cost, injuries and life losses, repercussion also on a higher level.
- **Current situation**: many structures and infrastructures are in precarious condition, the consequences of the failure are almost unaffordable, budget cut-backs worsen the lack of maintenance.
- **Structural Health Monitoring (SHM)**: ongoing field of research. It aims to provide continuous real time assessment methodologies, reduce and support human decision.



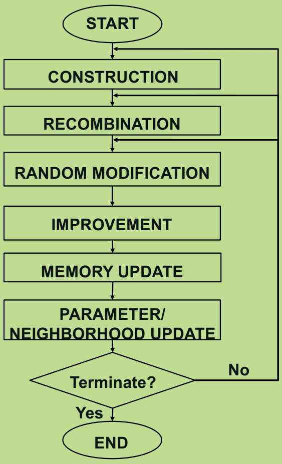
Framework for SHM through multi-objective optimization algorithm



New taxonomy for nature inspired algorithms

❑ OBJECTIVES

- **Main goal**: nature-inspired strategy for SHM to provide a risk-informed automated management system of structures.
- **Key components**:
  - Nature-inspired optimization algorithms for **Optimal Sensor Placement (OSP)** and Network Design
  - Nature-inspired pattern recognition algorithms for **Anomaly Detection (AN)**
  - Nature-inspired optimization algorithms for Model Updating and **Damage Identification (DI)**



Unifying framework of nature-inspired optimization algorithms

❑ RESEARCH METHODS

- **COMPUTATIONAL EXPERIMENT**: according to statistical design, to analyze: (1) **parameter setting** of the algorithms, (2) **comparison** between nature-inspired algorithms and with other traditional or advanced methods and (3) **influence** of noise, incomplete data and features damage related
- **SMALL SCALE LAB TEST**: beam and shear-type buildings, to analyze: (1) **robustness**, (2) **scalability** and (3) **applicability** to real world
- **FULL SCALE CASE STUDY**: monitoring system for bridges and buildings. Following methods are implemented: (1) OSP and bio-inspired strategies for network optimization (max. information; min. cost and energy consumption), (2) On-line AD. Algorithms embedded in the sensors and (3) DI and assessment. Algorithm implemented in an automated management unity

❑ EXPECTED OUTCOMES

The thesis aims to test the applicability of nature-inspired algorithms to SHM and to provide a framework to allow a continuous process of safety assessment and DI, addressing more sequential problems, from the sensor network design to the diagnosis of the structure,

U C
University of Minho School of Engineering
FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

isise Institute for Sustainability and Innovation in Structural Engineering

Alberto Belarmino dos Santos Simões

Supervisors: Rui Simões/ Sandra Jordão

Innovative System for Metal Cladding of Buildings

❑ OBJECTIVE OF RESEARCH

- With the construction market increasingly dominated beyond the architectural, sustainability, and energy aspects of the economy. Since facades are one of the key components of buildings, it is therefore critical to obtain façade solutions that are economically and structurally more favorable. However, it is noted that buildings already use metal facades but these need a secondary structure (figure 1) and are also not dimensioned to work together.
- It is therefore pertinent to obtain metal façade solutions that do not require secondary structures, are quick to assemble, are more structurally optimized and therefore economically more favorable. The figure 2 shows a metallic façade made up of modules, with no need for secondary structure.

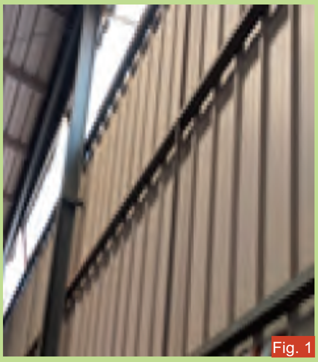


Fig. 1

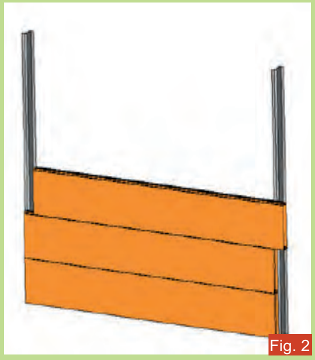


Fig. 2

❑ NUMERICAL AND EXPERIMENTAL MODELS

- Several numerical models were created and the models that obtained the best results in terms of strength and stability were selected. These models are improved by parametric analysis of the thickness of the plate, shape of the sheet forming in order to obtain an economically more economical solution for the metal façade.
- In figure 3 is present one sample in profile, in front and in the perspective partial. In the figure 4 we have the sample of graph with results for force vs displacement.
- In figure 5 we have some of the deformed ones obtained from profile.
- The numerical results will be verified through the experimental route.

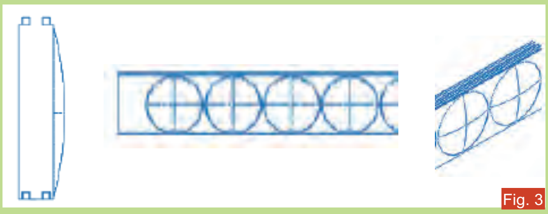


Fig. 3

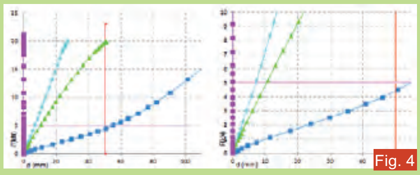


Fig. 4

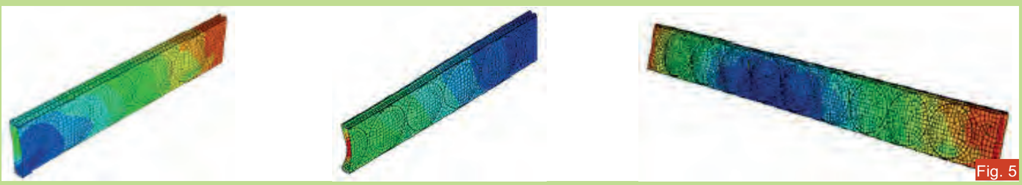


Fig. 5

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Ali Edalat Behbahani

Supervisors: Joaquim António Oliveira de Barros / António Ventura-Gouveia

CONSTITUTIVE MODELS TO SIMULATE FAILURE OF STRUCTURES MADE BY CEMENT BASED MATERIALS

❑ MOTIVATION

- **Develop a constitutive model capable of capturing inelastic nonlinear behaviour of cement based materials under tension and compression.**

❑ THE PROPOSED MODEL

- **In order to simulate cracking in tension and crushing in compression for cementitious materials, a plastic-damage multidirectional fixed smeared crack model is proposed. According to this approach different domain of stress space is separately described by the plasticity theory, for compression, and fracture theory, for tension. So a composite criterion is formed by a fracture surface for cracking, and a yield surface to simulate the inelastic deformation of concrete between cracks.**

❑ COMPONENTS OF THE PROPOSED MODEL

- **The plasticity part of the model is based on the yield function, flow rule and evolution law for hardening variable. The yield function, inspired from the work of Willam and Warnke, works based on a hardening process. It lies on the assumption that the plastic flow occurs on undamaged volume of the material; therefore damages, due to compression, are not modeled using the plasticity approach. Strength and stiffness degradation of concrete under compression is controlled by an explicit damage approach which is decoupled from the plasticity part.**
- **The crack opening process is initiated based on the Rankine tensile criterion whereas a trilinear softening diagram is used to simulate the crack propagation. Two methods namely based on the concept of shear retention factor, and the shear softening diagram are adopted for modeling the sliding components of the crack constitutive law.**

❑ VALIDATE THE PROPOSED MODEL

- **In order to demonstrate the robustness of the developed model, experimental tests that covers a wide range of specimens regarding type of intervening material, geometry, loading configurations, and reinforcement conditions were simulated.**

❑ SELECTIVE SIMULATIONS OF THE PROPOSED MODEL

- **Predictive performance of the proposed model (called PDS) is represented here for two structural applications.**

➢ Simulation of RC beam shear strengthened according to NSM-CFRP technique (beam number 3S-4LI-S2)

Fig. 1a

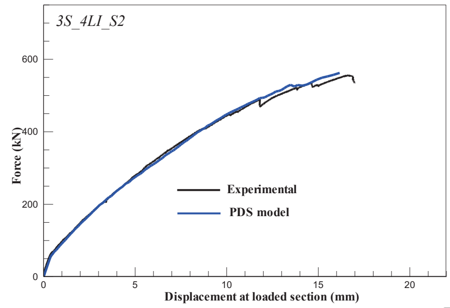


Fig. 1b

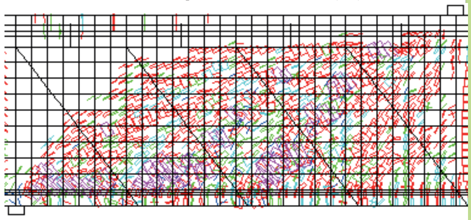


Fig. 1c

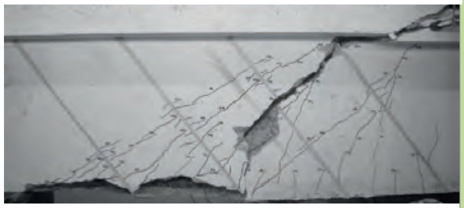


Fig. 1a-c : result of the proposed model (PDS model) Versus the test observations for the beam 3S-4LI-S2

➢ Simulation of the shear wall panel test (panel number S1)

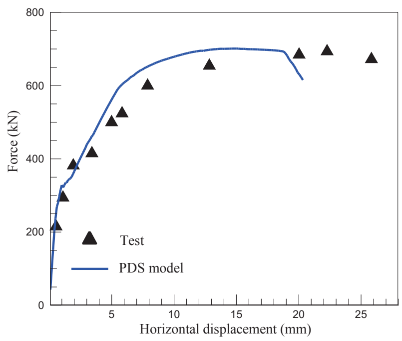


Fig. 2 : load-deformation result of the proposed model (PDS model) Versus test for the panel S1

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

MULTI-SCALE INVESTIGATION OF THE DURABILITY PERFORMANCE OF TRM-STRENGTHENED MASONRY

Ali Dalalbashi Esfahani

Supervisors: Daniel V. Oliveira / Bahman Ghiassi

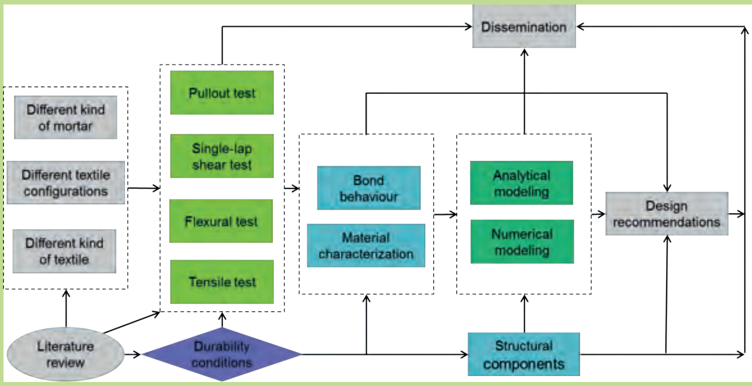
❑ Introduction

Textile-reinforced mortars (TRMs) have recently received extensive attention as a sustainable solution for the strengthening of masonry and historical structures. Due to the novelty of this method, several issues such as durability and long-term performance are still open and relevant test standards and design methods do not exist yet. This project aims at the investigation of the long-term performance of TRM-strengthened masonry through advanced multi-scale experimental testing and refined computational analysis.

For this purpose, the mechanics and degradation mechanisms at the material level (brick, mortar, fiber), at the bond level between fiber and mortar (Fig. 1), at the TRM-to-masonry bond (Fig.2), at the composite level (Fig. 3), and at the structural level (Fig. 4) will be investigated. Then the results will be used for development of suitable time-dependent constitutive laws for numerical/analytical simulations. A refined numerical/analytical model will be developed and calibrated against experimental data, and then will be used for performing a parametric study. The results will be used for development of guidelines for durability-based design of TRM-strengthened masonry.

Fig. 1 Fig. 2 Fig. 3 Fig. 4

❑ Workplan



University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

FIRE RISK AND EVACUATION MODELLING IN HOSPITALS – THE CASE OF THE HOSPITAL SOUSA MARTINS IN GUARDA

Amarildo Leonel Mailito Guiane Benzane

Supervisors: Luís Laím/João Paulo Rodrigues

❑ Object of Study

- **This study investigates safety measures against fires, in the case of evacuation of three fire compartments of the new extension of the Sousa Martins hospital in Guarda, namely: operating room (Fig.1), emergency room (Fig. 2) and the nursing division (Fig. 3). The study was based on numerical simulations performed with the software FDS+Evac.**
- **The fire fighting in hospitals requires a huge effort and an adequate preparation of the building for passive response, which consists in the capacity of having an environment safe to fire, as well as having the necessary resources for an active response (automatic systems for detection and mitigation of fires).**

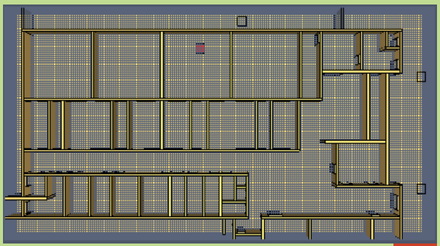


Fig. 1

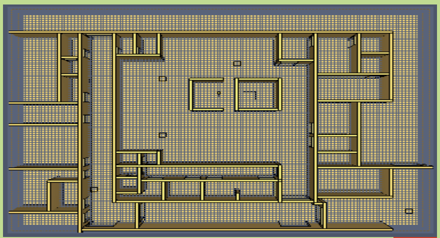


Fig. 2

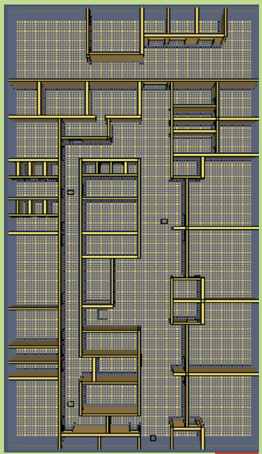


Fig. 3

❑ OBJECTIVES

- **This thesis deals with a hospital evacuation plan, which was built under the aegis of a fire safety regulation prior to Decrew-Law 220/2008, of November 12 and Law 1532/2008, of December 29. However, this study focus on the effects of smoke extraction of three fire compartments for evacuation of the patients inside.**
- **That being said, the main goal of this work is to create a model for the fire safety measures, in order to verify if they meet the standards imposed by the new legislation, in respect to evacuation of imperiled patients during a fire.**
- **Analise the impact of the increase of number of emergency exit doors in the fire compartments in study, as well as the use of elevators for evacuation of patients at risk.**

❑ PARAMETERS

- **The numerical simulation has the following parameters: age, position and speed of the occupants, geometrical conditions of the fire compartments, type of fire (fire curve showing a release rate of energy of mean growth – Fig, 4), existence and location of smoke extraction ducts (with the respective flow rate of extraction and flow rate of insufflation).**

Along with above-mentioned parameters, the following parameters were also considered:

- **Maximum temperature of evacuation: 80 °C;**
- **Fractional Effective Dose (FED) less than 1.0;**
- **The Minimum visibility at 1.80 m from the ground is 2.0 m;**
- **The extraction grids are at 3 m from the ground and the insufflation grids are at 0.5 m. The insufflation grid has 1/3 of the volume of the extraction grids.**

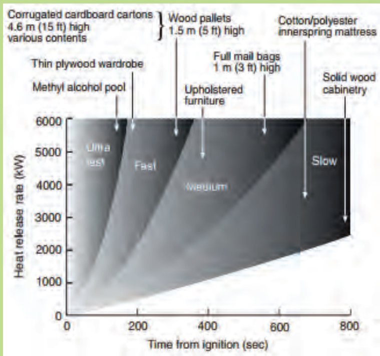
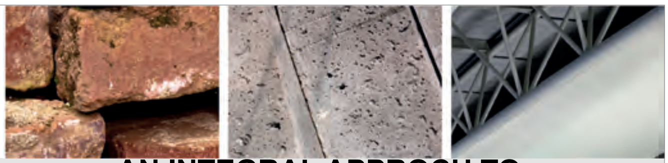


Fig. 4

University of Minho
School of Engineering



AN INTEGRAL APPROCH TO SIMULATE THE CREEP BEHAVIOUR OF STEEL FIBRE REINFORCED SELF-COMPACTING CONCRETE LAMINAR STRUCTURES

isise Institute for Sustainability and Innovation in Structural Engineering

Amin Abrishambaf

Supervisors: Joaquim Barros / Vitor Cunha

❑ OBJECTIVES

- **Determination of the fibre distribution/orientation parameters in the laminar structures,**
- **Evaluation of instantaneous nominal tensile stress – crack opening relationship,**
- **Execution of fibre pull-out creep tests with fibres preliminary subjected to distinct grades of slips,**
- **Performing flexural creep tests on the pre-cracked specimens extracted from a panel,**
- **Developing a model to predict instantaneous and long-term behaviours of the cracked SFRSCC laminar structures.**

❑ EXPERIMENTAL RESEARCH

- **In a panel, fibres tend to align perpendicular to the concrete flow direction:**

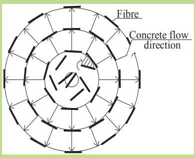


Fig. 1 Explanation for fibre alignment

- **Instantaneous stress-crack opening width (*σ – w*) was assessed by both uniaxial, Fig.2, and splitting, Fig.3, tensile tests on cores extracted from a panel and notched either parallel or perpendicular to the concrete flow direction.**

Fig. 2 Uniaxial tensile test

Fig. 3 Splitting tensile test

- **The time-dependent fibre pull-out behaviour was assessed by the means of single fibre pull-out creep tests (Fig.4) on the pre-slip fibres. The influences of the fibre orientation (0, 30 and 60°) and pre-slip level (0.3 and 0.5 mm) were evaluated. Then, the assembled curves (Fig.5) were compared to the monotonic force-slip relationships.**

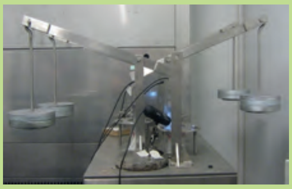


Fig. 4 Fibre pull-out creep test

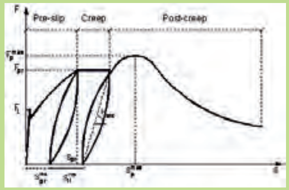


Fig. 5 Assembled curve

- **A series of flexural four-point creep tests were performed on the beams extracted from a panel. The influences of following parameters were studied: initial crack opening level (0.3 and 0.5 mm), applied stress level (50 to 100%), fibre orientation/distribution and distance from the casting point. Finally, the assembled curves were compared to the monotonic force-CTOD relationships.**

Fig. 6 Creep flexural test

Fig. 7 Monotonic flexural test

❑ NUMERICAL SIMULATION

- **SFRSCC was assumed as a two phase material: plain concrete, Fig.8, and discrete steel fibres, Fig.9. The fibres were oriented using Gaussian distribution. Taking the results of fibre pull-out tests, the force-CTOD relationship and creep response of the beams were predicted.**

Fig. 8 Concrete phase

Fig. 9 Fibre phase

· U C ·

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Ana Araújo

Supervisors: Paulo B. Lourenço / Daniel V. Oliveira / Guido Magenes

MODELLING OF THE SEISMIC PERFORMANCE OF CONNECTIONS AND WALLS IN ANCIENT MASONRY BUILDINGS

❑ IN-PLANE MASONRY WALLS BEHAVIUOR

- **Numerical study was based on the experimental campaign performed at the University of Pavia on stone masonry piers with two distinct slenderness ratios and axial load levels:**

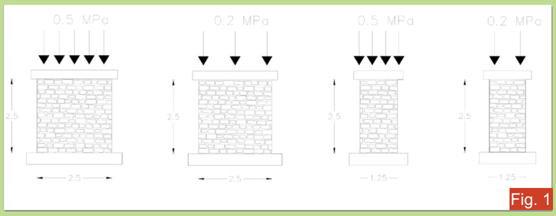


Fig. 1

- **FEM were calibrated against experimental results and nonlinear analysis results show good agreement with the experimental behaviour of each wall. The validated models were used to carry parametrical analyses. Drift capacity and the application of analytical expressions to predict the in-plane strength were also studied.**

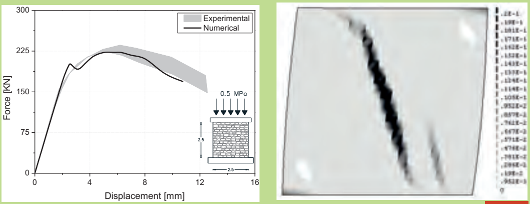


Fig. 2

❑ CONNECTIONS – INJECTED ANCHORS IN MASONRY

- **This study was supported on the experimental campaign carried out at University of Minho for the characterization of a strengthening solution for connection between elements based on the use of injected anchors in masonry.**

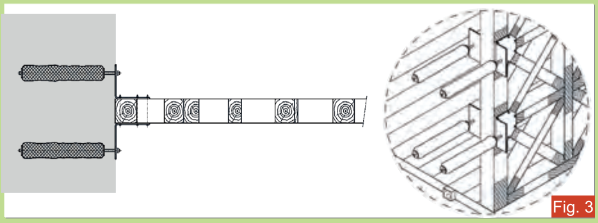


Fig. 3

The numerical study included:

- **Construction of a detailed 3D FEM;**
- **Model validation against the experimental results;**
- **Parametric analyses in order to evaluate the influence of key parameters and analytical evaluation.**

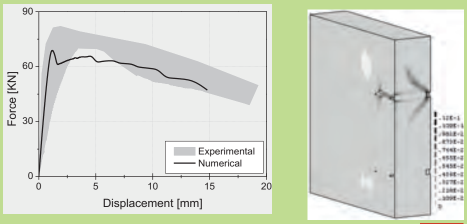


Fig. 4

❑ BEHAVIOUR OF A MASONRY BUILDING

- **The seismic assessment of a typical masonry building is carried out through pushover analysis proportional to the mass. The influence of the connections between walls and floors and also the external and interior walls in the global behaviour of the structure is assessed numerically.**

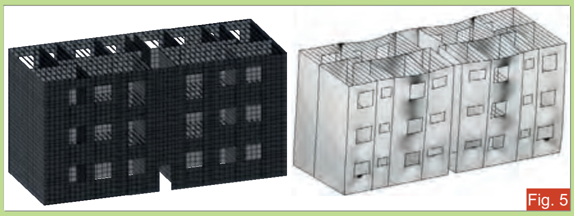


Fig. 5

❑ FINAL CONSIDERATIONS

- **The study of the behaviour of walls and connections in masonry constructions have proven the potential of numerical analyses when used as a complementary tool for experimental campaigns, allowing for the deeper characterization of the behaviour and for parametrical analysis. The knowledge taken from these research works were the basis for the study of the masonry building considering the in-plane walls and connections behaviour.**

U C
University of Minho School of Engineering
NIKER
FCT Fundação para a Ciência e a Tecnologia
SEVENTH FRAMEWORK PROGRAMME

isise Institute for Sustainability and Innovation in Structural Engineering

Ana Gaspar

Supervisors: António Gomes Correia / Fernando Lopez-Caballero / Arézou Modaressi

CONTRIBUTION TO CONTROL UNCERTAINTIES IN NUMERICAL MODELLING OF DAM PERFORMANCES. AN APPLICATION TO A RCC DAM.

❑ Framework

- **RCC properties:** low cement content; dry consistency.
- **Advantages:** rapid construction (Willow Creek dam: V = 331000m^3 in 5 months)

Fig. 1 Pedrógão dam

❑ Objectives

- **What?** To identify the influence of some uncertain parameters in the probability of failure obtained for a certain limit-state.
- **How?** By coupling Finite Element Methods with Reliability Methods (LHS, Monte Carlo, FORM, Subset).
- **Why?** Probabilistic tools in dam's safety assessment as a complement to the deterministic classical tools based on an empiric global security coefficient.

Dam Safety Assessment → Risk Analysis → R = V x H x E

- **Uncertainties:**
  - Into Vulnerability (V): by giving a random character to some material parameters (i.e. w/c, compressive strength, E modulus).
  - Into Hazard (H): by giving a random character to the loads (i.e. ambient temperature, solar radiation).

❑ Numerical model:

- **Thermo-chemo-mechanical coupled model:**

(through the ageing degree)

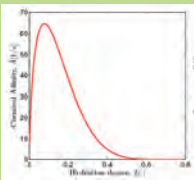


Fig. 2 Chemical affinity curve

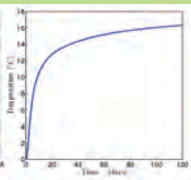


Fig. 3 Adiabatic temperature rise

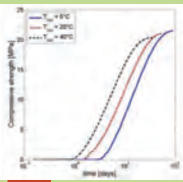


Fig. 4 Compressive strength

❑ Boundary conditions:

- **External loads:**
  - Daily varying temperature: summer and winter

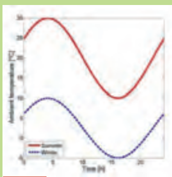


Fig. 5 Ambient temperature evolution

❑ Thermo-chemo-mechanical behaviour:

Layered construction phase.

Construction speed: 0.6m / day

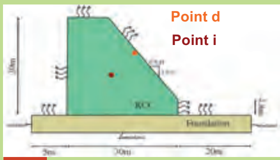


Fig. 6 Dam's model geometry

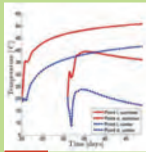


Fig. 7 Temperature on points "d" and "i"

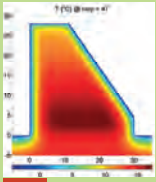


Fig. 8 Temperature

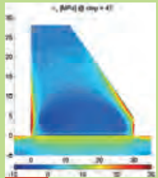


Fig. 9 First principal stress

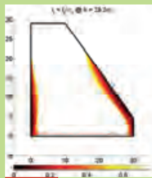


Fig. 10 Cracking index

❑ Probabilistic model:

- **Sensitivity analysis via RBD-FAST:** to assess the impact of each input random variable (such as the water-to-cement ratio w/c, the cement content, the thermal conductivity and the convection coefficient), in the variability of the output.

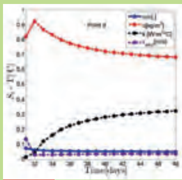


Fig. 11 Sensitivity indexes in point "d" over temperature output

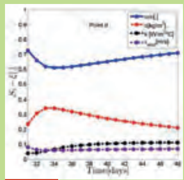


Fig. 12 Sensitivity indexes in point "d" over hydration degree output

❑ Conclusions:

The presented methodology allows for the estimation of a probability of exceeding a given cracking limit as a function of the material's age and of the position within the dam body (near face or in body mass), by means of a cracking density concept. Here, the cracking density (ρ_f) is assessed within one layer.

$$I_f = \frac{f_t}{\sigma_1}$$

$$\rho_f = \frac{N_{0 \le I_f < \zeta}}{N_T}$$

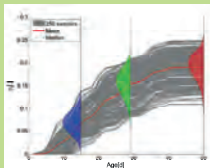


Fig. 13 Cracking density in layer 19

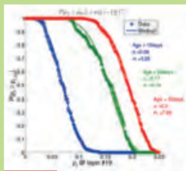


Fig. 14 Cracking probability curve at different ages

University of Minho School of Engineering

UMR 8579

CENTRALE

isise Institute for Sustainability and Innovation in Structural Engineering

Ana Francisca Santos

Supervisors: Aldina Santiago / Gianvittorio Rizzano

BEHAVIOUR OF FRICTION JOINTS UNDER IMPACT LOADS

❑ Objectives

This work program, within the European FREEDAM, deals with the evaluation of the behaviour of a beam-to-column connection equipped with friction damper, labelled as "Free from Damage Connection", under exceptional loading conditions as impact loading.

❑ EXPERIMENTAL RESEARCH – FRICTION DAMPER

- The friction damper component will be tested for impact loading conditions (using the layout in Fig.2) and for quasi-static loading;
- Tested parameters:
  - internal plates thickness (30mm or 10mm);
  - Bolt class (10.9HV or 8.8SB);
  - Typology of the slotted hole on the sliding plate;
  - Friction material;
  - Type of impact: sequential impact or full impact;

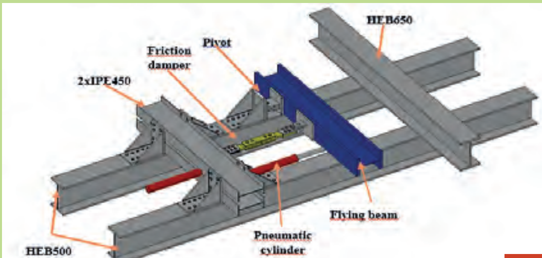


Fig.1

<u>Main objective:</u> assess the influence of high strain rates in the friction damper strength and ductility

❑ EXPERIMENTAL RESEARCH – BEAM-TO-COLUMN CONNECTION

- <u>Two impact tests</u> (one sequential and one full impact) and <u>one quasi-static</u> test will be performed to characterized the behaviour of the connection (Fig.2).
- <u>Main objective:</u> assess the influence of high strain rates in the connection strength, stiffness and rotation capacity.

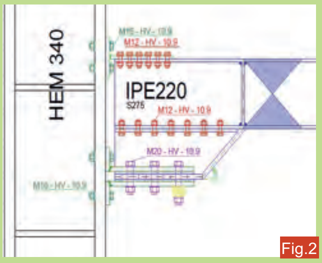


Fig.2

❑ NUMERICAL ANALYSES

- 3D FEM models of the friction damper and beam-to-column connection - Calibrated with the experimental results;
- Numerical parametric studies:
  - Friction damper: Thickness of the plates, variation of the preload, number of bolts;
  - Connection: Different steel class, different geometrical parameters of the connection;
- Evaluation of the structure robustness using numerical and analytical models.

Fig.3

❑ <u>DESIGN PART</u>

- Design procedure for the proposed beam-to-column connection typology following the component method approach of the EC3 part 1-8;
- Design rules for steel frames with friction joints.

University of Minho School of Engineering

ArGEnCo

FIP INDUSTRIALE INGEGNERIA PER LE COSTRUZIONI

O FELIZ

Institute for Sustainability and Innovation in Structural Engineering

Andreia Martins

Supervisors: Graça Vasconcelos / Alfredo C. Costa

SEISMIC BEHAVIOUR OF MASONRY VENEER WALLS

Background

The masonry veneer walls is a construction typology used in current practice and is increasingly used in Portugal and other countries due to aesthetic qualities, better thermal comfort and better moisture behavior.

Fig. 1 – Masonry veneer walls, England

A major concern on the use of this constructive element, which is not seen as structural, is the seismic performance, when it is applied in regions of seismic hazards

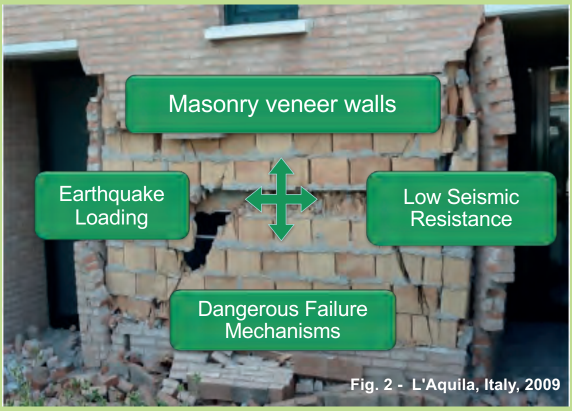


Fig. 2 - L'Aquila, Italy, 2009

Taking into account the vulnerability of these walls to seismic actions, it is necessary to understand the behavior of this constructive system submitted to earthquakes

Research Strategy

– Mechanical characterization of materials

– Experimental characterization of the mechanical behaviour of different ties

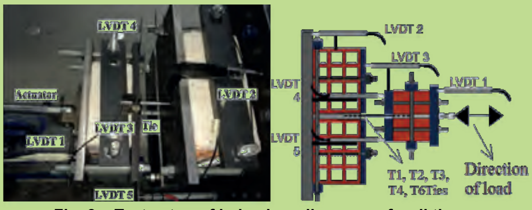


Fig. 3 – Test setup of behavior adherence of wall ties

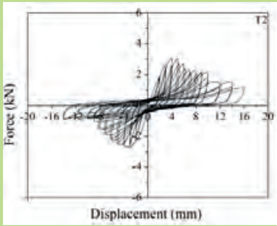


Fig. 4 – Force vs displacement diagrams

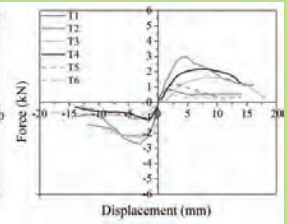


Fig. 5 – Envelope curves from cyclic tests

– Experimental evaluation of the cyclic static behavior

Fig. 6 – Test setup of static tests

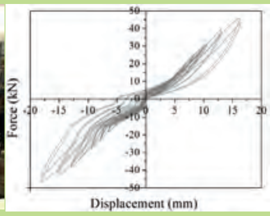


Fig. 7 – Force vs displacement diagrams of static behaviour

– Experimental evaluation of the dynamic static behavior

– Numerical analysis of masonry veneer walls

Expected Results

- Static cyclic and dynamic behaviour of veneers
- Parametric study from numerical modelling
- Developing guidelines for designing masonry veneer walls

University of Minho
School of Engineering

FCT Fundação para a Ciência e a Tecnologia

Institute for Sustainability and Innovation in Structural Engineering

Angelo Gaetani

Supervisors: Paulo B. Lourenço / Giorgio Monti

SEISMIC PERFORMANCE OF MASONRY CROSS VAULTS: LEARNING FROM HISTORICAL DEVELOPMENTS AND EXPERIMENTAL TESTING

Considering the seismic behavior of cultural heritage buildings, an influential role is played by masonry vaults, often representing the most vulnerable part of the construction. Accordingly, the thesis is devoted to the study of masonry cross vaults, considered as one of the most diffused vault type in European seismic prone areas in cloisters, palaces and churches.

❑ DESIGN AND ANALYSIS OF CROSS VAULTS ALONG HISTORY

The first part of the dissertation deals with the historical developments of the cross vault and the structural methods adopted throughout the centuries by masons and scholars to assess the stability of the vault. Fig. 1 shows the graphical representation of the so-called Fr. Derand (ante 1546 AD) and Hernán Ruiz el Joven's rule (1560).

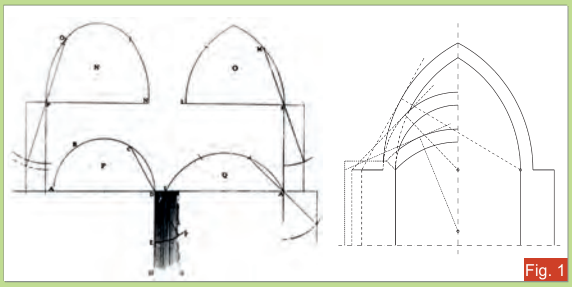


Fig. 1

❑ SHAKING TABLE TESTS ON A SCALED ARCH

The experimental campaign gave insight into the seismic behavior of masonry arches and, thanks to the tracking motion system employed to record the tests, it provided valuable information to calibrate a three-dimensional numerical model.

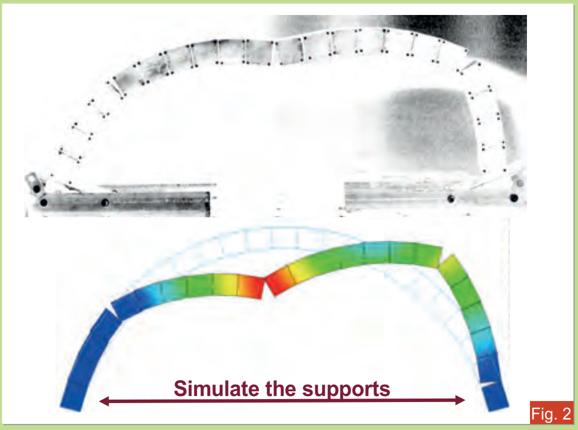


Fig. 2

❑ 3-DIMENSIONAL BEHAVIOR OF CROSS VAULTS

The FEM analyses were carried out assuming rigid-infinitely resistant blocks and Coulomb friction interfaces. The static nonlinear analyses shaded light on the influence of interface stiffness on the maximum strength and the failure mechanism.

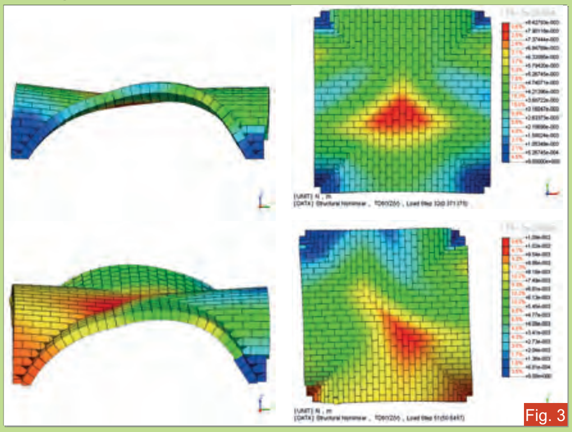


Fig. 3

❑ SENSITIVITY ANALYSIS

The study was aimed at evaluating the influence of the main geometrical and mechanical parameters on the seismic capacity and failure mechanisms of cross vaults. A non-commercial code based on the upper bound approach of standard limit analysis, was used. The results were finally processed through a multiple linear regression analysis. Fig. 4 shows two failure mechanisms relative to different boundary conditions.

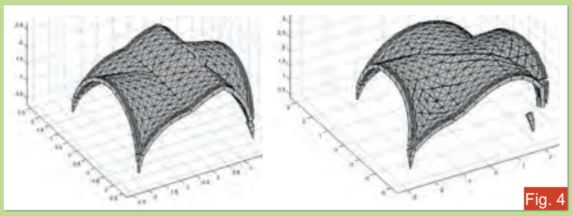


Fig. 4

· U C ·

University of Minho
School of Engineering

SAPIENZA
UNIVERSITÀ DI ROMA

isise Institute for Sustainability and Innovation in Structural Engineering

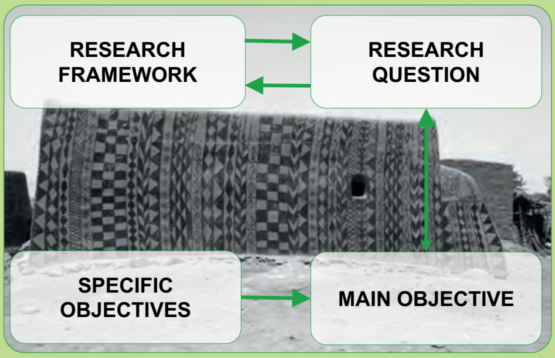
Antonio Romanazzi

Supervisors: Daniel V. Oliveira / Rui A. Silva

SEISMIC PERFORMANCE OF RAMMED EARTH CONSTRUCTIONS CONSIDERING AN INNOVATIVE STRENGTHENING TECHNIQUE

❑ RESEARCH FRAMEWORK

Rammed Earth (RE) is among the most widespread earth construction techniques in the World and has important presence in UNESCO World Heritage. These buildings are associated to a high seismic risk, consequence of their high seismic vulnerability combined with the moderate seismic hazard of the region. The proper preservation of this heritage requires adopting compatible solutions and materials. The strengthening with Textile Reinforced Mortars (TRMs) is a solution here proposed to respond effectively to this need, by incorporating earth based mortars and low-cost meshes.



- Literature review
- Material characterization
- Experimental and analytical characterization of interaction behavior
- Static behavior of strengthened rammed earth walls
- Dynamic behavior or structural components
- Guidelines and recommendations


Fig. 1


Fig. 2

❑ MAIN OBJECTIVE

To further develop TRM as a compatible and Low-Cost strengthening technique for seismic protection of RE heritage, by integrating the use of earth-based mortars and geosynthetic meshes.

❑ SPECIFIC OBJECTIVES

- ❑ To characterize and define analytical bond-slip laws for describing the response of LC-TRM strengthened systems
- ❑ To implement numerical models capable of simulating LC-TRM strengthening of RE
- ❑ To assess the effectiveness of LC-TRM strengthening of RE in static and dynamic conditions
- ❑ To develop guidelines for design and application of LC-TRM strengthening, as well as definition of testing procedures

❑ WORKPLAN

The research involves data gathering in the field of interest, followed by the characterization of materials for the proposed strengthening technique (Fig.1).

Experimental tests on the interaction between the three components of the strengthening system will be conducted to define analytic laws (Fig. 2). The latter will be used to implement numerical models for the structural behavior of strengthened RE buildings. The effectiveness of the LC-TRM strengthening will be firstly evaluated by means of static tests on structural components. Then, dynamic tests on scale samples will be performed on shaking table to validate and calibrate numerical models in line with the results of the previous phases.

· U C ·

University of Minho School of Engineering

FCT Fundação para a Ciência e a Tecnologia

Institute for Sustainability and Innovation in Structural Engineering

Bruno Samuel Ferreira Gonçalves

Supervisors: Paulo Lourenço/José Campos e Matos

THE USE OF ADVANCED TECHNOLOGIES ON LIFECYCLE ASSESSMENT OF INFRASTRUCTURES

❑ FRAMEWORK

- This work program, in the scientific domain of the Lifecycle Infrastructures Management, consists in developing a tool for infrastructure lifecycle management integrating all stages of the management process, from the data collection in field inspections until decision-making.
- The work is divided in 3 main areas of development: 1st – Determining inspectors real needs in field inspections and development of a inspection platform for mobile devices; 2nd – Development of next condition state index models based on Markov Chains; Optimization and Decision-Making scenarios generation towards a predefined objective function.

❑ MIP – MOBILE INSPECTION PLATFORM AND MARKOV CHAINS

- Structured Information: the application presents a relational information scheme that correlates all the information gathered in field inspections;
- “one-step data handling”:by gathering the information directly to the mobile device there is no need for posterior treatment and re-handling of the information because information is automatically stored;
- Support inspectors in the field: by supplying several types of information to the inspectors they will feel more confident and will produce more objective assessments;
- Normalized inspections forms: data gathered and outputs are normalized independent on the type of inspection.
- Multimedia items describing the component, technical information, and hints on how and what to inspect;
- “5-step” Condition State index assessment;
- Maintenance Condition state assessment;
- Possibility to take notes and to take photos and videos (multimedia items with GPS, altitude and orientation information);
- Presents a list of predefined damages for the component under inspection;
- Next condition index prediction based on Markov chains;
- Real-time assessment and Markov prediction feedback on several inspection parameters (in development).

Fig. 1

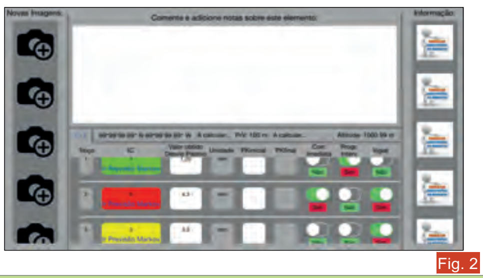


Fig. 2

❑ OVERVIEW AND SCOPE

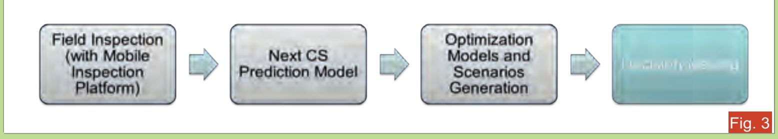


Fig. 3

- The main objective consists in the development of a management tool that integrates inspections data collection (with the MIP), the prediction of next condition state indexes, and the optimization and scenarios generation. The tool will deliver useful information for the decision-making, task that will always be taken by managers and not the tool.

University of Minho
School of Engineering

MIT Portugal

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA


isise
Institute for Sustainability and Innovation in Structural Engineering
Carlos Barroso
Supervisors: Daniel V. Oliveira / Luís F. Ramos
THE RURAL VERNACULAR CONSTRUCTION FROM THE ENTRE-DOURO-E-MINHO
OBJECTIVES: 1. Vernacular materials' physical and mechanical characterization;
2. Rehabilitation methodology and guidelines;
3. Promote heritage protection and disclose vernacular constructive information.
METHODOLOGIE AND RESEARCH TOPICS:
Natural territory conditioning
Buildings to attend different human needs
Vernacular building knowledge
TERRITORY AND SETTLEMENTS ANALYSIS
BUILDINGS' MORPHOLOGICAL AND CONSTRUTIVE CARACTERIZATION
MATERIALS' PHYSICAL AND MECHANICAL CHARATERIZATION
REHABILITATION METHODOLOGY
EXPERIMENTAL WORK
intervention guidelines
Available vernacular construction resources
STONE PHYSICAL CHARACTERIZATION: This set of tests aim to the determination of natural stone's basic physical properties related to their natural resistances and this way assist in the determination of their compatibilities with other materials. Other ongoing tests: petrographic analysis; density and porosity analysis; Schmidt hammer; frost resistance.
NATURAL STONE WATER ABSORPTION
BY CAPILLARITY
AT ATMOSPHERIC PRESSURE
Water Ab. (g/m²)
Time (S⁰⁵) (min)
Average Ab. (%)
Time (S⁰⁵) (min)
X1 P
X1 N
X2 P
X2 N
NATURAL STONE RESISTENCE TO SALT CRYSTALLIZATION
ULTRASOUND PROPAGATION VELOCITY
Loss of mass (gr)
cycles (days)
X1.12
X1.13
X1.14
X1.15
X1.16
X1.11
Wave Speed (m/s)
specimens
M1 N M2 P M3 P
STONE SPECIMENTS: Schist and Granite
MORTAR SPECIMENTS: Soil based mortar
STONE MECHANICAL CHARACTERIZATION: This set of tests aim to the determination of natural stone's mechanical behavior and, this way assist in the determination of the mechanical behavior of vernacular structural masonry. Other ongoing tests: flexural resistance.
AXIAL COMPRESSIVE STRENGHT
UNCONFINED WITH DISPLACEMENT CONTROL
Stress (MPa)
strain (‰)
X2
STUDY CASE: The field survey was performed using a laser scanning equipment, with the objective of gathering detailed constructive and morpho-typological data to characterize the granite masonry corbelled domes buildings of the Serra da Peneda. For its complete structural analysis, using the data gather, an Discrete Element Method's model (DEM) will be built. Other ongoing analysis: statistic analysis of data
U C
University of Minho
School of Engineering
FCT
Fundação para a Ciência e a Tecnologia

Institute for Sustainability and Innovation in Structural Engineering

HEALTH ASSESSMENT OF STRUCTURAL GLUED LAMINATED TIMBER MEMBERS

Carlos Martins

Supervisors: Alfredo Dias / Helena Cruz

❑ Objectives

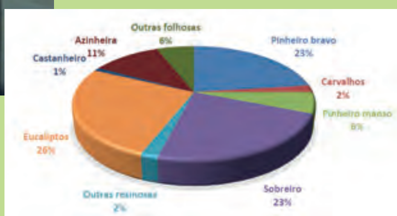
- **The main objective of this work program, is the study of the viability of using native species for Glued Laminated Timber production.**

❑ Experimental program

- **Task 1: Non-destructive characterization of raw material**
- **Task 2: Definition of gluing procedures for all species**
- **Task 3: Gluing of all species**
- **Task 4: Finger-joint connection assessment**
- **Task 5: Technical guide for gluing the species in study**
- **Task 6: Mechanical assessment of structural glued laminated timber elements**
- **Task 7: Assessment of glue lines integrity after natural ageing**

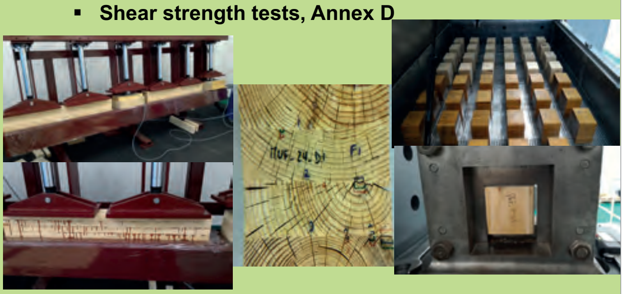
❑ Task 1

- **Measurement of the dimensions of each board**
- **Assessment of Dynamic Modulus of Elasticity through longitudinal vibration method.**
- **The species were considered according to its availability and potential for use as structural element.**
- **Softwoods:**
  - **Untreated Maritime pine (*Pinus pinaster*)**
  - **Treated Maritime pine (*Pinus pinaster*)**
  - **Cryptomeria (*Cryptomeria japonica*)**
- **Hardwoods:**
  - **Poplar (*Populus*)**
  - **Blue gum (*Eucalyptus globulus*)**



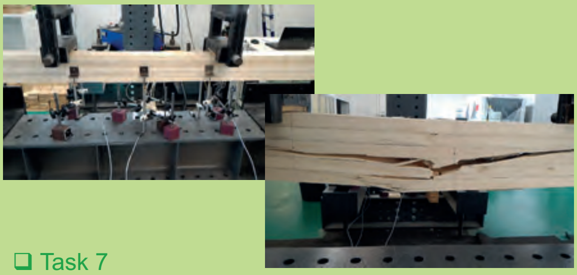
❑ Task 2 and 3

- **Gluing of several elements of 1m length and with 4 lamella and using different parameters, namely: i) amount of adhesive, ii) pressure level, iii) time of pressure, and iv) thickness of lamella.**
- **Quality control of the gluing parameters, EN 14080:**
  - **Delamination tests, Annex C**
  - **Shear strength tests, Annex D**



❑ Task 6

- **Production of elements with approximately 2,5m length.**
- **Assessment of the main mechanical properties (MOE and bending strength) through the EN 408.**
- **Numerical modelling in order to predict the mechanical properties**



❑ Task 7

- **Natural ageing of 42 elements with 1,5m length and 105 mm x 180 mm (b x h).**
- **Exposure to wind, rain, temperature and relative humidity variations.**

With collaboration of:

isise Institute for Sustainability and Innovation in Structural Engineering

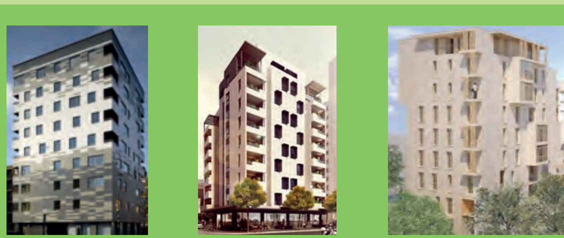
Catarina Vilaça Silva

Supervisors: J. M. Branco/ P. B. Lourenço

TALL BUILDINGS USING CLT. AN INTEGRATED DESIGN CONSIDERING MOISTURE INDUCED EFFECTS

MOTIVATION

- **Sustainability awareness which promotes timber construction;**
- **Overall trend for building in height due to progressive increase of population living in urban areas;**
- **Positive market trend for timber construction in the European context;**
- **Proved adaptability of CLT to multi-storey buildings (fig.1) .**

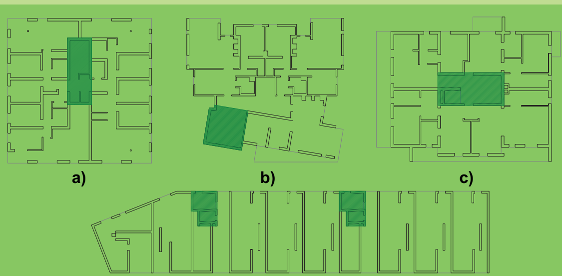


a) b) c)

Fig. 1 - Constructed buildings using CLT. a) Stadthaus, London (9storeys); b) Forté, Australia (10 storeys); c) Via Cenni, Milan (10 storeys)

OBJECTIVES

- **Promote CLT multi-storey construction as a solution that fulfills the best practices currently advocated;**
- **Add value in knowledge of CLT shrinkage/swelling and CLT self-tapping screwed connections considering moisture induced effects;**
- **Combine architectural requirements and engineering issues in order to find more attractive buildings than constructed buildings (fig.2);**
- **Find the best constructive solutions to more flexible multi-storey CLT constructions.**



a) b) c) d)

Fig. 2 – Limited flexibility of CLT multi-storey buildings. a) Stadthaus, central core; b) Forté, decentralized core and irregular shape; c) Via Cenni, central core; d) Bridport, multiple cores and elongated shape.

WORK DEVELOPED

- **Exploratory tests on moisture induced movements on CLT through LVDT's and manual acquisition (fig.3 a);**
- **Exploratory tests on withdrawal capacity of self-tapping screws for different moisture contents of CLT (fig.3 b e c);**
- **Search the right paints and pattern to apply digital image correlation (DIC) as measurement technique (fig.3 d).**

a) b) c) d)

Fig. 3 – Work developed. a) LVDT's acquisition of CLT movements during a stabilization period after CLT saturation; b) specimens used to pull-out tests after induced changes on moisture content; c) pull-out test layout and failure mode; d) sprayed patterns created to test paints.

FUTURE WORK

- **Experimental campaign to evaluate withdrawal capacity of self-tapping screws after reductions on moisture content and subjection to humidity cycles;**
- **Experimental campaign to quantify CLT internal stresses caused by changes on timber moisture content using DIC technique;**
- **Interpret the results and use them to elaborate recommendations for controlling movements and stresses induced by changes in humidity and to propose an integrated design.**

· U C ·

University of Minho School of Engineering

FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Institute for Sustainability and Innovation in Structural Engineering

CÉCILE HAREMZA

Supervisor: Aldina Santiago

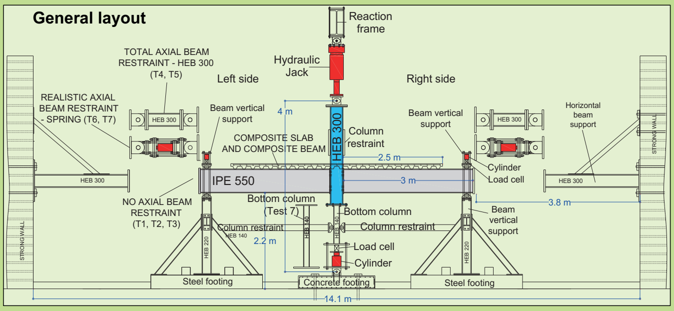
ROBUSTNESS OF STEEL COMPOSITE OPEN CAR PARKS UNDER LOCALISED FIRE

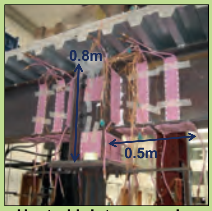
❑ DETAILED STUDY OF THE BEAM-TO-COLUMN JOINT BEHAVIOUR

- Type of joint studied: Composite steel-concrete joint (flush end-plate) in open car park buildings;
- Main objective: to provide sufficient robustness so that the loss of a column under localised fire should not lead to the progressive collapse of the entire building

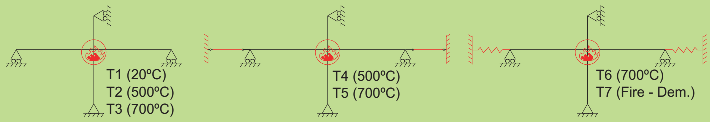
❑ SEVEN FIRE TESTS

- Objective of the tests: to observe the combined bending moment and axial loads in the heated joint when catenary action develops in the frame;
- Loss of the column simulated in the composite frame subject to mechanical and thermal loadings;
- Influence of the beam axial restraints coming from the undamaged structure is studied (zero, total and realistic restraints)



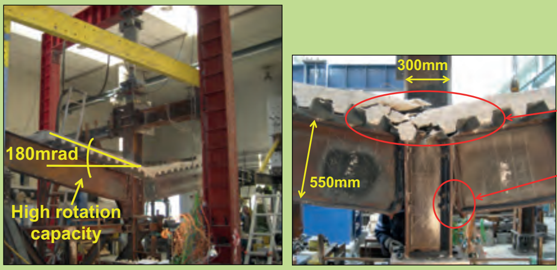


Heated joint zone using Ceramic Pad elements



Seven experimental tests

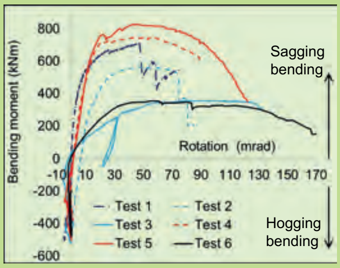
Bolts M30, grade 10.9



Final deformation of the tested structure (test 6)

Failures under sagging bending moment and elevated temperature:

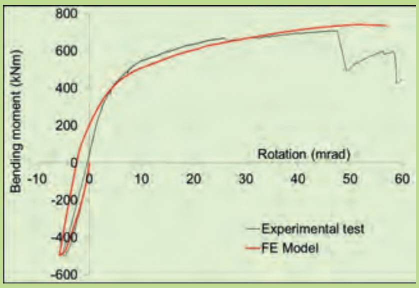
- Crushing of the concrete in compression
- Failure of bolts in tension in the bottom bolt row
- Local deformation of the steel plate



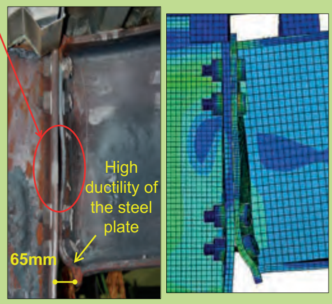
Joint bending moment *vs* rotation at the connection

❑ NUMERICAL SIMULATIONS – *Under development*

- Commercial general finite element (FE) package Abaqus
- FE analysis of the steel composite sub-structure, combining 3D solid and contact elements
- FE models calibrated against the experimental tests results
- Parametric study: influence of the axial restraints to the beams on the joint behaviour



Comparison (test 1 at ambient temperature)



Experimental and numerical deformations for test 3 (elevated temperature)

Institute for Sustainability and Innovation in Structural Engineering

César Javier Chácara Espinoza

Supervisors: Paulo B. Lourenço/ Ivo Caliò

MACRO-ELEMENT NONLINEAR DYNAMIC ANALYSIS FOR THE ASSESSMENT OF THE SEISMIC VULNERABILITY OF MASONRY STRUCTURES

❑ INTRODUCTION

- The response of masonry structures has been deeply investigated throughout experimental campaigns, analytical procedures, and numerical simulations. Regarding the latter, advanced software based on Finite Element FE method are usually employed for the seismic assessment of this type of structures in the static field. On the contrary, the dynamic response of masonry structure is mainly devoted to research applications since a large computational cost is required. In this regard, simplified numerical models based on macro-elements have been developed during the last decades.
- The macro-element model employed in this work corresponds to the one developed by Caliò et al. [1], and further upgraded by Pantò et al. [2]. This modelling approach consists on the assemblage of panels composed of rigid plates and a link that governs the shear-diagonal mechanism of masonry structures. Such assemblage is conducted by means of interface elements capable of simulating in-plane and out-of-plane flexural and shear-sliding responses of masonry structures (see Figure 1).

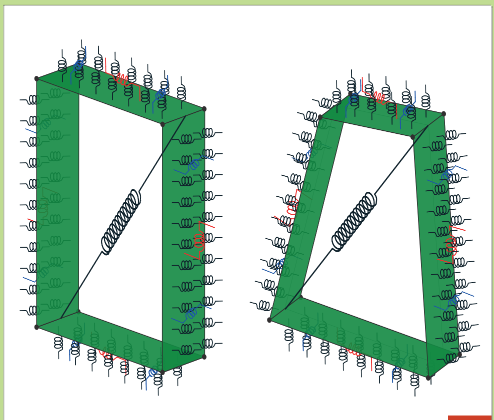


Fig. 1

❑ MACRO-ELEMENT ASSESSMENT OF MASONRY STRUCURES

- Pushover (see Figure 2) and time history (see Figure 3) analyses were conducted to a brick masonry structure by means of a macro-element model, and the corresponding response was further compared to the results from a FE model. It was evidenced the accurate applicability of this macro-element modelling approach for the seismic assessment of masonry structures in the static and dynamic field. It is worth noting that due to the mechanical scheme of this model (7 degrees of freedom per macro-element), there is a significant reduction of the computational cost making it suitable for practical applications.

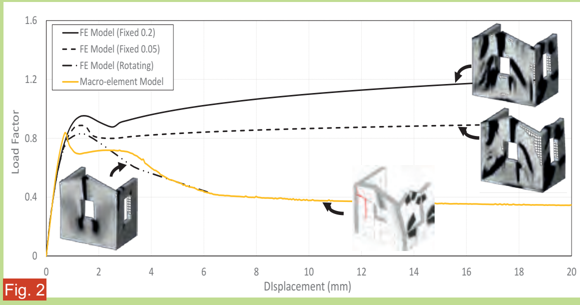


Fig. 2

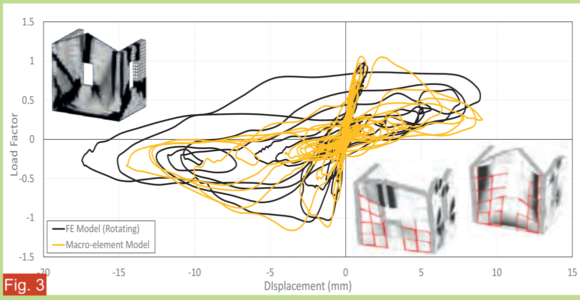


Fig. 3

❑ ONGOING WORK

- Aiming at assessing the seismic vulnerability of masonry structures, fragility curves are estimated by means of the application of dynamic nonlinear analyses, and taking into consideration different uncertainties such as mechanical, and geometrical properties, as well as the characteristics of the ground motion.

[1] I. Caliò, M. Marletta, and B. Pantò, "A new discrete element model for the evaluation of the seismic behaviour of unreinforced masonry buildings," Engineering Structures, vol. 40, pp. 237-338, (2012).

[2] B. Pantò, F. Cannizzaro, I. Caliò, and P. B. Lourenço, "Numerical and experimental validation of a 3D macro-model for the in-plane and out-of-plane behaviour of unreinforced masonry walls," International Journal of Architectural Heritage, (2017).

University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

Chandan Gowda

Supervisors: Joaquim Barros/ Maurizio Guadagnini

USE OF NSM FRP FOR TORSIONAL STRENGTHENING OF THIN WALLED TUBULAR RC STRUCTURES

❑ INTRODUCTION & AIM

- Thin walled tubular structures found in bridges, circular staircase etc. often require torsional strengthening. However, there are no efficient practical strengthening solutions available on the market and the understanding of torsional behavior is still limited. In addition no experimental or numerical research is currently available in the field using innovative strengthening techniques.
- To develop an innovative near surface mounted (NSM) fiber reinforced polymers (FRP) system for torsional strengthening of thin walled tubular RC structures
- To develop design guidelines for torsional strengthening with NSM FRP

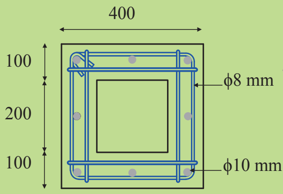


Fig. 1

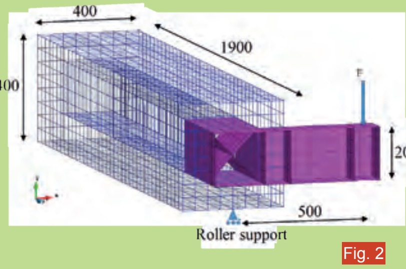


Fig. 2

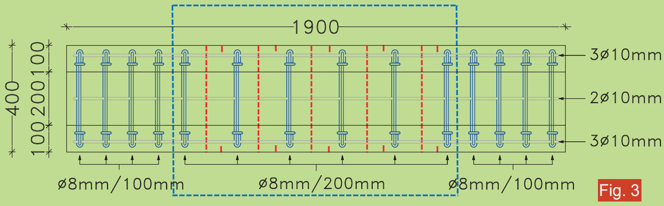


Fig. 3

❑ EXPERIMENTAL WORK/ PROPOSAL OF STRENGTHENING TECHNIQUES

Fig. 4

- The experimental test setup for torsion is as shown in figure 4 with the details of beam presented in figures 1-3. 8 strengthening schemes are proposed where only 4 are shown in figure 5 and the other techniques involves using special L-CFRP laminates

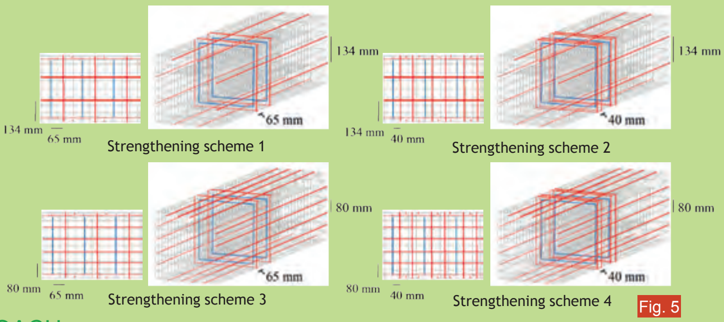


Fig. 5

❑ ANALYTICAL AND NUMERICAL APPROACH

- Torsional numerical analysis of all strengthened beams after validation of the numerical model will be performed (preliminary numerical results shown in figure 6)
- Analytical model and design guidelines will be proposed

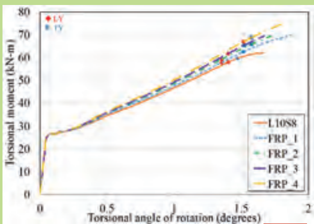


Fig. 6

❑ EXPECTED OUTCOME

- Increase ultimate torsional capacity by 20%
- Increase in torsional stiffness in the elasto-plastic range
- Control in crack propagation
- Develop design guidelines for torsional strengthening

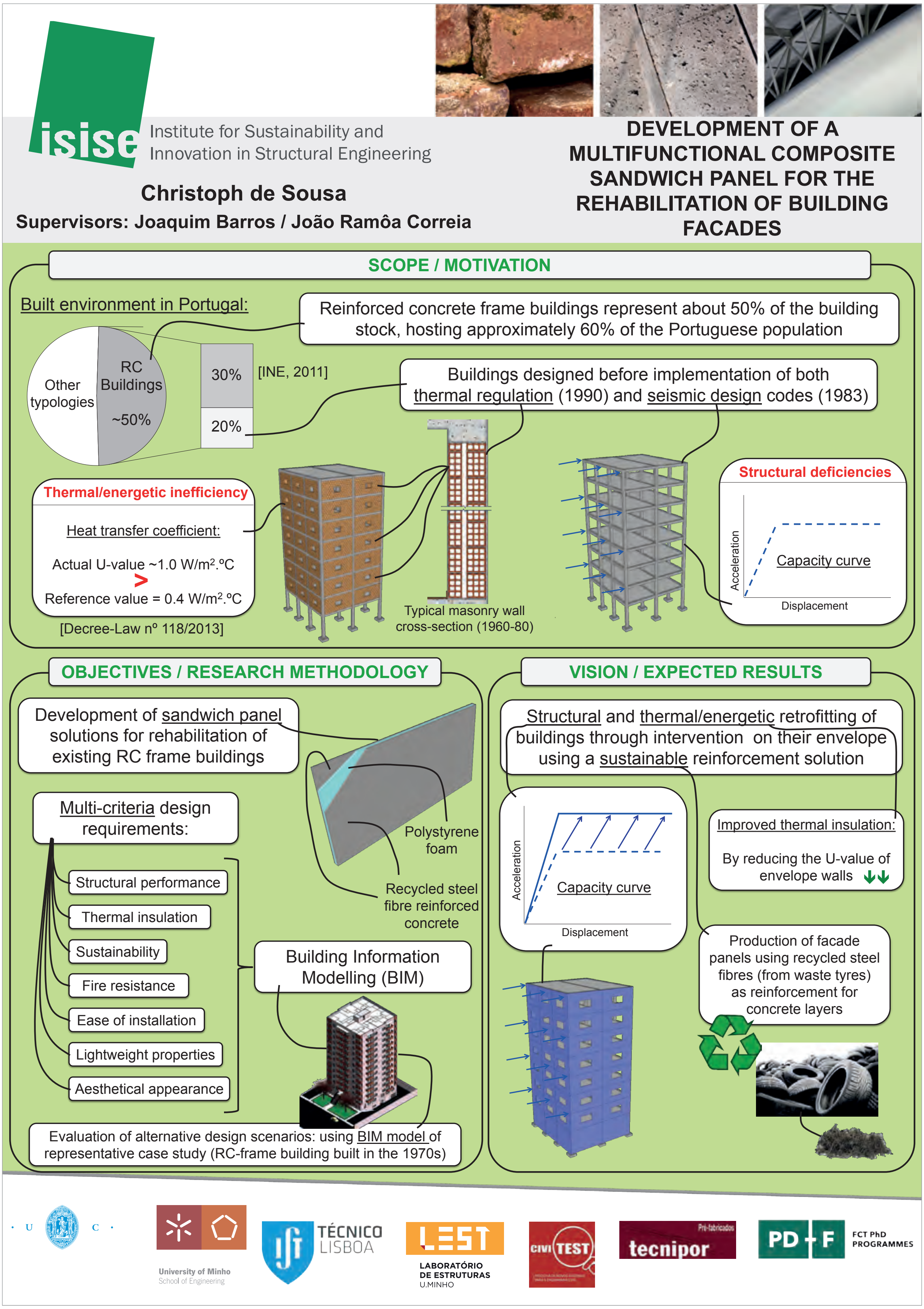
University of Minho
School of Engineering

TU1207

SEVENTH FRAMEWORK PROGRAMME

endure

Marie Curie Initial Training Network
European Network for Durable Reinforcement and Rehabilitation Solutions
http://www.endure-itn.eu



isise
Institute for Sustainability and Innovation in Structural Engineering
Christoph de Sousa
Supervisors: Joaquim Barros / João Ramôa Correia
DEVELOPMENT OF A MULTIFUNCTIONAL COMPOSITE SANDWICH PANEL FOR THE REHABILITATION OF BUILDING FACADES
SCOPE / MOTIVATION
Built environment in Portugal:
Other typologies
RC Buildings
~50%
30%
20%
[INE, 2011]
Reinforced concrete frame buildings represent about 50% of the building stock, hosting approximately 60% of the Portuguese population
Buildings designed before implementation of both thermal regulation (1990) and seismic design codes (1983)
Thermal/energetic inefficiency
Heat transfer coefficient:
Actual U-value ~1.0 W/m².ºC
>
Reference value = 0.4 W/m².ºC
[Decree-Law nº 118/2013]
Typical masonry wall cross-section (1960-80)
Structural deficiencies
Acceleration
Capacity curve
Displacement
OBJECTIVES / RESEARCH METHODOLOGY
Development of sandwich panel solutions for rehabilitation of existing RC frame buildings
Polystyrene foam
Recycled steel fibre reinforced concrete
Multi-criteria design requirements:
Structural performance
Thermal insulation
Sustainability
Fire resistance
Ease of installation
Lightweight properties
Aesthetical appearance
Building Information Modelling (BIM)
Evaluation of alternative design scenarios: using BIM model of representative case study (RC-frame building built in the 1970s)
VISION / EXPECTED RESULTS
Structural and thermal/energetic retrofitting of buildings through intervention on their envelope using a sustainable reinforcement solution
Acceleration
Capacity curve
Displacement
Improved thermal insulation:
By reducing the U-value of envelope walls
Production of facade panels using recycled steel fibres (from waste tyres) as reinforcement for concrete layers
University of Minho
School of Engineering
TÉCNICO LISBOA
LEST
LABORATÓRIO DE ESTRUTURAS
U.MINHO
CIVITEST
tecnipor
PD F
FCT PhD PROGRAMMES

isise Institute for Sustainability and Innovation in Structural Engineering

Chrysl Assumpta Aranha

Supervisors: Jorge Branco / Paulo Lourenço

EXPERIMENTAL AND NUMERICAL ASSESSMENT OF THE SEISMIC BEHAVIOUR OF LOG AND CROSS-LAMINATED TIMBER SYSTEMS

❑ CONTEXT OF THE RESEARCH

- Engineered timber structures can be effective housing solutions in seismic areas.
- However, the widespread use of engineered timber structures is limited by the fact that design codes lag behind construction practice.
- The doctoral research aimed at improving the working knowledge of the seismic performance of log and Cross-Laminated Timber (CLT) structures as described in Fig. 1.

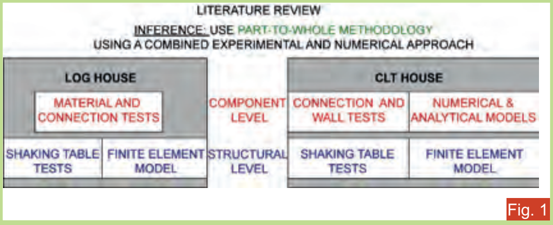


Fig. 1

❑ THE LOG HOUSE

- A 2-storey log house (Fig. 2) with glulam logs was tested at the shaking table in LNEC, Lisbon under the SERIES project on timber buildings.
- An FE model of the house was developed in SAP2000 using the data obtained from characterization tests conducted on the logs, connections and walls. The results of the numerical model were validated against the results of the shaking table tests of the full-scale house.
- Only a simple representative model of the structure, whose validity was determined based on linear modal analysis, was developed in SAP2000 (see experimental and numerical mode shape comparison in Fig. 3).
- The values of the modulus of elasticity along the grain and the shear modulus in the radial-tangential direction were found to hugely influence the behaviour of the model.


Fig. 2

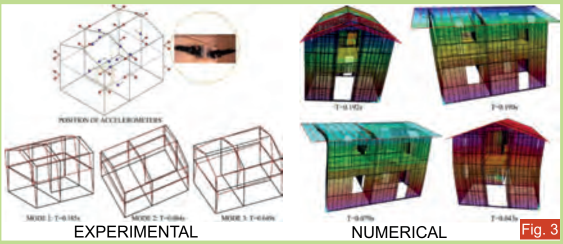


Fig. 3

❑ THE CLT HOUSE

- The CLT house tested was similar to the log house in plan but was 3 storeys tall (Fig. 4).
- Models that simulate the behaviour of the connections were developed in OpenSees and SAP2000 and were validated at both connector and wall levels.
- An analytical prediction of the lateral load capacity of CLT walls connected to a rigid foundation using connectors with known mechanical properties was made using MATLAB.


Fig. 4

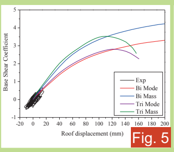


Fig. 5

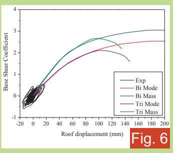


Fig. 6

- A 3D finite element model of the CLT building was developed in SAP2000. The validity of the full-scale model was determined by subjecting it to linear and non-linear analyses.
- As in the tests, the pushover analyses revealed that the CLT house was quite far from collapse (see Fig. 5 and 6 for comparison of pushover curves in the Y-direction of the original and weakened configuration of the building).

- With regard to the finite element modelling of CLT structures, the importance of the definition of the load-slip behaviour of the connectors was highlighted both at the component level and at the structural level through the findings of this thesis.

University of Minho
School of Engineering
SERIES

Institute for Sustainability and Innovation in Structural Engineering

Cristiana Bonifácio

Supervisors: José Campos e Matos / Cecília Vale

A CUTTING-EDGE ASSET MANAGEMENT FRAMEWORK FOR RAILWAY TRACKS

❑ RESEARCH OBJECTIVES

- **In Railway Industry, one of the main aspects in terms of costs and efficiency of the industry is the infrastructure maintenance. To achieve the aims and overcome the challenges of the Railway industry, the maintenance paradigm is being reformulated: RAMS – Reliability, Availability, Maintainability and Safety; CBM – Condition Based Maintenance; Condition Monitoring; Degradation Models; Performance Models; Nowcasting; Forecasting; Decision Support**
- **The framework will be focused on the railway track and its components and it will incorporate: data mining algorithms for the analysis of existing databases, so that it is possible to take the maximum advantage of historical data; performance predictive model for each asset, Hidden Markov Models (HMM) or more complex algorithms; an evolutionary framework for multi-objective and multi-criteria optimization and probabilistic based decision trees, that will incorporate risk concepts to help owners and operators finding the optimal management strategy**

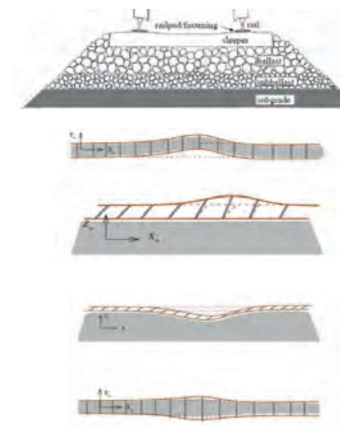


Fig. 1

❑ MONITORING SYSTEMS

- **The real condition monitoring data will be collected throught monitoring systems, both onboard systems installed in CPA4000 and on wayside systems installed in the track (Fig3 and Fig4).**

Fig. 2

Fig. 3

❑ NUMERICAL MODELS

- **Implementation of numerical models of the train and track allows the simulation of the assets performance and degradation, to fill the missing data related with events that have never been measured and the development of algorithms that allows to extract the KPIs related with each asset and from each data source (Fig5 and Fig6).**

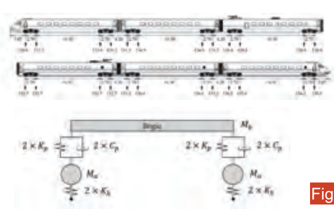


Fig. 4

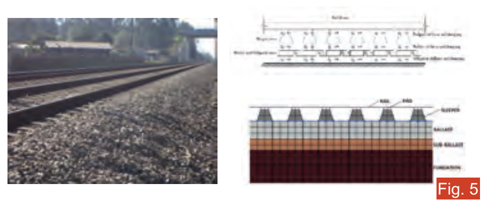


Fig. 5

University of Minho
School of Engineering

U.PORTO
FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

Institute for Sustainability and Innovation in Structural Engineering

CRISTINA CALMEIRO DOS SANTOS

Supervisor: João Paulo Correia Rodrigues

RESIDUAL MECHANICAL PROPERTIES OF ORDINARY CONCRETES AFTER FIRE

❑ OBJECTIVES

- The aim of this research work was to evaluate the influence of the fire extinguishing methods, the maximum temperature that the concrete was subjected to and the loading level on the residual mechanical properties of calcareous and granite aggregate concretes.

❑ RESEARCH PLAN

Materials

- Calcareous (CC) and Granite (GC) concretes were tested.

Cooling processes, maximum temperatures and load level

- Two cooling processes: cooling in the air (simulating a fire extinguished in a natural way) and the cooling by water jet (simulating the action of the firefighters) (Fig.1a, 1b and 1c).
- The temperature levels tested were 20, 300, 500 and 700°C.
- The load levels tested were $0.3f_{cd}$ or $0.7f_{cd}$.

Type of tests

- Residual compressive strength tests (Fig.1).
- Residual direct and splitting tensile strength tests (Fig.2 and 3).
- Residual flexural tensile strength tests (Fig.4).
- Residual modulus of elasticity and Poisson's ratio tests (Fig.5).

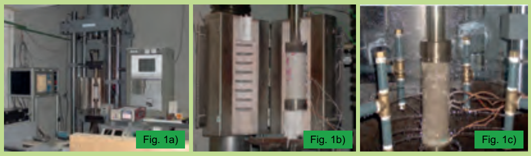


Fig.1 Residual compressive strength; a) test set-up; b) cooling in the air; c) cooling by water jet.

Fig.2 Test set-up for the residual direct tensile strength tests.

Fig.3 Test set-up for the residual splitting tensile strength tests.

Fig.4 Test set-up for the residual flexural tensile strength tests.

Fig.5 Test set-up for the residual modulus of elasticity and Poisson's ratio tests.

❑ SOME RESULTS

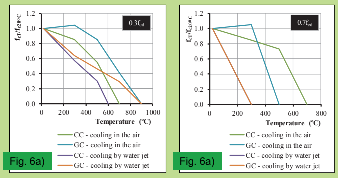


Fig.6 Residual compressive strength; a) $0.3f_{cd}$; b) $0.7f_{cd}$.

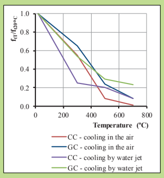


Fig.7 Residual direct tensile strength.

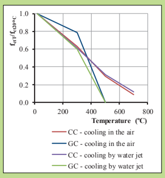


Fig.8 Residual splitting tensile strength.

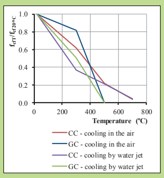


Fig.9 Residual flexural tensile strength.

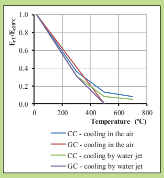


Fig.10 Residual modulus of elasticity.

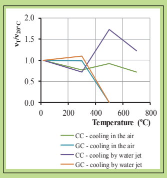


Fig.11 Residual Poisson's ratio.

❑ SOME CONCLUSIONS

- The high temperatures have had a negative influence on the residual compressive strength of the concrete being this most noticeable in calcareous than in the granite aggregate concrete.
- The loading level, if not too excessive, interferes positively on the residual compressive strength of concrete avoiding cracking.
- The cooling process influenced very much the residual compression strength of the concretes after heating and cooling.
- The residual tensile strength of concrete decreased also with the temperature.
- The residual flexural strength has reduced in function of the maximum temperature that the concrete was subjected to.
- Independently of the aggregate type of concrete and cooling process used, the residual modulus of elasticity and Poisson's ratio shows a sharply decrease with temperature.

University of Minho
School of Engineering

Escola Superior de Tecnologia

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

isise Institute for Sustainability and Innovation in Structural Engineering

Cristina Frazão

Supervisors: Joaquim Barros / Alexandre Bogas

NEW CONSTRUCTION SYSTEMS IN CONCRETE REINFORCED WITH RECYCLED FIBERS

❑ OBJECTIVE

- **This work program, in the scientific domain of the Concrete Structures, consists in assessing the potential of using recycled steel fibers from the tire recycling industry (Fig. 1 and 2) as an effective reinforcement of concrete for the development of ductile, high-strength and durable constructive systems (Fig. 3), as it is required for tetrapods, often used in the effective protection of coastal zones (Fig. 4 and 5).**
- **The development of this new generation of breakwaters with more effective protection of the coastal zone and lower maintenance costs, includes experimental work associated with advanced numerical modeling.**

❑ EXPERIMENTAL AND NUMERICAL RESEARCH

- **This PhD work involves two main group tasks; the first one dedicated to the optimization of RSFRC and the assessment of its mechanical and durability properties, and the second one dedicated to the investigation on the corrosion susceptibility of RSFRC. Experimental programs are being performed with small test specimens in laboratory environment in order to obtain results to perform numerical simulations aiming to address the possibility of calibrating the constitutive models by inverse analysis for the material nonlinear analysis of RSFRC structures.**

Technology of RSFRC manufacturing

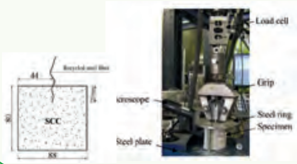
Rheology properties

Flexural behavior

Energy dissipation capacity

Compressive behavior

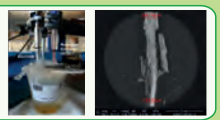
•• Steel fiber pullout behavior



Corrosion susceptibility of RSFRC

Characterization of fiber corrosion

- Electrochemical tests
- SEM analysis
- Nanoindentation testing

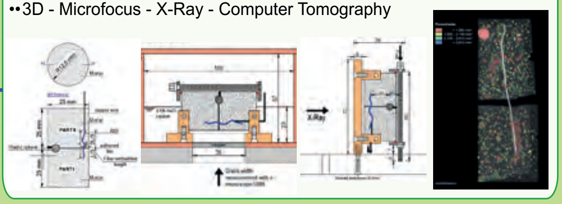


Post-cracking behavior under corrosive action

- Splitting tensile tests

Steel fiber pullout behavior under corrosive action

- 3D - Microfocus - X-Ray - Computer Tomography



Numerical study

Inverse analysis

Material nonlinear simulations

University of Minho School of Engineering

UNIVERSITAT LEIPZIG

isise Institute for Sustainability and Innovation in Structural Engineering

David Andrade

Supervisors: Dulce Rodrigues/ Carlos Leitão

ANALYSIS OF THE THERMO-MECHANICAL CONDITIONS IN FRICTION STIR BASED TECHNOLOGIES

❑ Summary

This work aims to study the thermo-mechanical conditions governing the heat generation and material flow in friction stir based processes. As schematized in Figure 1, these processes make use of a rotating non-consumable tool, subjected to an axial force and linear translation, for welding (FSW) or enhancing (FSP) metallic materials. The tool rotation and translation promote not only the heating by friction of the materials to be joined/processed, but also its plastic deformation under complex loading conditions and very high strain rates. Material stirring during FSW/P is so complex that the flow of the material is usually described as a complex combination of forging and extrusion. Many new stir-based technologies have been derived from FSW (Figure 2), and have been adapted to several industrial applications (Figure 3) , such as joining, processing by microestrutural enhancement and/or mechanical alloying, additive manufacturing or weld repair.

Stir based Technologies

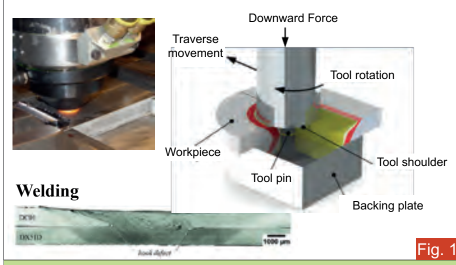


Fig. 1

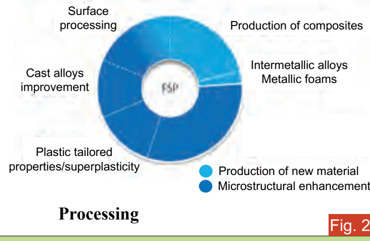


Fig. 2

Industrial applications

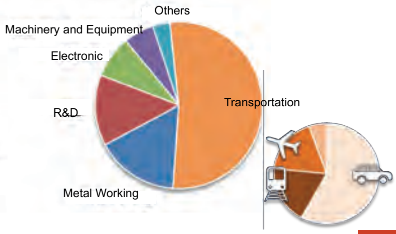


Fig. 3

❑ OBJECTIVES/EXPERIMENTAL PROCEDURE

The objectives/experimental procedure will be composed by the following steps:

- **Problem modelling - Static and dynamic analysis of the contact between the rigid FSW/P tool and the deformable body, i.e., the base material being welded/processed. Empirical relations between the processing parameters.**
- **Experimentation - The stir based processing mechanisms will be identified and decoupled. Mechanical characterization, at very high temperatures and strain rates, of the metals selected for the investigation, together with microestrutural analysis of welded/processed samples, will be performed (Figure 4).**
- **Model optimization/calibration –The model developed will correlate process parameters, base materials properties and processing conditions (Figure 5).**
- **Validation – The mechanical model will be validated by fitting it to a broad range of welding/processing results available from previous experimental researches on processing parameters optimization.**

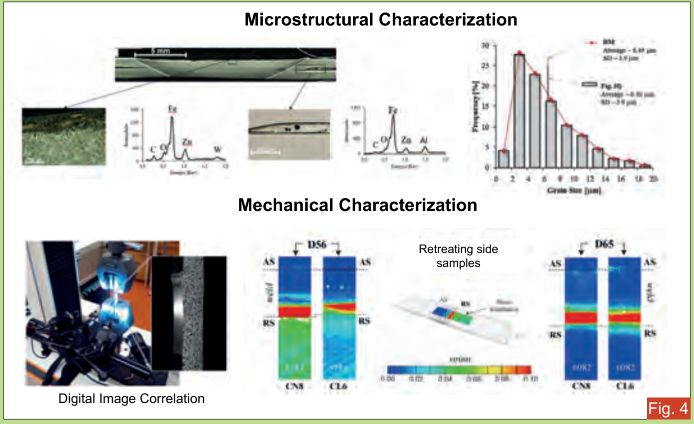


Fig. 4

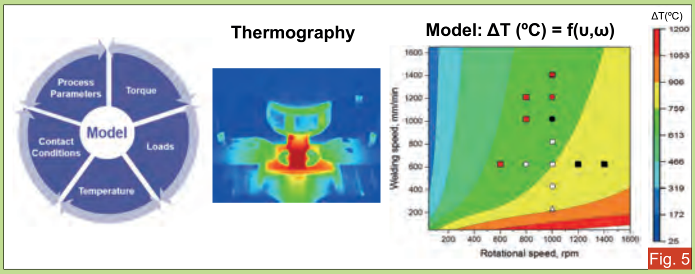


Fig. 5

University of Minho School of Engineering

CEMMPRE

isise Institute for Sustainability and Innovation in Structural Engineering

David Cassiano

Supervisors: C. Rebelo / M. D'Aniello / R. Landolfo

POST SEISMIC STRUCTURAL ROBUSTNESS IN MOMENT RESISTING FRAME STEEL BUILDINGS

❑ EXPERIMENTAL CYCLIC INELASTIC TENSILE TESTS OF BOLT ASSEMBLIES

- The experimental activities were devoted to investigating the nonlinear response and failure modes of European SB, HR and HV bolt assemblies (Fig.1-2).
- Bolt assembly response to variable and constant amplitude cyclic actions is presented, characterizing the damage induced by cyclic actions in the plastic range for seismic applications. Criteria for numerical finite element (Fig.3) and for analytical modelling of bolt assemblies were proposed.

Fig. 1

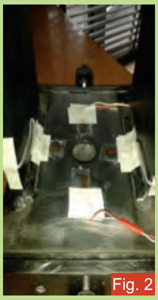


Fig. 2

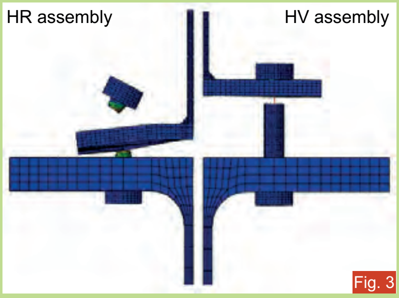


Fig. 3

❑ PARAMETRIC NUMERICAL ANALYSIS OF FLUSH END-PLATE (FEP) BEAM-TO-COLUMN JOINTS

- The rotation capacity of FEP joints and its flexural interaction with catenary forces developing under column loss and under column loss following cyclic bending was investigated via FE analysis (Fig.4).
- The influence of the different variables such as the number of bolt rows (Fig.6), the bolt diameter, the end-plate thickness (Fig.6) and the type of beam section profile on joint response, dynamic increase factors (DIF) (Fig.7) and on design procedures was discussed.
- A design criterion based on end-plate thickness and on the predicted T-Stub failure mode was proposed to maximize joint performance under column loss action.

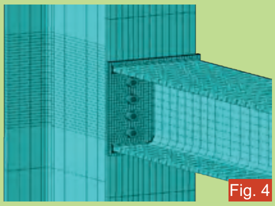


Fig. 4

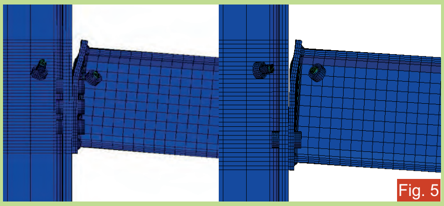


Fig. 5

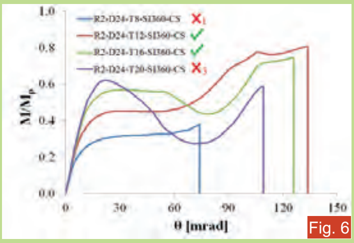


Fig. 6

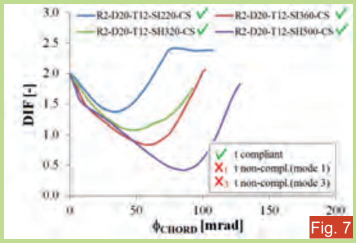


Fig. 7

❑ NONLINEAR DYNAMIC ANALYSIS OF MOMENT FRAMES UNDER COLUMN LOSS SCENARIOS

- The response of 3D structures to column loss and post seismic column loss was numerically investigated (Fig.8).
- The contributions of the secondary "gravity" frame connections and of the façade claddings for progressive collapse arresting were explicitly modelled (Fig.9).
- The post seismic and initially undamaged column loss responses were compared to assess the impact of seismically induced damage on structural robustness (Fig.10).

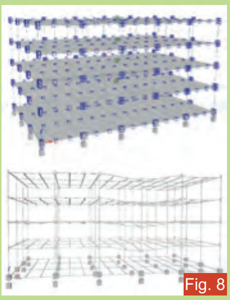


Fig. 8

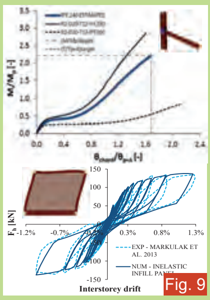


Fig. 9

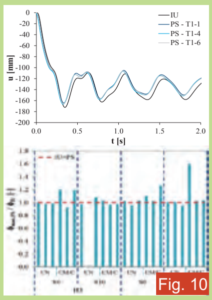


Fig. 10

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Eduardo José Escaroupa Roque

Supervisor: Paulo Santos

Energy performance of Lightweight steel-framed buildings in warm climates under the Passive House umbrella

❑ MOTIVATION

- Population growth allied with the demand for high indoor comfort levels turns the construction sector as one of the greatest energy consumers.
- Statistics are showing that the buildings sector is the major primary energy consumer in Europe, overriding the industry or the transports sectors.
- In the European Union, residential buildings cooling and heating energy demand represents de biggest share of the total operational energy.

❑ OBJETIVES

- Development of new smart adaptive constructive solutions and operation strategies that potentiate the advantages of the LSF constructive system in the pursuit for high energy efficient buildings and compliance with the Passive House (PH) standard/ requirements.
- Minimize Lightweight steel-framed (LSF) buildings possible drawbacks regarding the thermal performance (e.g. low thermal inertia, thermal bridges) in order to reach high standards on the energy efficiency.

❑ MAIN COMPUTATIONAL TOOLS

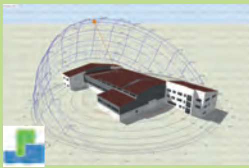


Fig.3 – DesignBuilder Software

Fig.4 – PHPP Tool

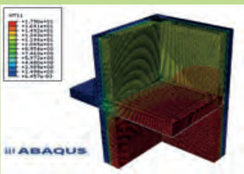


Fig.5 – ABAQUS Software

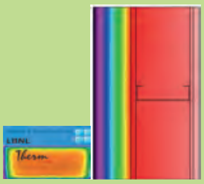


Fig.6 – THERM Software

Fig.1 – LSF building

Fig.2 – PH basic principies

❑ LSF BUILDINGS AND THE PASSIVE HOUSE CONCEPT

- To fulfil the Energy Performance of Buildings Directive (EPDB) goals the PH concept is an essential premise in order to reduce annual energy demand and achieve Nearly Zero Energy Buildings (nZEB).
- The PH standard is based on five main principles: adequate thermal insulation; efficient windows; perfect air tightness; minimization of thermal bridges and a ventilation system with heat recovery.
- In spite of the PH concept was initially established for cold climates, the applicability of this concept is already spreading to the Southern European climates.
- In Portugal, it is estimated that the adjustment of the PH concept can reduce nearly 90% of thermal energy consumption in buildings [1].
- Despite the benefits of LSF constructive system, the effect of thermal bridges on LSF elements, caused by the high thermal conductivity of the structural steel and the low thermal inertia of buildings, can be a disadvantage, impairing the compliance with Passive House requirements.

❑ REFERENCES

[1] H. Gonçalves, L. Brotas, Passivehauss Applied to Warm Climates in Europe Instituto Nacional de Engenharia, Tecnologia e Inovação, Lisbon, Portugal, 2007.

· U C ·

University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

ENHANCEMENT OF THE TUBE-JACK NON-DESTRUCTIVE TEST METHOD FOR HISTORICAL STRUCTURAL MASONRY DIAGNOSIS

Elizabeth Campbell Manning

Supervisors: Luis Ramos / Francisco Fernandes

❑ RESEARCH GOAL

- The aim of this work was to develop a minor destructive test method that can estimate the state of stress and deformability characteristics in large unit historical masonry. The enhancement of the tube-jack test method has the potential to provide an alternative method to traditional flat-jack testing to obtain more accurate information during the investigation of a historical masonry structure.

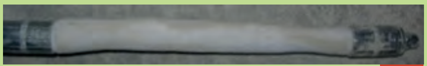


Fig. 1

❑ TUBE-JACK SYSTEM

- Tube-jack testing is similar to traditional flat-jack testing, except that a series of tubular jacks (Fig. 1) are used to pressurize holes in the masonry rather than using flat-jacks to pressurize slots in the masonry.
- The line of tube-jacks forms an equivalent flat-jack (Fig. 2). The discrete nature of the tube-jacks allows them to be placed in irregular joints. The single tube-jack test is used to estimate the state of stress in the masonry.
- The double tube-jack test (Fig. 3) is used to determine the deformability characteristics of the masonry.

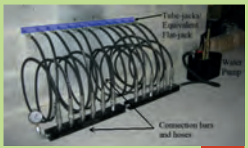


Fig. 2

Fig. 3

❑ LABORATORY AND FEM TESTING

- Single and double tube-jack testing was performed in the laboratory in three masonry walls with different typologies; regular, semi-irregular, and irregular. Flat-jack testing was also performed in the same walls for comparison. The walls were loaded in compression to simulate additional building levels above. The test arrangement for the irregular wall is shown in Fig. 4.
- The mechanical characterization of the constituent materials of the tube-jack system; rubber (Fig. 5) and fabric (Fig. 6); the masonry; granite (Fig. 7) and mortar; and small masonry wallets (Fig. 8) was performed.
- Each of the tube-jack and flat-jack tests were modeled using the Finite Element Modeling program Diana (Fig. 9). Modeling helped to understand the results of the laboratory tests.

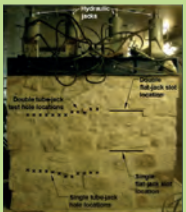


Fig. 4

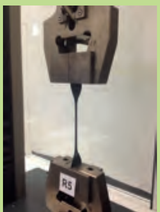


Fig. 5

Fig. 6

Fig. 7

Fig. 8

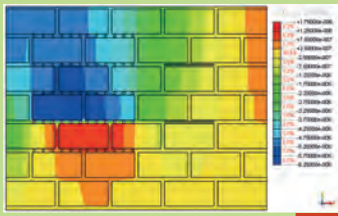


Fig. 9

❑ TESTING AT THE SAN FRANCISCO CONVENT

- The developed tube-jack system was tested on a historical masonry convent in Braga (Fig. 10).
- The single tube-jack test was able to estimate the state of stress in the masonry and was comparable to the single flat-jack test (Fig. 10).

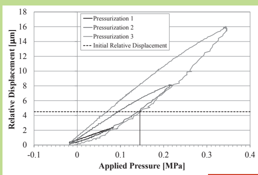


Fig. 11

Fig. 10

❑ CONCLUSIONS

- The tube-jack test method was developed from a theory to a functioning system.
- The single and double tube-jack tests were able to estimate the state of stress and Young's modulus in a historic masonry structure, when compared with flat-jack testing.
- Further research is required to improved and standardize the method.

University of Minho
School of Engineering

PROGRAMA DOUTORAL EM ENGENHARIA CIVIL
UNIVERSIDADE DO MINHO

isise Institute for Sustainability and Innovation in Structural Engineering

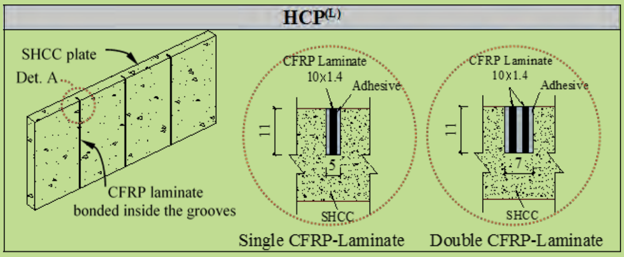
Esmaeel Esmaeeli

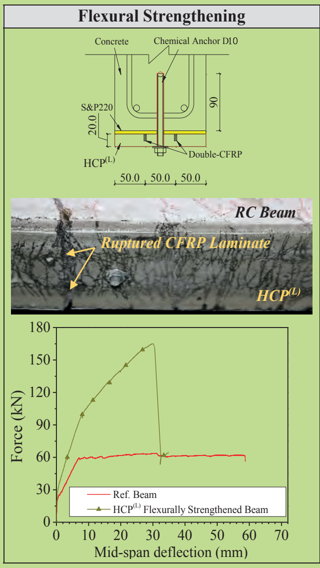
Supervisors: Joaquim Barros & Said Jalali

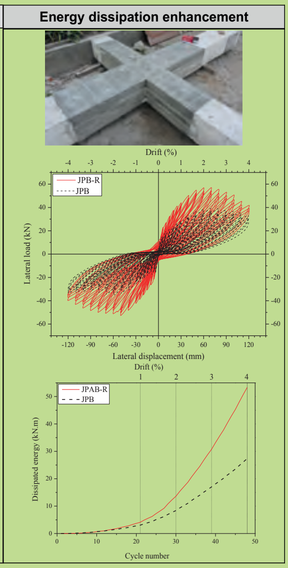
Development of Hybrid Composite Plate (HCP) for Strengthening and Repair of RC Structures

❑ Introduction

- As part of the research project PrePam, and with the collaboration of other researchers of this project, it was **developed** an innovative element for retrofitting RC structures, designated "**Hybrid Composite Plate (HCP)**".
- HCP is composed of a thin **Strain Hardening Cementitious Composite (SHCC)** plate reinforced with **CFRP** bonded onto the face of the SHCC plate either in the form of Externally Bonded Sheets or NSM Laminates.
- HCP was developed in response to the **shortcomings of** the classical strengthening techniques, such as **FRP** or **TRM** systems.
- HCP utilizes the **synergetic advantages** of SHCC and CFRP, namely **high ductility** and **high tensile strength**, respectively, for the retrofitting of RC members.







- The **self-controlled crack width** mechanism of SHCC assures that up to almost the tensile rupture of the CFRP the **average width of cracks** in SHCC remains **fine enough**, to be hardly permeable.
- **Bearing capacity** of SHCC is suitable to attach HCP to the RC using **mechanical fasteners**, individually or in combination with **adhesive**.
- The excellent **Flexural Strengthening Efficiency of HCP** as well as its capability for **Enhancing Energy Dissipation Capacity** are demonstrated through sets of experimental tests on retrofitted RC beams and beam-column joints.
- An **analytical approach** along with a **numerical strategy** are proposed to predict the **load-deflection response** of flexurally strengthened beams with HCP.
- Finally, **design recommendations** for an **optimized HCP** and **HCP-RC connection** are provided, based on the results obtained from a combination of **experimental tests** and **Finite Elements Models (FEM)**.

❑ Main Outcomes

- **Industry is provided** with a **sustainable retrofitting element**, where durability, connection reliability and application feasibility are all integrated in one solution.
- **Patent PT107111**
-

IIFC

International Institute for FRP in Construction

Certificate for being shortlisted for the IIFC 2016 Best PhD Thesis Award

is presented to

Esmaeel Esmaeeli

for the thesis entitled

Development of Hybrid Composite Plate (HCP) for Strengthening and Repair of RC Structures

Jian-Fei Chen, President of IIFC

December 2016

The author would like to acknowledge the FCT –for financial support provided under the Doctoral grant (SFRH/BD/ 65663 /2009).

· U C ·

University of Minho School of Engineering

S&P Clever Reinforcement Company

FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Institute for Sustainability and Innovation in Structural Engineering

Fatemeh Soltanzadeh

Supervisor: Joaquim António Oliveira de Barros

HIGH PERFORMANCE FIBRE REINFORCED CONCRETE FOR THE REPLACEMENT OF SHEAR STIRRUPS

❑ MOTIVATION AND OBJECTIVES

- **This study presents** a methodology to develop a durable and sustainable prefabricated concrete beam with emphasis on eliminating the conventional stirrups, taking in to account the arrangements introduced in Fig.1.
- **These elements were produced by means of:**
- Development of a HPFRC aiming to suppress the steel stirrups without occurring shear failure, and
- Application of an effective system of reinforcement for pre-fabricating the HPFRC beams of larger life cycle, by combining the glass fiber reinforced polymer (GFRP) and steel bars, with the reinforcing ratio and the pre-stress level that assure the required load caring capacity and ductility of the elements.

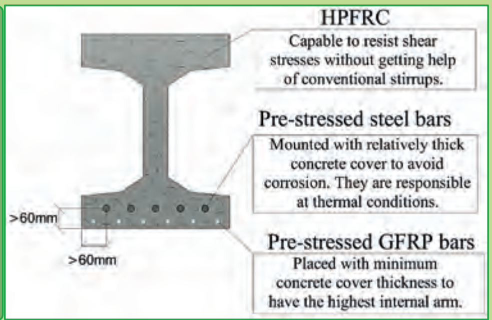


Fig. 1

- **The interest on using this system** is related to the structural efficiency, longer life cycle and lesser costs maintenance that can be obtained using this system.
- **The main purpose is** to develop a design guideline to predict the shear resistance of such beams without stirrups.

Fig.2 outlines the procedure of this research project.

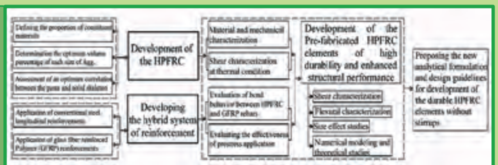


Fig. 2

❑ SUMMARY OF THE STUDIES & RESULTS

1. Characterizing the behavior HPFRC slender beams (with $a/d_{eff} > 2.5$)

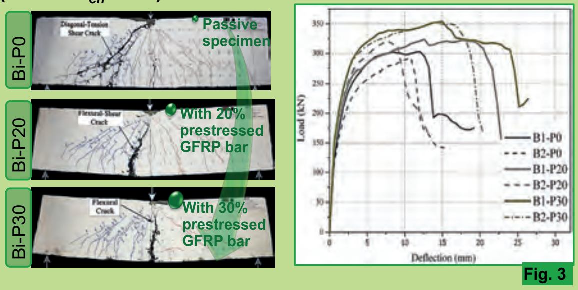


Fig. 3

2. Characterizing the behavior HPFRC slender beams (with $a/d_{eff} > 2.5$)

A. Evaluating the effectiveness of the prestressing on improvement the shear behavior of the elements

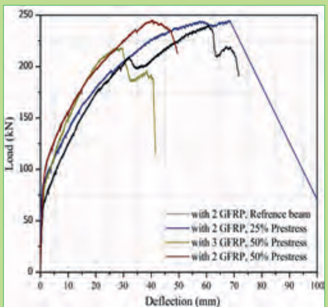


Fig. 4

B. Evaluating the effectiveness of the discrete steel fiber on improvement the shear behavior of the elements (Prestress: S70%&G30%)

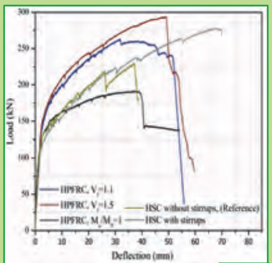
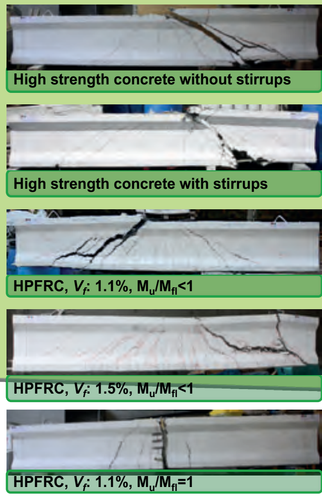


Fig. 5



University of Minho
School of Engineering

Acknowledgements:
Tensacciaci in the name of Eng. F. Pimenta for the assistance on the application of prestress reinforcements; Sireg and Schoeck (GFRP bars); Casais (moulds); Maccaferri and Exporplas (fibers); Secil (Cement), SIKA (superplasticizers); CiviTest (production of HPFRC specimens).

isise Institute for Sustainability and Innovation in Structural Engineering

FERNANDA LOPES

Supervisors: Aldina Santiago and José Guilherme S. da Silva

COMPOSITE JOINTS FOR IMPROVED FIRE ROBUSTNESS

❑ OBJECTIVE

- Study of the behaviour of the joints between **steel beams** and **concrete-filled tube columns** (room and high temperatures).
- Joint typology to be studied: **reverse channel connection**.
- Demonstration of the **influence of the joints on the global behaviour** of frames (coupled problem).
- Numerical and experimental assessments to predict **progressive collapse** of composite structures under **fire attack** (heating and cooling phases).
- Development of **joint design criteria** for practical applications.

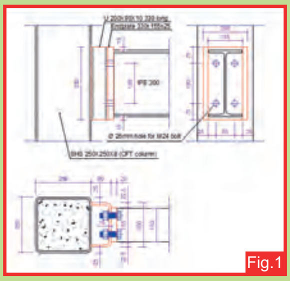


Fig.1

Reverse channel joint: details

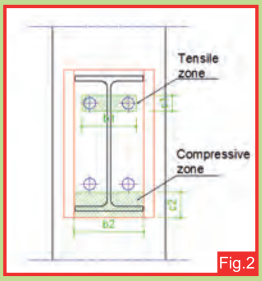


Fig.2

Critical zones

❑ COMPONENT TESTS

- Tensile and compressive tests on reverse channel section at **ambient and high temperature** to obtain a relationship between **force-deflection-temperature** of the components of the joint typology.
- 3 types of channel sections**: welded**, **rolled** and **cut from square tube** sections.
- 3 test temperatures: **ambient**, **550ºC** and **750ºC**.

Fig.3

Welded channels to be tested

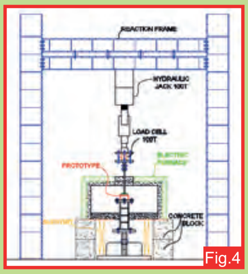


Fig.4

Tensile tests

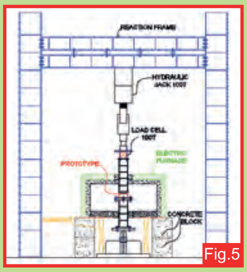


Fig.5

Compressive tests

❑ FIRE TESTS ON SUB-FRAMES

- Interaction between the **reverse channel joint** (channel sections from cut tubes) and the surrounding **structural elements**.
- Different fire exposure conditions, including the **cooling phase.**
- Joint behaviour under bending, compression due to restrained thermal expansion of the beam, local yielding and buckling and catenary action.

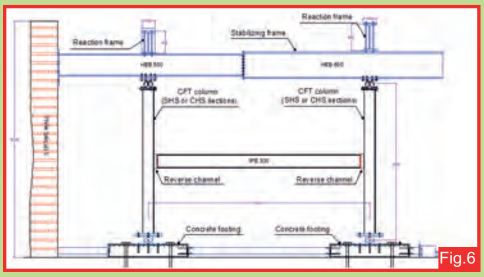


Fig.6

Full-scale test on composite frame assemblies

❑ NUMERICAL ANALYSIS

- Predicting the **failure modes** of the connection at **ambient and high temperatures**.
- Parametric study to assess the influence of the **geometrical parameters** of the joints in the strength, stiffness and ductility of the most relevant joint components.
- Appropriate modelling of joints (commercial FE software **ABAQUS**): contact behaviour, temperature dependent material properties, material nonlinearity and mesh refinement.

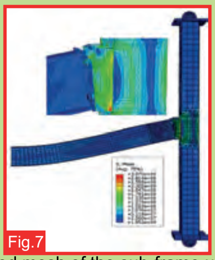


Fig.7

Deformed mesh of the sub-frame under standard fire curve ISO 834

University of Minho School of Engineering

SUSTAINABLE STEEL CONSTRUCTION

CZECH TECHNICAL UNIVERSITY IN PRAGUE

The University Of Sheffield.

TATA

DESMO

isise Institute for Sustainability and Innovation in Structural Engineering

Filip Ljubinković

Supervisors: João Pedro Martins/ Helena Gervásio

CYLINDRICALLY CURVED STEEL PANELS IN BRIDGE DESIGN

❑ OBJECTIVES

This work program, in the scientific domain of the Steel Composite Structures, aims to promote the use of the curved steel panels in steel and composite bridge applications, for its unique architectural and structural efficiency (Fig. 1). Therefore, it is necessary to fulfil two main goals:

- **Development of a new methodology for life cycle assessment of bridges, where aesthetical indicator will be balanced with the other environmental, social and economic criteria**
- **Development of the design methodologies for curved panels, and this way to extend the field of application in current design code EN 1993-1-5**

Fig. 1: Stonecutters Bridge (Hong Kong, 2009)

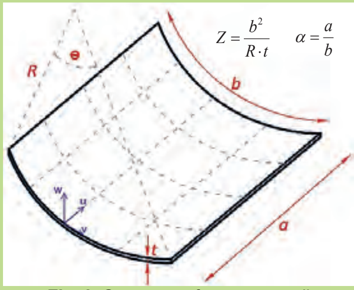


Fig. 2: Geometry of a transversally curved panel

Tab. 1: Range of geometric parameters

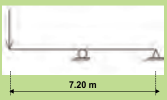
Width, b	***Thickness, t***	***Curvature, Z***	***Aspect ratio, α***
1000 – 2500 mm	15 – 25 mm	0 - 150	0.5 - 5

❑ EXPERIMENTAL TESTS

Within this work, two sets of experimental test will be executed:

- The first set of experimental test is the scope of the ULTIMATEPANEL project, within which **32 squared curved panels** will be studied as the individual members under uniaxial compressive stresses (Fig. 3). It is aimed to test curved panels both without stiffeners, but also with one, two or three longitudinal stiffeners. The thickness of all panels is constant and equal to **4 mm**, whereas four different radii are veried (**2.5 m, 5.0 m, 10.0 m and 20 m**).
- In the second set of tests, two full-scale prototype box-girder bridge segments are to be tested as three-point bending tests (Fig. 4), with the aim to obtain the compressive stresses in the lower curved flange.

Length (L)	7200
Width (w)	2340
Height (h)	750



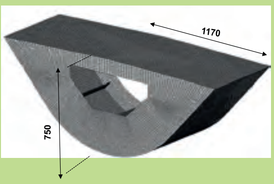


Fig. 4: Layout of the experimental test 2

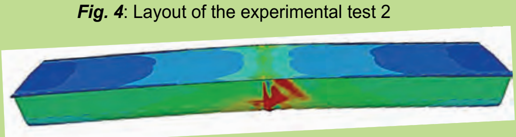


Fig. 5: Numerical model of the bridge segment used in the Experimental test 2

- **Digital Image Correlation System (ARAMIS)** is used to measure full-field 3D initial imperfections, deformations, strains and stresses of the panel during the load application.

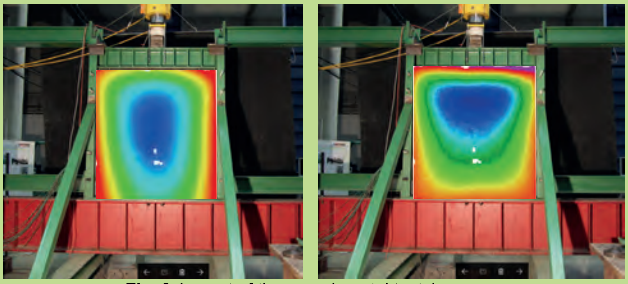


Fig. 3: Layout of the experimental test 1

❑ NUMERICAL STUDY

- Based on the experimental results, the finite element models will be calibrated both for individual panels and bridge segments (Fig. 5).
- These models will be used for the parametric study, where the influence of several parameters will be investigated on the buckling and post-buckling behavior of the curved panels (geometry (Fig.2 and Tab.1), material, imperfections, boundary conditions, etc.).
- Finally, the particular emphasis is brought to the behavior of the curved panels subjected to pure shear stresses.

· U C ·

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

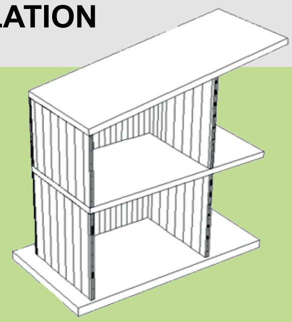
Filipe T. Matos
Supervisor: Jorge M. Branco (UM)
Co-supervisor: Patrício Rocha (IPVC)

SEISMIC BEHAVIOUR ASSESSMENT OF TIMBER BUILDINGS APPLYING THE NEW REGULATION

❑ NEW PROVISIONS OF CHAPTER 8 OF EUROCODE 8

- **In this thesis, in the scientific domain of timber buildings when subjected to seismic loading, the aim are:**
  - **Promote the use of timber structures in the seismic areas;**
  - **Safety factors (comparison between the new and current regulation);**
  - **Studying the influence to the different components (stiffness of the diaphragms, q-factors, ductility, over-strength factors, among others);**
  - **Recommendation of construction and seismic design.**

Structural type	DCM	DCH
X-Lam buildings (CLT)	2,0	3,0
Light-Frame buildings	2,5	4,0
Log House buildings	2,0	-
Moment resisting frames	2,5	4,0



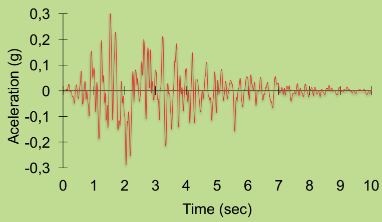
$$\frac{\gamma_{Rd}}{\beta_{sd}} \times F_{Rd,d} \leq F_{Rd,b}$$

OVER-STRENGTH FACTOR

Structural type	γ_{Rd}
X-Lam buildings (CLT)	2,0
Light-Frame buildings	2,5
Log House buildings	2,0
Moment resisting frames	2,5

❑ EXPERIMENTAL COMPAIGN - CONNECTORS, TIMBER COMPONENTS AND CLT BUILDING

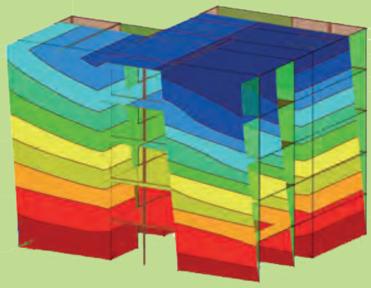
- **For this purpose, will be applied the new version of Eurocode 8 in experimental tests for comparison between the existing tests the current regulation.**
- **The experimental test of CLT building will be tested under quasi-static monotonic (pushover) and cyclic loading (time-history).**



- **The main objectives are to investigate 3-D system performance of CLT structure subjected to lateral loads in terms of lateral strength and deformability capacity, global behaviour of the structure, frequency response of the structure before and after each test, and performance of connectors and connections between CLT panels.**

❑ ANALYTICAL AND NUMERICAL ANALYSIS OF TIMBER BUILDINGS

- **For validate of the regulation, will be carried out the calculation of certain timber structures to the seismic actions, which will allow to assess the quality of seismic design.**
- **However, the structures will be performed through the analytical and numerical models, in which will be varied the some factors (number of storeys, PGA, seismic masses and length of shear walls)**



U C
University of Minho School of Engineering
Instituto Politécnico de Viana do Castelo

isise Institute for Sustainability and Innovation in Structural Engineering

Georgios Karanikoloudis

Supervisors: Paulo B. Lourenço / João Bilé Serra

RISK MANAGEMENT APPLIED TO CULTURAL HERITAGE BUILDINGS. THE EFFECT OF SOIL SETTLEMENTS AND VIBRATIONS INDUCED BY UNDERGROUND STRUCTURES.

❑ EXPERIMENTAL RESEARCH

- **In this task, real scale testing components can be considered as part of load bearing, single leaf masonry walls of more than one stories, with weak horizontal diaphragms of timber floors (Fig. 1). They will be configured by two piers and a spandrel and will be experimentally tested under asymmetrical settlements. The crack and strain distributions will be continuously monitored.**
- **Long term fatigue tests, under low level of strain reversals, will be conducted, replicating the strain levels, from ground borne vibrations (Fig. 2). One set of tests will be performed under dynamic loading, from a vertical actuator. The second type of tests will reproduce strain reversals, under impact loads from a drop mass.**

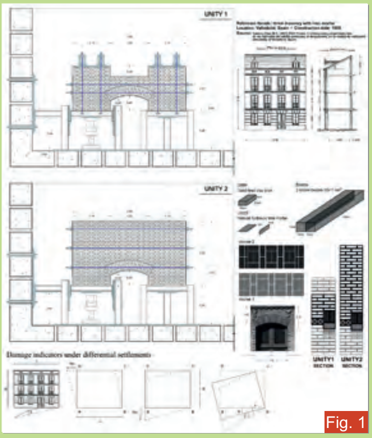


Fig. 1

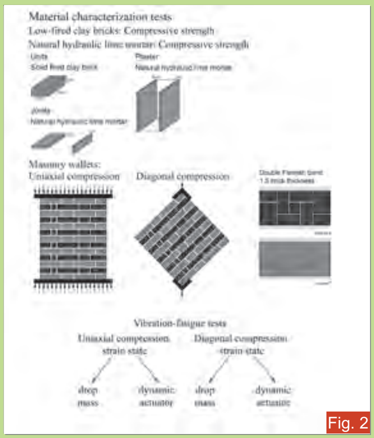


Fig. 2

❑ NUMERICAL MODEL VALIDATION AND PARAMETRIC ANALYSIS

- **The main objective of this task is to develop and validate the experimental data from masonry assemblies, tested under settlements, for the entire facade. Figure 3 shows the first step of a sequential analysis, regarding the application of self weight. Boundary conditions need to be established, depending on the level of confinement.**

Fig. 3

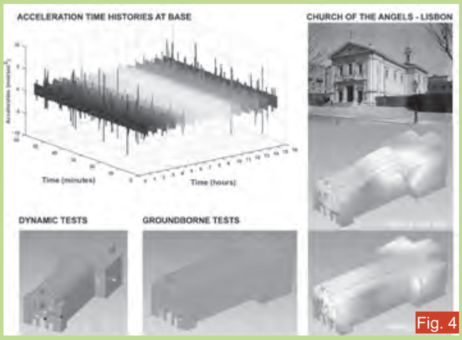


Fig. 4

❑ MONITORING AND ASSESSMENT OF REAL CASE STUDIES

- **Ambient vibration tests are to be carried out in two locations (Lisbon, Portugal and Isfahan, Iran), in selected monuments, close to metro lines (Fig. 4).**
- **Dynamic identification tests will be carried out, to allow proper FE modelling and assessment.**

Vibration limits for buildings of cultural heritage

Type and condition of structure	Vibration source/type	Description	Dominant vibration frequency range (Hz)	Peak particle velocity (mm/s)	Indicator	Reference	Country
Structures of particular sensitivity to vibration and of great intrinsic value (e.g. listed buildings under preservation order)	Short-term	Vibrations at foundation level	1-10	3	$\lvert V_{max} \rvert$	DIN 4150-3 1999	Germany
			10-50	3-8			
			50-100	8-10			
		Vibration at a horizontal plane of highest floor	-	8	$\lvert V_{max} \rvert$		
	Long-term	Vibration in horizontal plane of highest floor	-	2.5	$\lvert V_{max} \rvert$		
Historical buildings or under protection	Occasional Frequent	Measures vibrations at foundation level	<30	1.5-3	$\lvert V_R \rvert$	SN 640312 1992	Switzerland
			30-60	2-4			
			>60	3-6			

- **The main <u>objective</u> of the current work is to develop the necessary tools for investigating the problem of settlements and vibrations in cultural heritage buildings. Acceptable risk levels and damage thresholds are to be evaluated.**

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Giovanni Ferrante Cavallaro

Supervisors: Gianvittorio Rizzano / Aldina Santiago

SEISMIC RESPONSE OF BEAM-TO-COLUMN CONNECTIONS EQUIPPED WITH FRICTION PADS

Cyclic tests on internal joints

❑ EXPERIMENTAL RESEARCH

- **This experimental campaign is part of the European research project "FREEDAM" which aims to develop an innovative beam-to-column connection equipped with friction dampers that dissipate the seismic energy without damage the connection (FREE from DAMage connections).**
- **A FREEDAM connection is detailed to include in correspondence of the lower beam flange a friction device realized with steel plates and friction pads pre-stressed with high strength bolts.**
- **In order to verify if the joints equipped with FREEDAM connections are able to dissipate the earthquake input energy without any damage, 8 cyclic tests on beam to column connections have been planned.**
- **The column is connected to the floor through an hinge, while the beam ends are fixed in such a way as to allow horizontal sliding without vertical displacements and rotations. The cyclic load is applied on the column using a 100Tf actuator. (Fig.1)**

Fig. 1

❑ CYCLIC TESTS – BEHAVIOUR OF FREEDAM CONNECTIONS

- **The 8 cruciform specimens designed for the tests are equipped with the FREEDAM friction devices in correspondence of the lower flanges. In detail: 4 specimens are designed using HE220M steel columns and IPE270 steel beams, and 4 specimens are designed using HE500B steel columns and IPE450 steel beams. The friction dampers to be test have 2 different configurations: the first one with friction pads in horizontal position (Fig.2), the second one with friction pads in vertical position (Fig.3).**

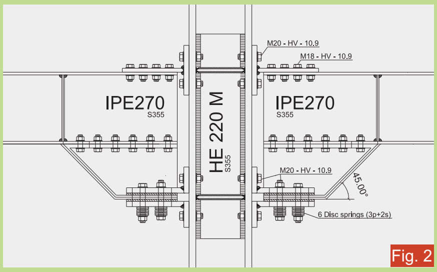


Fig. 2

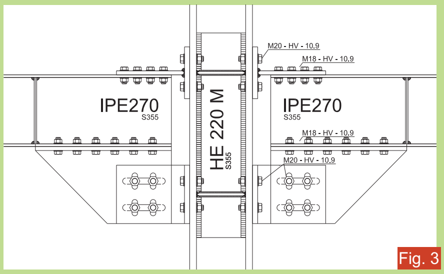


Fig. 3

❑ PARAMETERS

- **The main parameter that characterizes the tests is the preload in the bolts of the friction dampers. The preload influences the friction behaviour of the dampers and it is applied according to the "torque method" as defined in EN-1090 code.**
- **The loading program was planned according to AISC 341/2010 seismic provisions in order to assure an adequate interstory drift angle. The loading protocol is shown in Fig.4.**

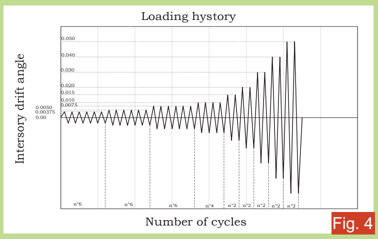


Fig. 4

U C

University of Minho
School of Engineering

UNIVERSITÀ DEGLI STUDI DI SALERNO

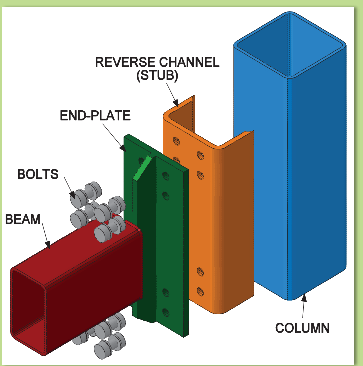
Institute for Sustainability and
Innovation in Structural Engineering

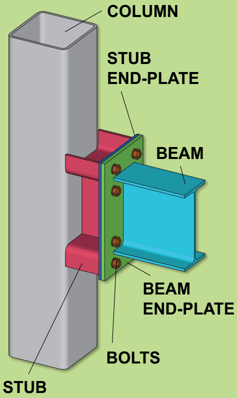
Guiomar da Silva Ferreira Vicente

Supervisors: Rui Simões / Carlos Rebelo

MOMENT RESISTING BOLTED JOINTS CONNECTING STEEL TUBULAR SECTION MEMBERS

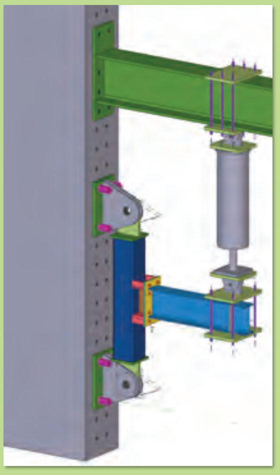
❑ PURPOSE OF THE RESEARCH WORK

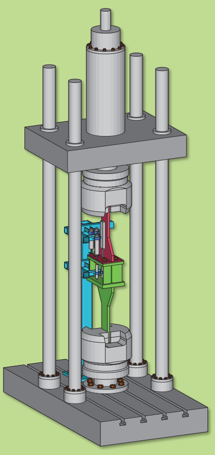




- Assess the structural response of two configurations of bolted joints with a tubular member
- Identify and characterize the basic components of the joint with a U-stub
- Propose analytical expressions to determine the resistance and stiffness of the new basic components
- Enable the use of the component method according to EN 1993-1-8

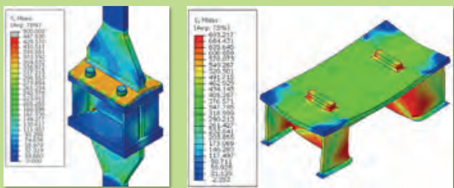
❑ EXPERIMENTAL WORK





- Component tests – Individual characterization of the new basic components in transverse tension and in transverse compression
- Tests on real scale joints with a U-stub – monotonic and cyclic loadings

❑ PARAMETRIC STUDY



- Parametric numerical analysis on the new basic components;
- Proposal and validation of simplified equations to predict the resistance and stiffness of the new basic components

U C
University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

Hadi Baghi

Supervisors: Joaquim Barros

THE EFFECTIVENESS OF SHCC-FRP PANELS FOR THE SHEAR RESISTANCE OF RC BEAMS

Motivation

- A new technique based on the use of Hybrid Composite Plates (HCPs) is used to increase the shear strength of RC beams. HCP is a thin plate of Strain Hardening Cementitious Composite (SHCC) reinforced with CFRP laminates. (Fig. 1 and Fig. 2)
- Due to the excellent bond conditions between SHCC and CFRP laminates, these reinforcements provide the necessary tensile strength capacity to the HCP, while the high post-cracking tensile deformability and resistance of SHCC avoids the occurrence of premature fracture failure of this cement composite in the stress transfer process between these two materials when the HCP is crossed by a shear crack.

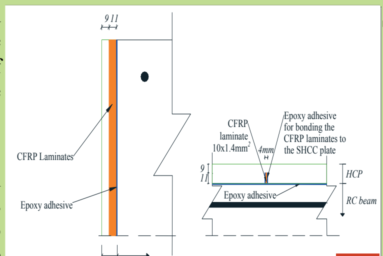


Fig. 1

- The shear strengthening contribution of the HCPs is limited by the tensile strength of the concrete of the strengthened beams. Mechanical anchors prevent a premature debonding of the HCPs and a certain concrete confinement is introduced in the zone of the beam to be strengthened, resulting favorable effects in terms of shear strengthening.

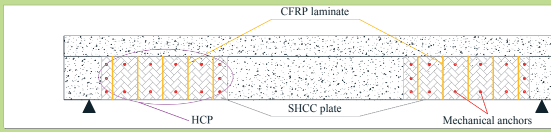


Fig. 2

Experimental Research

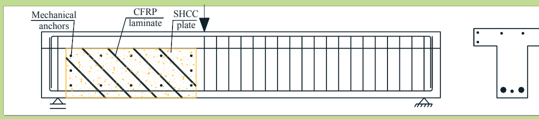
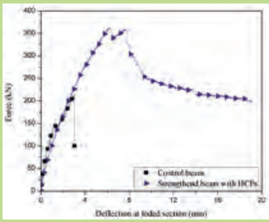


Fig. 3

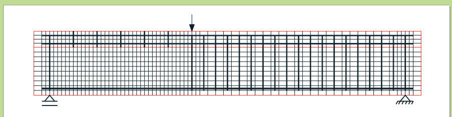
- The behaviour of the RC beams strengthened with HCPs is assessed by three point bending test as shown in Fig. 3.
- The HCPs are capable of increasing not only the load carrying and deflection capacity, but also the post-peak resisting load, with favorable effects in terms of energy absorption capacity (Fig. 3).

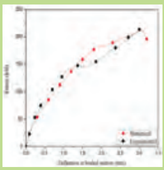


- Besides the contribution of the SHCC for the strengthening efficiency of HCPs, the SHCC also assures some protection to the CFRP laminates and adhesive in terms of vandalism, aggressive environmental conditions, and fire.

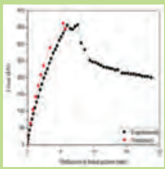
Numerical Simulation

- In order to explore further the potentialities of HCPs for the shear strengthening, advanced numerical simulations were performed by using a FEM-based computer program.

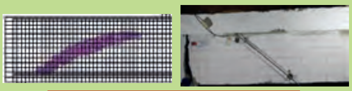




Control beam



Strengthened beam with HCPs



Crack Pattern of the Control beam

Crack Pattern of the strengthened beam with HCPs

Shear Behaviour of SHCC

- The shear characteristics of SHCC are determined by Iosipescu shear test developed at university of Minho.

- The main objective of these tests is to assess the effectiveness of Hybrid Composite Plates for shear strengthening of reinforced concrete beams.

University of Minho
School of Engineering

S&P Clever Reinforcement Company

GRUPO CASAIS

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Institute for Sustainability and Innovation in Structural Engineering

Hadi Mazaheripour

Supervisors: Joaquim Barros/ / Jose Sena-Cruz

STRUCTURAL BEHAVIOR OF HYBRID GFRP AND STEEL REINFORCED FRC PRESTRESSED BEAMS

❑ OBJECTIVES AND MOTIVATION

- **The present study intends to contribute for the development of a new generation of high durable and sustainable reinforced concrete (RC) structures, by combining the benefits that fiber reinforced polymers (FRP) and steel bars can provide. Combining GFRP and steel bars constitutes a high performance reinforcement strategy with low probability of corrosion occurrence. Additionally, the structure is made by high performance fiber reinforced concrete (HPFRC) in order to eliminate steel stirrups as the most susceptible to corrosion in this type of structural elements.**

❑ EXPERIMENTAL RESEARCH ON PRE-FABRICATED HPFRC PRE-STRESSED BEAMS

- **The new reinforcing system for HPFRC beam has been fabricated and tested in the laboratory under monotonic and fatigue loading condition. Fig. 1 shows the fabrication process of the prestressed HPFRC beams that are reinforced by hybrid GFRP bars and steel strand. The test setup and measuring instruments are shown in Fig. 2.**

❑ NUMERICAL MODELS

- **2D and 3D finite element models are carried out to simulate the structural behavior of the tested beams. The geometrical details about the models are shown in Fig. 3. Concrete Damage Plasticity (CDP) and Concrete Smeared Crack (CSC) approaches were used in 3D and 2D models, respectively. Some important models parameters are defined in Fig. 4.**

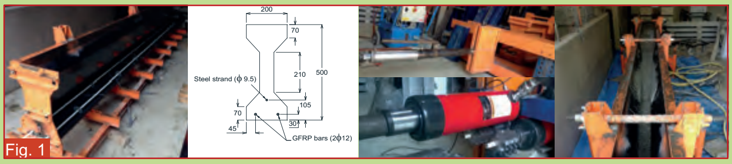


Fig. 1

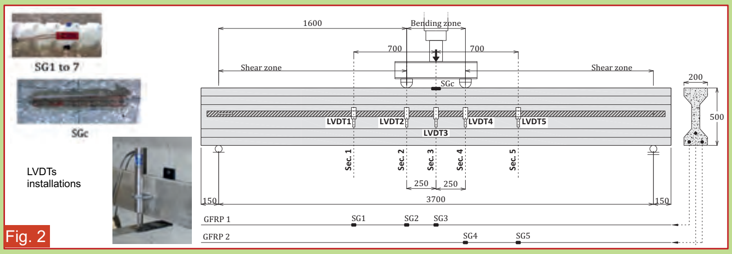


Fig. 2

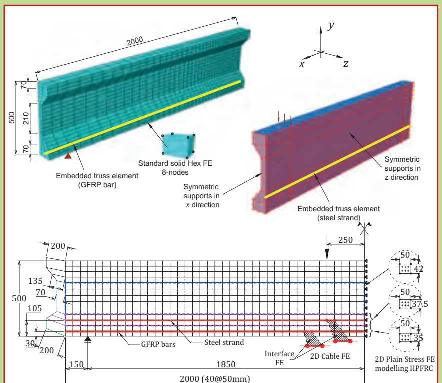
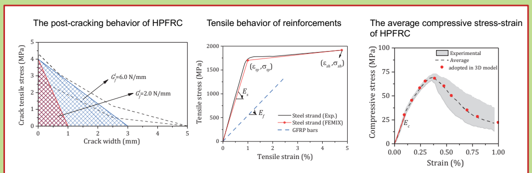


Fig. 3



The values define the CDP model for HPFRC material

Parameter	f_{ct} (MPa)	E_c (GPa)	α * (-)	K_c (-)	e (-)	ψ (degree)
Values	4.0	35	1.16	0.67	0.1	[15-45]

Fig. 4

❑EXPERIMENTAL RESULTS VERSUS NUMERICAL RESULTS

- **The 2D models were solved using FEMIX computer software while the 3D models were carried out in Abaqus. The results of models were compared with those obtained from the experiments in terms of strain of GFRP reinforcing bars and mid-span deflection of the beams. This comparison is shown in Fig. 5. The Cracking pattern obtained from the numerical models are also shown and compared with the test at the ultimate stage.**

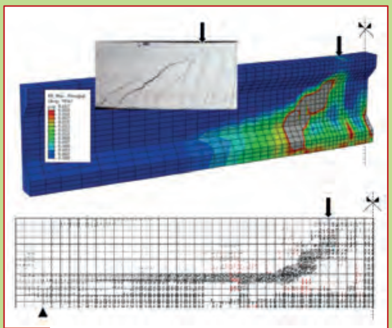


Fig. 4

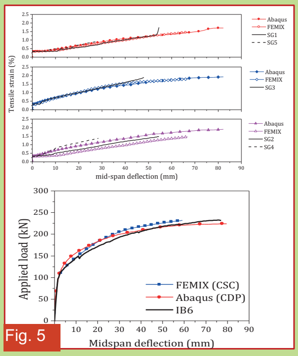
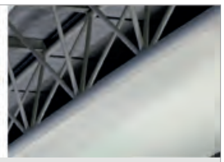


Fig. 5

University of Minho
School of Engineering

Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR





isise Institute for Sustainability and Innovation in Structural Engineering

Hamed Azizi-Bondarabadi

Supervisors: Paulo B. Lourenço/ Nuno Mendes

Seismic assessment of unreinforced masonry structures

❑ INTRODUCTION

- Most of the fragility curves of masonry buildings are obtained using empirical methods due to the complexity related to their nonlinear behavior and relative shortage of robust numerical tools for performing nonlinear analyses in a quick and accurate way.
- Considering both computational effort and accuracy of the results, macro-element models implemented in TreMuri software and pushover analysis have been adopted for the seismic assessment of masonry buildings.
- N2 method has been used as the nonlinear static procedure (NSP) to determine the target displacement. Similarly to other NSPs, N2 method does not consider the higher mode effects.

❑ MAIN OBJECTIVE

- The main objective of the present thesis is to develop a methodology for generating analytical-based fragility curves considering the effects of higher modes to be used in seismic loss assessment studies. As inventory of elements at risk, masonry school buildings located in the province of Yazd (Iran) have been selected.

❑ MAIN TASKS

- Validation of numerical model against shaking table test results, which were performed on four masonry mockups with irregular and regular geometry, in terms of capacity curves (Fig. 1). and damage pattern (Fig. 2).
- Development of N2 method for masonry building considering the higher mode effects in both plan and elevation. As a result, the pushover-obtained demands (inter-story drifts and displacements) were often improved in such a way that the underestimate results were amplified to the conservative ones within a narrow range with respect to the nonlinear dynamic mean response (Fig. 3).
- Generation of analytical fragility curves considering uncertainties associated with demand and capacity. The curves have been obtained by using the extended N2 method developed in the prior task (Fig. 4).
- Generation of empirical fragility curves to validate the analytical curves. Within a proposed methodology, Macroseismic, GNDT II level and an Iranian index-based method are combined together in order to provide the empirical curves.

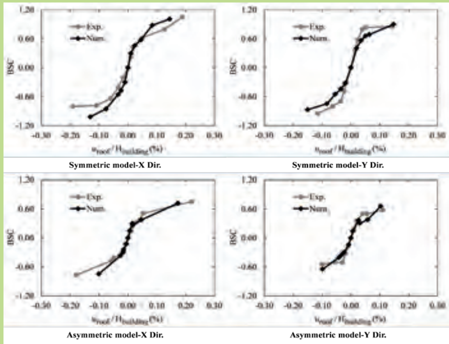


Fig. 1

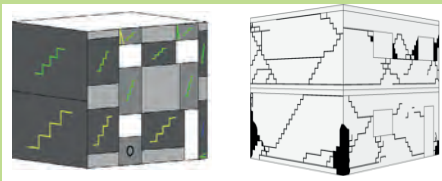


Fig. 2

A NEW PROCEDURE FOR DAMAGE PATTERN

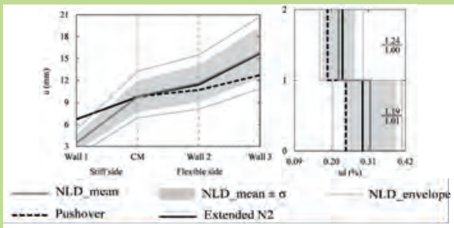


Fig. 3

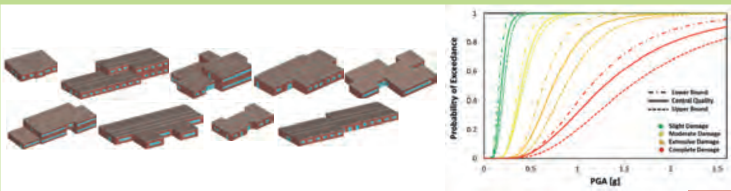


Fig. 4

University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

Hamidreza Salehian

Supervisor: Joaquim Barros

Evaluation of the Performance of Steel Fibre Reinforced Self-Compacting Concrete in Elevated Slab Systems; from the Material to the Structure

❑ MOTIVATION

- Potentialities of post-cracking response of fibrous concrete can be effectively mobilised in elevated steel fibre reinforced self compacting concrete (E-SFRSCC) slabs with multiple cracking due to the indeterminacy character of these elements. In E-SFRSCC slabs the use of longitudinal reinforcement is restricted to the anti-progressive collapse bars applied in both alignments of the columns.

❑ STRUCTURAL RESPONSE OF E-SFRSCC SLAB

- A quarter scaled prototype of E-SFRSCC slab (Fig. 1) was designed and built and tested under two different load configurations:

Fig. 1

1) Long-term response of E-SFRSCC slab was evaluated under Different levels of uniformly distributed load were suspended on the slab (Fig. 2)

Fig. 2

2) Load carrying capacity of E-SFRSCC slab was assessed under concentric loading applied to centre of two corner panels (Figs. 3 and 4)

Fig. 3

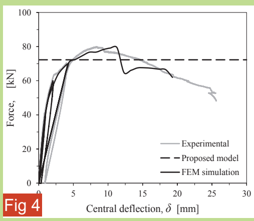


Fig 4

❑ PREDICTION OF THE LOAD CARRYING CAPACITY OF E-SFRSCC SLABS

- A novel methodology was developed for predicting the load carrying capacity of E-SFRSCC slab systems capable to take into account distribution of fibres along the depth of cross section.
- In the proposed model the height of the slabs' cross section is discretized into layers (Fig. 5).

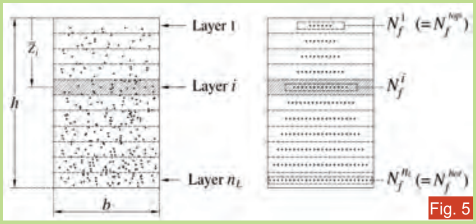


Fig. 5

- The flexural residual strength of SFRCs obtained from the three-point notched beam bending tests and the number of fibres counted on each layer have provided the stress-crack width laws for defining the post-cracking behaviour of that layer.
- These constitutive laws are implemented in a numerical model developed based on the moment-rotation approach for determining the positive and negative resisting bending moment of the slab's unit width cross section which are implemented in equations developed based on yield line theory.

❑ ASSESSMENT OF PREDICTIVE PERFORMANCE OF THE DEVELOPED MODEL

- The predictive performance of the developed model is evaluated by comparing to the test results registered in the experiment (Fig. 4).
- Regarding Fig. 4, predictive performance of the proposed methodology is approved.

❑ MAIN CONCLUSIONS OF THE RESEARCH

- Noticeable influence of volume fraction of fibres on the post-cracking response of the SFRSCCs was revealed.
- Ductile response of E-SFRSCC system was observed. At the ultimate deflection of 26 to 30 mm, the residual load was 65 to 60% of peak load.
- Noticeable influence of the fibre distribution along the depth of cross section was observed on load carrying capacity of E-SFRSCC slabs.

University of Minho
School of Engineering

FCT Fundação para a Ciência e a Tecnologia

isise Institute for Sustainability and Innovation in Structural Engineering

Hassan Abdolpour

Supervisors: Joaquim Barros/ Jose Sena-Cruz

Development of Prefabricated Modular Houses in Pure Composite Sandwich Panels

❑ EXPERIMENTAL RESEARCH

- A residential modular temporary building was proposed and developed to accomodate, in urgent situation, disclosed families due to e.g. The occurence of natural disasters (Fig.1).
- In this context, the team composed of members of University of Minho (UMinho), Instituto Superior Técnico (IST) from University of Lisbon and the company ALTO - Perfis Pultrudidos, Lda., developed a R&D proposal, named "ClickHouse", for developing a new system of prefabricated temporary buildings into the emergency shelter market.

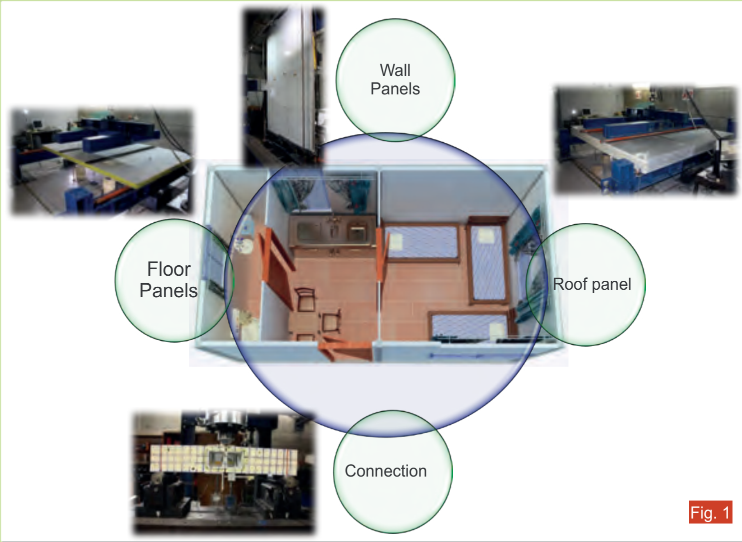


Fig. 1

❑ FLOOR PROTOTYPE SUBJECTED TO UNIFORMLY DISTRIBUTED LOAD

- Maximum distributed load of 2 kN/m2 was selected according to the Eurocode 1 (EN1991:2002) as a characteristic live load. This load was applied by 48 the filler bags (weighing 25 kg of each bag) as depicted in Fig. 2. The results are indicated in Fig. 3.

Fig. 2

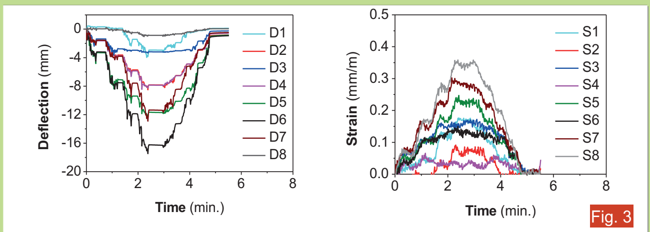


Fig. 3

❑ AXIAL PERFORMANCE OF JOINTED SANDWICH WALL PANELS

- Axial performances of single wall panel and jointed wall panels were studied under eccentric axial loading (see Fig. 4). The results are shown in Fig. 5.

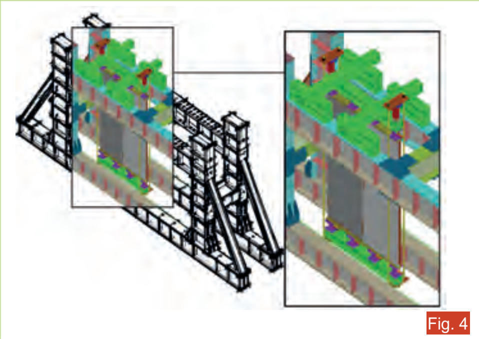


Fig. 4

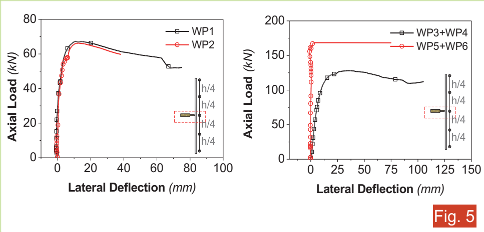


Fig. 5

U C University of Minho School of Engineering COMPETE QREN ALTO Perfis Pultrudidos Lda.

Institute for Sustainability and Innovation in Structural Engineering

Hélder David Craveiro

Supervisors: João P. Rodrigues / Luís Laim

FIRE RESISTANCE OF COLD-FORMED STEEL COLUMNS

❑ OBJECTIVES

- Assess the load bearing capacity of CFS columns considering different cross-section shapes (single and built-up open and closed cross-section) and different end-support conditions (pinned-pinned and fixed-fixed);

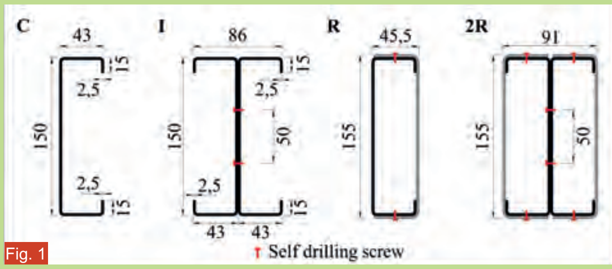


Fig. 1

- Investigate instability phenomena on cold-formed steel columns with restrained thermal elongation under fire conditions; influence of the cross-sections, the axial and rotational restraint to the thermal elongation of the column, end-support conditions and initially applied load level;
- Assess mechanical and thermal properties of CFS S280GD+Z;
- Development of simplified calculation methods for fire design of CFS columns, based on experimental and numerical results.

❑ RESEARCH PLAN

- 24 load bearing capacity tests – 4 cross-sections and 2 end-support conditions;
- 96 fire tests with restrained thermal elongation;
- Mechanical properties both at ambient and elevated temperatures;
- Thermal properties (thermal conductivity, specific heat and thermal diffusivity) using the Transient Plane Source equipment (TPS).
- Parametric study, using the finite element method and finite element software ABAQUS, based on the available experimental results.

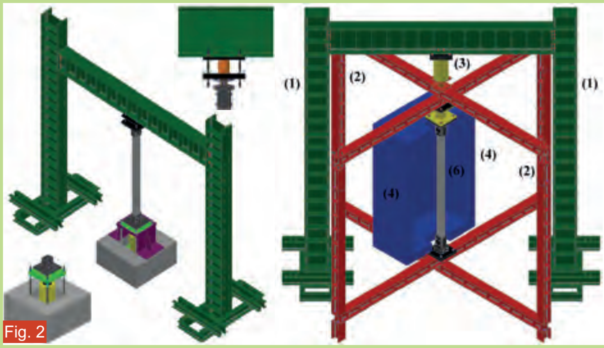


Fig. 2

❑ RESULTS AND CONCLUSIONS

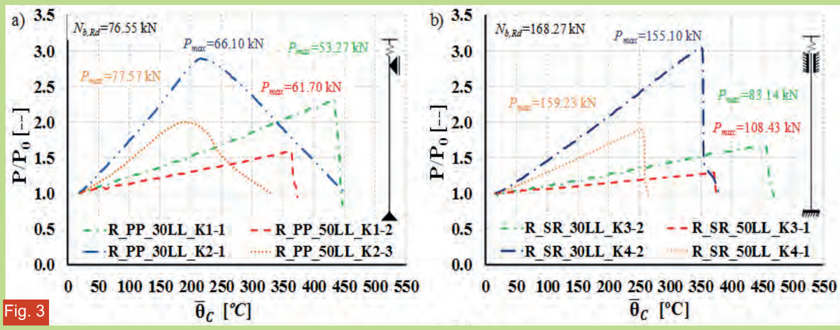


Fig. 3

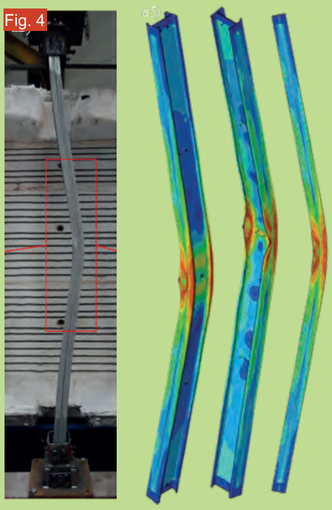


Fig. 4

- The higher the stiffness of the surrounding structure was the higher the maximum restraining forces generated during the heating phase;
- Increasing the level of restraint to thermal elongation may lead to the reduction of critical temperatures.

University of Minho
School of Engineering

PF - PERFISA
Fábrica de Perfis Metálicos, S.A.

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

isise Institute for Sustainability and Innovation in Structural Engineering

Hugo Augusto

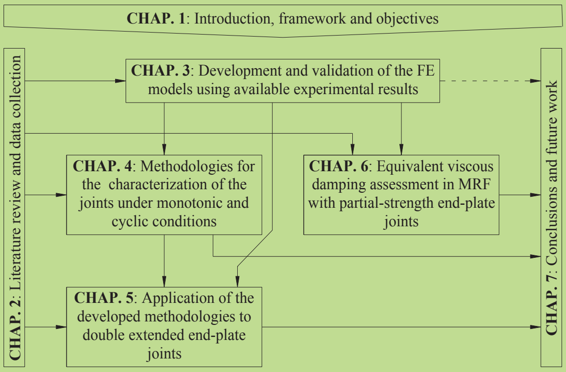
Supervisors: Carlos Rebelo / J. Miguel Castro

CHARACTERIZATION OF THE BEHAVIOUR OF PARTIAL-STRENGTH JOINTS UNDER CYCLIC AND SEISMIC LOADING CONDITIONS

❑ SCOPE AND OBJECTIVES

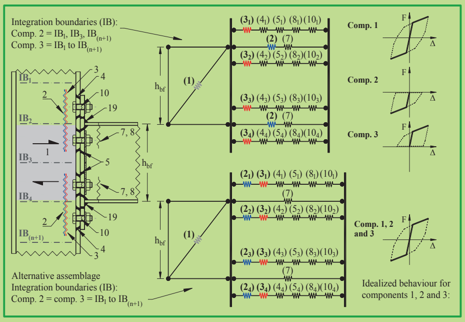
- The purpose of this research is to reduce the gap between the characterization of MRF structures with full-strength joints, and the characterization of MRF structures with partial-strength joints, for seismic design. The focus of the research is on the behaviour of the joints when subjected to cyclic but also dynamic loads.
- The main objective of the research is to contribute to the extension of the components method to account for the cyclic behaviour of the various components, presenting a procedure to obtain some of the F-Δ components response, using detailed finite elements models, needed for the spring mechanical models, hence allowing its application in the characterization of partial-strength beam-to-column joints subjected to cyclic loading conditions
- In parallel it is intended to contribute to the development of practical guidelines for analysing steel moment-resisting frame structures that include performance criteria and a displacement-based design procedure capable of considering different beam-column joint typologies, particularly partial-strength bolted joints as defined in Eurocode 3.

❑ STRUCTURE OF THE THESIS

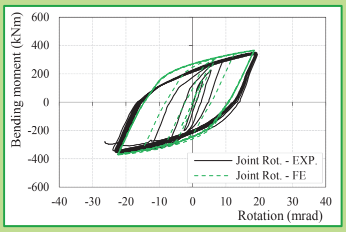


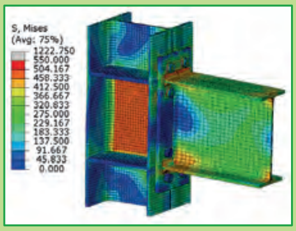
❑ MAIN OUTCOMES

- The development, calibration and validation of practical methodologies, capable of extracting the behaviour of the relevant basic components of beam-to-column joints.
- Proposal for improvement of the existing expressions for displacement-based seismic design methodologies, for steel moment-resisting frame structures with dissipative partial-strength joints, namely the ones proposed by Priestley *et al.* (2007).



❑ VALIDATION OF THE FE MODELS

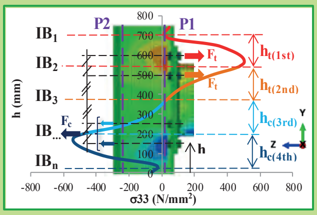


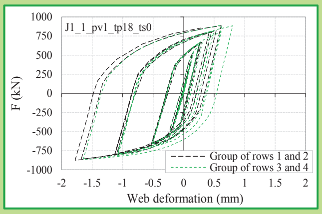


(Comparison with Nogueiro (2009) experimental tests)

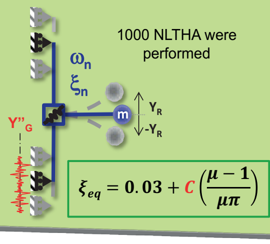
❑ SOME RESULTS

- Contribution to cyclic components model

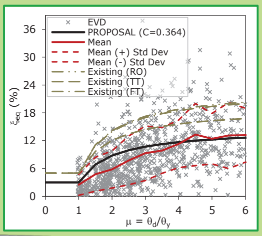




- Equivalent viscous damping results for MRF structures with beam-to-column partial-strength joints



$$\xi_{eq} = 0.03 + C\left(\frac{\mu - 1}{\mu\pi}\right)$$



U C · University of Minho School of Engineering · FCT Fundação para a Ciência e a Tecnologia · POPH · QREN · União Europeia Fundo Social Europeu · Research Fund for Coal & Steel

Institute for Sustainability and
Innovation in Structural Engineering

Hugo Filipe Santos Caetano

Supervisors: João P. C. Rodrigues / Pierre Pimienta

FIBROUS CONCRETES WITH IMPROVED FIRE BEHAVIOUR

❑ OBJECTIVES

One of the goals of civil engineering is to develop materials and structural solutions that will allow to improve the concrete structure`s reactions when subjected to the actions of different scenarios. One of the possible scenarios to which a concrete building may be subjected is the fire.

The proposed investigation aims to develop and characterize a fiber reinforced concrete (Fig. 1) with an improved fire behavior.

(a) (b) (c) (d)

Figure 1 - (a) Steel fibres 3D: (b) Steel fibres 5D; (c) Polypropylene fibres; (d) Fibres used.

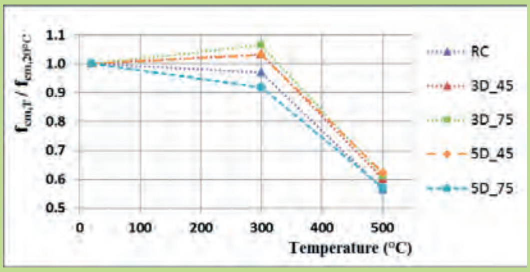
❑ EXPERIMENTAL PROGRAM

MECHANICAL PROPERTIES		THERMAL PROPERTIES	COMPLEMENTARY EXPERIMENTAL TESTS
Strength Parameters	**Elastic Parameters**		
Compressive strength[1]	Modulus of Elasticity	Thermal Conductivity [2]	**Thermal analysis (TGA) [1] X-Ray Diffraction (XRD) [1] Scanning Electron Microscopy (SEM) [1]**
Tensile strength [2]	Poisson's Ratio	Specific Heat [2]	
Bending strength [2]			

[1] - this task is concluded ; [2] – these tasks are under way.

❑ CONCLUSIONS

The results from the compressive strength seem to indicate that the introduction of steel fibers in concrete have no influence on the compressive strength at high temperatures.



U C
University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

Inês Gonçalves Costa

Supervisors: Joaquim Barros

PRESTRESSED CARBON FIBRE LAMINATES APPLIED ACCORDING TO NEAR SURFACE MOUNTED TECHNIQUE TO INCREASE THE FLEXURAL RESISTANCE OF REINFORCED CONCRETE BEAMS

❑ EXPERIMENTAL RESEARCH

- **Fibre Reinforced Polymer (FRP) materials are a viable alternative to other traditional strengthening solutions, such as section enlargement or external plate bonding. This strengthening strategy is attractive when the increase of load carrying capacity is required, with minimum intervention time and esthetical impact. This research is evaluated three of most relevant aspects associated to this strengthening system:**
  - **the instantaneous prestress losses;**
  - **the long term prestress losses;**
  - **the effectiveness of the proposed technique in terms of load carrying capacity and deflection, particularly at the serviceability limit state.**

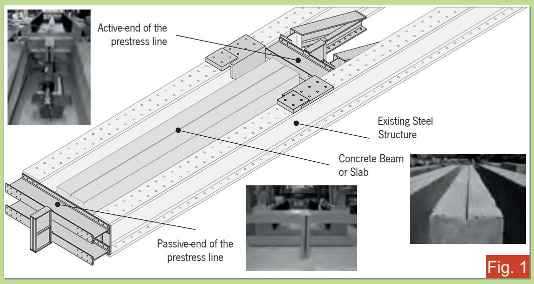


Fig. 1

❑ INSTANTANEOUS/LONG-TERM PRESTRESS LOSSES

- **Experimental results of Series I: beam with 20% prestress**

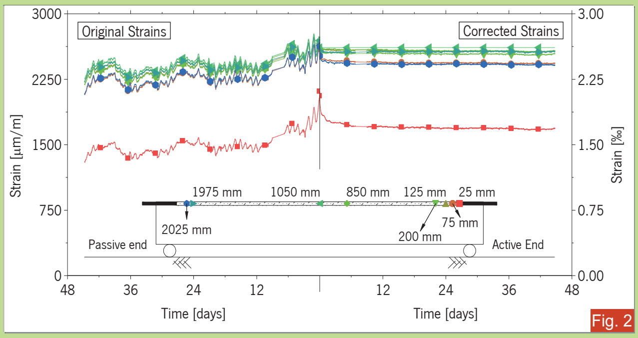


Fig. 2

- **Experimental/Numerical comparison: Series III**

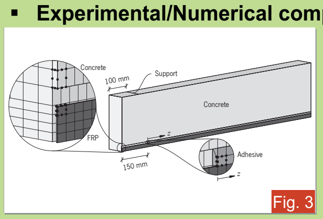


Fig. 3

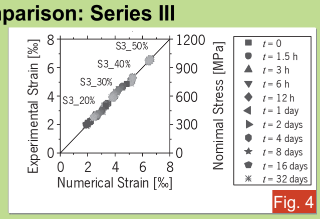


Fig. 4

❑ FAILURE TESTS ON PRESTRESSED BEAMS

- **Experimental results: Series II (Full Scale beams)**

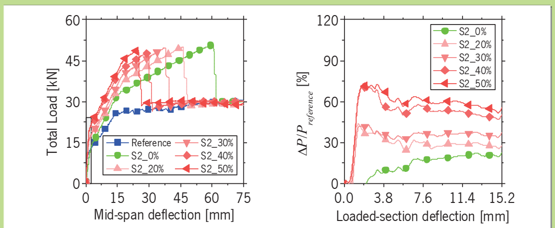


Fig. 5

- **Experimental/Numerical comparison: Series II**

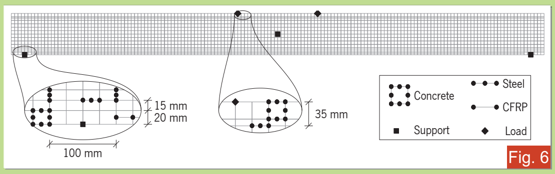


Fig. 6

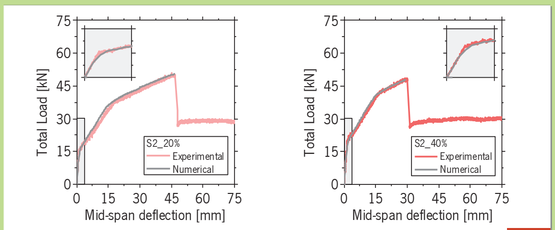


Fig. 7

❑ MAIN CONCLUSIONS

- **Low levels of strain loss along the majority of the bonded length and reasonable initial deflection levels were obtained due to the prestress application (maximum losses of about 3% at mid-span and initial deflections of 0.078mm~1.112mm)**
- **The load at crack and yield initiation increases significantly with the prestress level. A considerable decrease of ultimate deflection and total cracked length of the beam with the increase of the prestress level was observed.**
- **The losses of strain experienced by the CFRP laminate were modelled using a relatively simple numerical approach and the agreement between the experimental and numerical results was excellent. The load-deflection obtained by numerical simulations have fitted with good accuracy the corresponding curves registered experimentally.**

University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

JACINTO SILVA

Supervisor(s): Miguel Azenha / A. Gomes Correia

CONTINUOUS MONITORING OF DEFORMABILITY OF STABILIZED SOILS BASED ON MODAL IDENTIFICATION

❑ SCOPE OF THE WORK

- Using EMM-ARM (Elasticity Modulus Measurement through Ambient Response Method) continuous monitoring of stiffness of stabilized soils with lime and /or cement.
- Technique based on the continuous monitoring of the first resonant frequency of a composite beam, which evolves as a consequence of the hardening of the tested material, which can be correlated with its E-modulus.

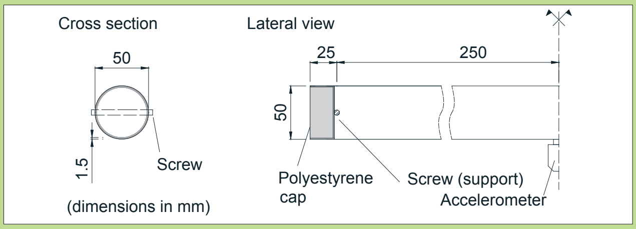


Figure 1: Cross-section and lateral view of testing mould

❑ MODAL IDENTIFICATION

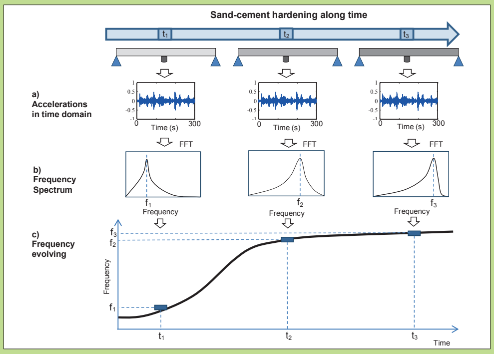


Figure 2: Modal identification methodology

❑ EVALUATION OF STABILIZED SOIL E-MODULUS

The first resonant frequency *f* of a simply supported beam with span *L*, homogenized E-modulus, homogenized moment of inertia and uniformly distributed mass is given by:

$$f = \frac{\pi}{2\cdot L^2}\sqrt{\frac{\overline{EI}}{\overline{m}}}$$

It is possible to extract the E-modulus of the stabilized soil as all other variables are known.

$$\overline{EI} = E_{Support} I_{Support} + \boxed{E_{Stab.Soil}} I_{Stab.Soil}$$

❑EXPERIMENTAL PROGRAM

Study specimens sampled from a sand-cement layer stabilized with a Portland cement CEM II/B-L 32.5N.

The mix proportions for the stabilized soil, given in relation to the weight of dry sand, comprehended 7% of cement and 9% of water content.

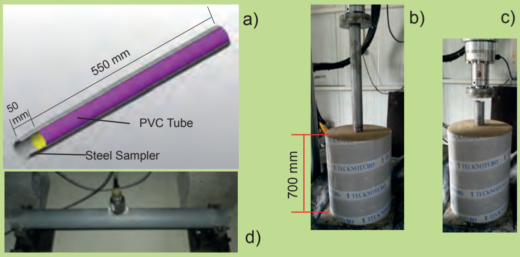


Figure 3: Sand-cement "layer": a) sampler; b, c) sampler introduction; d) EMM-ARM beam during testing

Table 1 - Specimens types and references

Type of test	Reference
EMM-ARM	S1;S2
Unconfined Cyclic Compression	UCC1 UCC2 UCC3

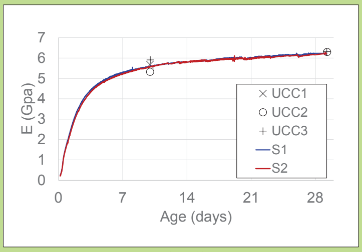


Figure 4: Evolution of stiffness for the first 30 days of curing

❑SOME ADDITIONAL TASKS

- Study of forced vibration solutions

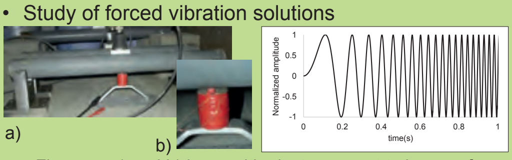


Figure 5: a) and b) bean with electromagnet to impose forced vibration; c) imposed sweep signal

- Propose a methodology based on Bayesian inference to estimate the stiffness at reference ages (e.g. 28 days) with short duration tests

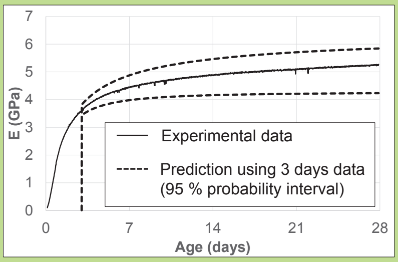


Figure 5: Prediction with 3 days data

University of Minho
School of Engineering

FCT Fundação para a Ciência e a Tecnologia

Institute for Sustainability and Innovation in Structural Engineering

Javier Ortega Heras

Supervisors: Graça Vasconcelos

Co-supervisors: Hugo Rodrigues / Mariana Correia

REDUCTION OF THE SEISMIC VULNERABILITY OF VERNACULAR ARCHITECTURE WITH TRADITIONAL STRENGTHENING SOLUTIONS

ABSTRACT

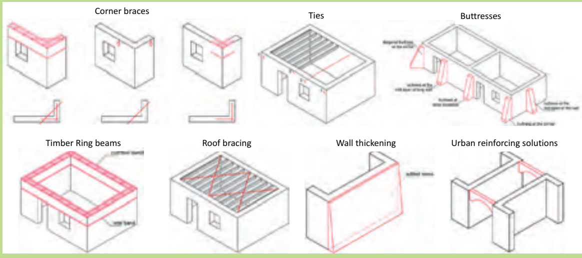
The main objective of the research is to contribute to the **awareness and protection of the vernacular heritage from earthquakes**, acknowledging that to value and preserve vernacular architecture and traditional construction techniques is a crucial key-element of cultural identity. The main research question deals with vernacular architecture earthquake preparedness with a focus on the **Portuguese context**.

In order to address the aforementioned research question, the thesis aims firstly at the better understanding of the **seismic behaviour** of vernacular architecture. Secondly, it also aims at the identification and the better understanding of **traditional strengthening solutions** for its eventual application for the preservation of vernacular architecture.

For that purpose, the research embraces three fundamental objectives: (1) Development of a seismic vulnerability assessment method for vernacular architecture; (2) Assessment of the efficiency of traditional strengthening solutions to mitigate the seismic vulnerability of vernacular architecture; and (3) Recommendations of traditional strengthening solutions to reduce the seismic vulnerability of in-use vernacular architecture.

TRADITIONAL EARTHQUAKE RESISTANT TECHNIQUES

Specific architectural elements can be identified in constructions located in regions frequently exposed to earthquakes. These earthquake resistant features were developed empirically by local communities to protect their built-up environment. Research in these traditional earthquake resistant practices, resulting from a local seismic culture, is a relevant and a positive approach, since it focuses on the strengths of a system rather than on its weaknesses. Its integration into current vernacular building practices can help to preserve and retrofit surviving in-use examples without prejudice to their identity.



DEVELOPMENT OF THE METHOD FOR THE SEISMIC VULNERABILITY ASSESSMENT OF VERNACULAR ARCHITECTURE

MOTIVATION

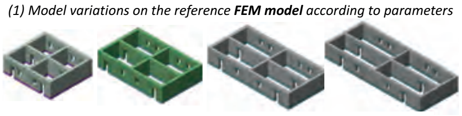
The development of an expedite method for the seismic vulnerability assessment of vernacular architecture is of paramount importance, since more detailed and sophisticated approaches are typically restricted for individual monumental buildings.

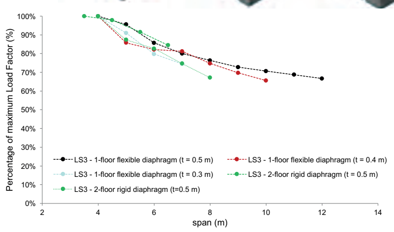
PARAMETER SELECTION

P1. Wall slenderness
P2. Maximum wall span
P3. Type of material
P4. Wall-to-wall connection
P5. Horizontal diaphragms
P6. Roof thrust
P7. Wall openings
P8. Number of floors
P9. State of conservation
P10. In-plane index

NUMERICAL PARAMETRIC ANALYSIS

*(1) Model variations on the reference **FEM model** according to parameters*





*(2) Compare quantitatively the seismic performance based on results on the **pushover analysis***

DEFINITION OF CLASSES

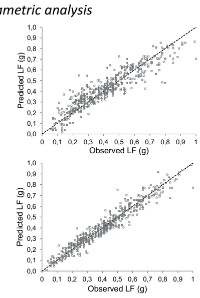
*(3) Define **vulnerability classes** according to the variations in the parameters*

P2. Maximum wall span

Class	Description
A	$s_{max} \leq 5$ m
B	5 m $< s_{max} \leq 7$ m
C	7 m $< s_{max} \leq 9$ m
D	$s_{max} \geq 9$ m

STATISTICAL REGRESSION ANALYSIS

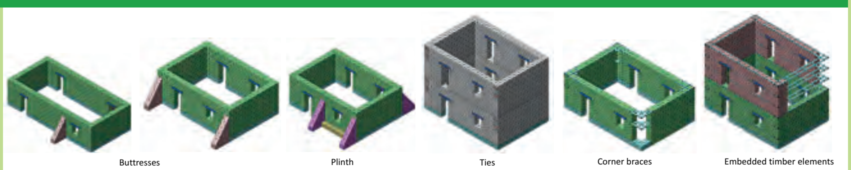
*(4) Build **regression models** based on the database composed by the results of the parametric analysis*



*(5) The regression models are intended to **predict the seismic behaviour** of vernacular structures using as inputs simple variables based on the parameters*

ASSESSMENT OF THE EFFICIENCY OF IDENTIFIED TRADITIONAL ERTHQUAKE RESISTANT TECHNIQUES

Comparative analysis of the seismic performance of the distinct traditional strengthening solutions identified. Their efficiency is assessed quantitatively by means of advanced numerical analysis and pushover analysis.



· U C ·

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

João Almeida

Supervisors: Eduardo Pereira / Joaquim Barros

HIGH DUCTILITY STRENGTHENING SYSTEM FOR MASONRY STRUCTURAL REHABILITATION

❑ THE PROBLEM: Masonry deficient performance when subjected to cyclic and dynamic loads, essentially due to the brittle behaviour and low energy dissipation capacity, Fig. 1

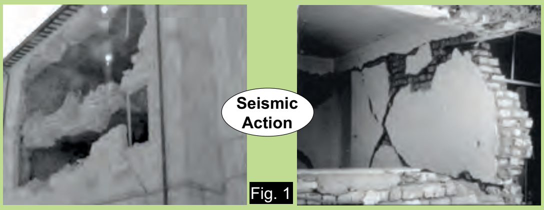


Fig. 1

Out-of-plane colapse — In-plane damage

❑ SOLUTION UNDER INVESTIGATION: System composed by a high ductility fibre reinforced cementitious mortar, see Figs. 2 and 3

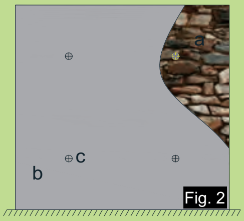
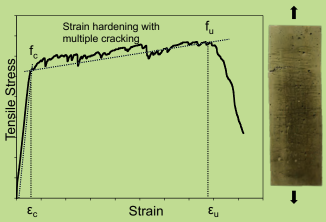


Fig. 2

Strengthening system: a) masonry; b) SHCC mortar; c) connectors



Typical tensile behaviour of a Strain Hardening Cementitious Composite

Fig. 3

❑ CHARACTERIZATION AND ANALYSIS OF THE PROPOSED SOLUTION

- Assessment of the strengthening system contribution to the in-plane load carrying capacity through diagonal tensile tests: example of ceramic brick masonry, Figs. 4 and 5.

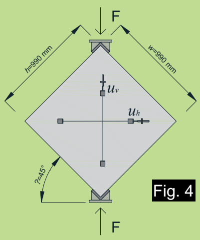


Fig. 4

Diagonal tensile test set-up

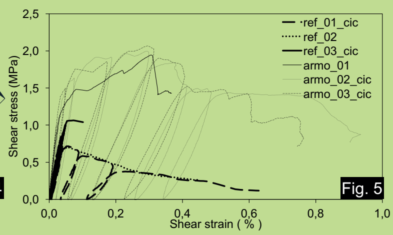


Fig. 5

Shear stress vs shear strain response

- The *delamination* of the render and strengthening layer is the prevailing failure mode.

- The mechanical properties of the interface between masonry and the strengthening layer are critical for the strengthening system efficiency. These properties were analyzed by performing shear and pull-off tests (Figs. 6 and 7).

Fig. 6

Pull-off test

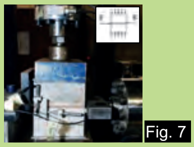


Fig. 7

Direct shear tests

- The experimental peak values of the tangential stress obtained for different normal stresses and the Mohr criterion fitted curves are depicted in Fig. 8.

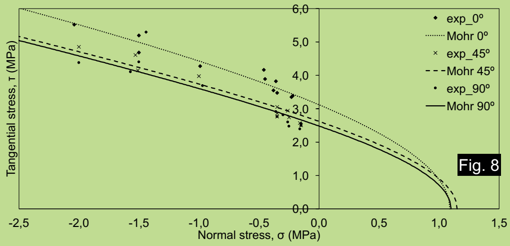


Fig. 8

Experimental peak data and Mohr criterion fitted curves

- A finite element analysis of the experimental diagonal tensile tests was carried out using the computer code FEMIX 4.0. Materials and interface properties obtained previously were assigned to the multilayered model presented in Fig. 9. The results from the numerical simulation are presented in Fig. 10 .

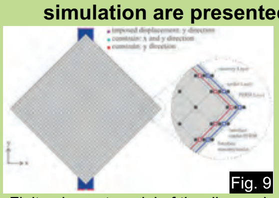


Fig. 9

Finite element model of the diagonal tensile tests with detail of the layers

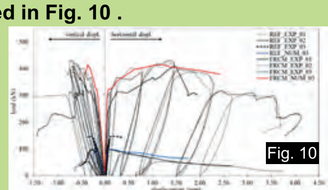


Fig. 10

Load vs displacement response of numerical simulation and experimental results

FURTHER DEVELOPMENTS

- Assessment of the importance of other physical properties to the reinforcement system performance, such as surface roughness and composition.
- Development of analytical models to describe the failure modes, and design rules to support the practitioner.

· U C ·

University of Minho School of Engineering

QREN QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL

COMPETE

Institute for Sustainability and Innovation in Structural Engineering

RISK-BASED RAILWAY INFRASTRUCTURE MANAGEMENT SYSTEMS

João Nuno Fernandes

Supervisors: Daniel V. Oliveira / António Abel Henriques

❑ PRELIMINARY RESULTS – EXAMPLE OF A RAILWAY BRIDGE

❑ NON-LINEAR ANALYSIS

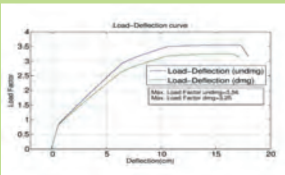
- A non-linear analysis through DIANA software will be carried out in order to provide an analysis deeper than the one made during the design project. About the type of analysis, a 2D non-liner structural analysis was performed with class II beam elements with incremental load steps until its failure

FEM model of the bridge

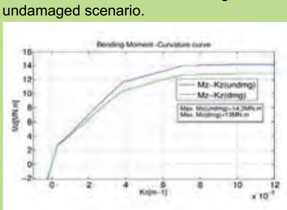
❑ OBTAINED RESULTS

- The main focus of this analysis to the deck was the maximum flexural response at mid-span. Once this is an existing bridge, a damaged scenario will be considered with a reduction of 20% of the area of the ordinary steel. This reduction factor was obtained through expert judgement.

❑ DETERMINISTIC APPROACH



Load-Deflection curve for a damaged and undamaged scenario.



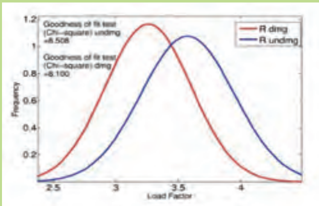
Moment-Curvature curve for a damaged and undamaged scenario.

❑ PROBABILISTIC APPROACH

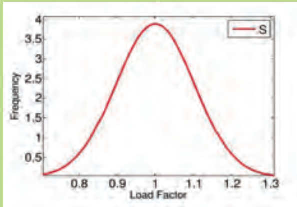
$R_{undmg} \sim N(3{,}575; 0{,}370^2)$

$R_{dmg} \sim N(3{,}262; 0{,}342^2)$

$S \sim N(1{,}0; 0{,}1^2)$



Resistance Curves



Load Curve

❑ OBTAINED PERFOMANCE INDICATOR – RELIABILITY INDEX

Method	Reliability Index (β)		Probability of Failure (p_f)	
	Undamaged	Damaged	Undamaged	Damaged
Cornell	6,703	6,340	$1{,}107^{-11}$	$1{,}351^{-10}$
FORM	6,719	6,341	$9{,}227^{-12}$	$1{,}143^{-10}$
SORM	6,718	6,341	$9{,}280^{-12}$	$1{,}143^{-10}$

❑FUTURE DEVELOPMENTS

- Possibility of another performance indicators to be studied;
- Development of the prediction models that best fits to the obtained performance indicators;
- Perform the risk assessment. There are still some possibilities to investigate in order to choose the best one for this work;
- Optimization process taking into account Cost (direct and indirect) and Performance;

U C

University of Minho
School of Engineering

FCT
Fundação para a Ciência e a Tecnologia

iRail

Institute for Sustainability and Innovation in Structural Engineering

João Leite

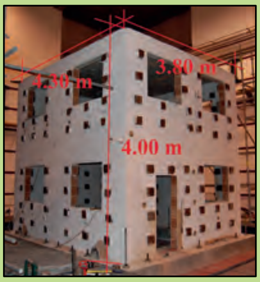
Supervisor: Professor Paulo B. Lourenço

SEISMIC BEHAVIOUR OF MASONRY INFILL WALLS: TEST AND DESIGN

❑ OBJECTIVES

- This work aims at understanding the seismic behaviour of infill walls when designed following the prescriptions of the EC8, therefore reinforced with bed joint and plaster reinforcement, and compares them to the seismic behaviour of the infill walls considered as a standard in the last three decades in Portugal, which is an unreinforced double leaf wall.

❑ SHAKING TABLE EXPERIMENTAL PROGRAM



Model Geometry

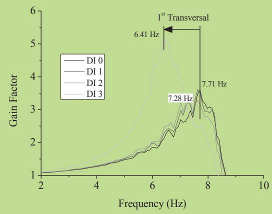
Bed Joint Reinforcement

Plaster Reinforcement

Unreinforced Double Leaf

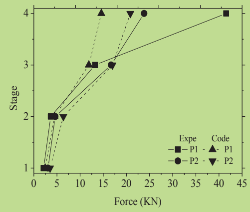
❑ DATA ANALYSIS

Mode Shape



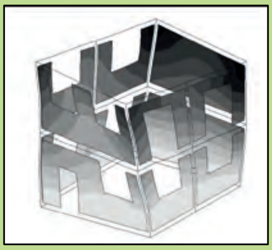
Modal Frequency

Damage Patterns

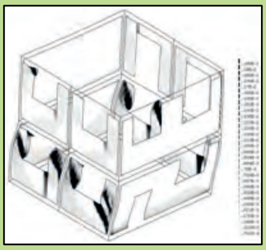


Standard and Experimental Out-of-Plane Load Comparison

❑ NUMERICAL SIMULATION

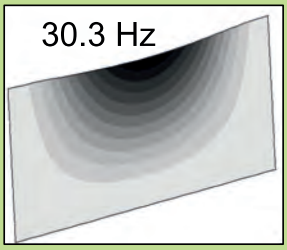


Model Updating Based on Experimental Dynamic Data

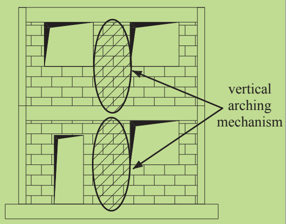


Non-Linear Static Analysis and Damage Patterns Analysis

❑ INFILL DESIGN PROPOSAL



Out-of-Plane Modal Frequency



Out-of-Plane Capacity Reduction Based on the Presence of a Vertical Arching Mechanism

University of Minho
School of Engineering

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Institute for Sustainability and Innovation in Structural Engineering

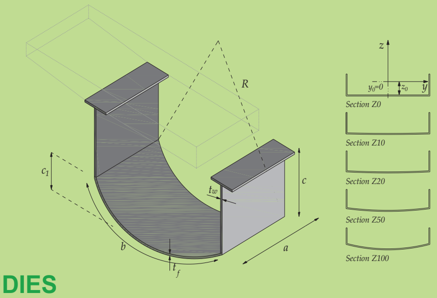
João Pedro Martins

Supervisors: Luís Simões da Silva / António Reis

BEHAVIOUR OF CYLINDRICALLY CURVED STEEL PANELS UNDER IN-PLANE STRESSES

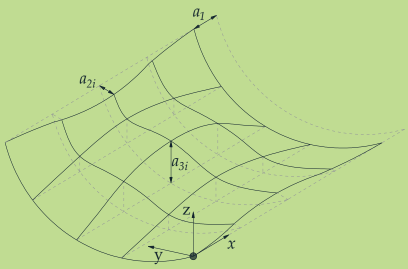
SCOPE

- The substantiation of this dissertation starts with a very simple statement: there are few design rules (in fact, there is no European standard in the framework of the Eurocodes), design recommendations/ guidelines or any other background document (at least relevant enough) allowing an accurate design of curved steel panels and sections built up with cylindrically curved steel panels in the civil & structural engineering field, namely transversally curved steel panels for structural application.



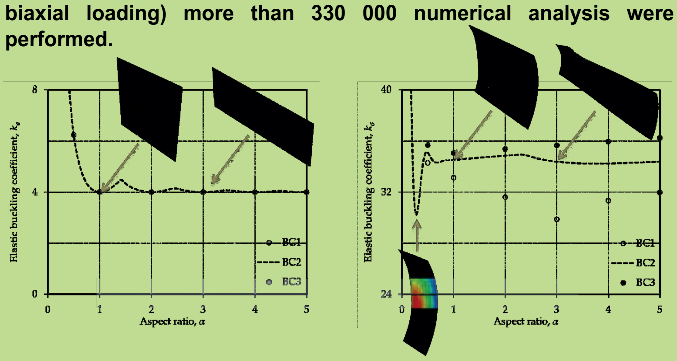
ANALYTICAL STUDIES

$$k_{\sigma,\min} = 2\left[1 + \frac{\sqrt{\pi^6 + 12\left(\pi^2 - 8\right) Z^2}}{\pi^3}\right]$$



NUMERICAL STUDIES

- Within the scope of 4 parametric studies (elastic critical stress and ultimate strength of curved panels under longitudinal stresses, imperfection sensitivity study of curved panels under pure compressive stresses and ultimate strength of curved panels under biaxial loading) more than 330 000 numerical analysis were performed.

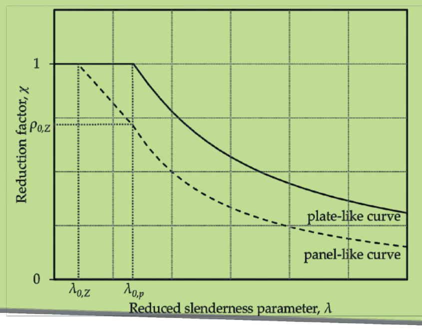


NEW FORMULAE FOR COMPUTING THE ELASTIC CRITICAL STRESS AND ULTIMATE STRENGTH

$$\sigma_{cr} = k_\sigma \sigma_E = k_\sigma \frac{\pi^2 E}{12\left(1-\nu^2\right)}\left(\frac{t}{b}\right)^2$$

ψ	$1 \geq \psi > 0$	$0 \geq \psi \geq -1$
EN1993-1-5:2006	$\frac{8.2}{1.05+\psi}$	$7.81 - 6.29\psi + 9.78\psi^2$
New Approach	$\frac{A}{B+\psi}$ $A=a_1+a_2Z+a_3Z^2$ $B=b_1+b_2Z+b_3Z^2$	$\frac{A}{B} + C\,\psi + D\,\psi^2$ $C=d_1+d_2Z+d_3Z^2$ $D=d_1+d_2Z+d_3Z^2$

$$\begin{cases} \rho = 1 & \text{if} \quad \bar\lambda \leq \bar\lambda_{0,Z} \\ \rho = \dfrac{\bar\lambda_{0,p} - \bar\lambda + \rho_{0,Z}\left(\bar\lambda - \bar\lambda_{0,Z}\right)}{\bar\lambda_{0,p} - \bar\lambda_{0,Z}} & \text{if} \quad \bar\lambda_{0,Z} < \bar\lambda < \bar\lambda_{0,p} \\ \rho = \dfrac{\bar\lambda - 0.055 a_Z (3+\psi)}{c_Z \bar\lambda^2} + S_Z & \text{if} \quad \bar\lambda \geq \bar\lambda_{0,p} \end{cases}$$



University of Minho
School of Engineering

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

POPH POTENCIAL HUMANO

UNIÃO EUROPEIA
Fundo Social Europeu

Institute for Sustainability and Innovation in Structural Engineering

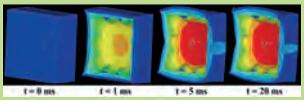
João M. Pereira
Supervisor: Paulo B. Lourenço

SECURITY EVALUATION AND DESIGN OF STRUCTURES SUBJECTED TO BLAST LOADING

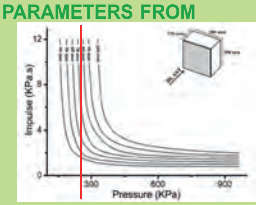
OBJECTIVES

This work intends to give insight on several topics related to **blast loading** and **structural response** to impulsive loading: (a) Provide **empirical tools** to help **assessing** the **blast loading parameters** for post-disaster scenarios; (b) **Quantify** the **strain rate effect** on the mechanical properties of **masonry** and its components; (c) Develop a **new test setup** able to test wall panels under out-of-plane **blast loading**; (d) Create **empirical tools** to help practitioners to **assess the behavior** and **design masonry infill walls** under blast loading; (e) Apply a **risk assessment** methodology to a **public transportation network**, identifying the elements with the highest risk associated to selected threats; (f) Perform a **structural safety evaluation** on a case study. Lastly, this work intends to **introduce these topics at a national level**, hoping they could lead to future developments in this field.

ASSESSING BLAST LOADING PARAMETERS FROM POST-DISASTER SCENARIOS

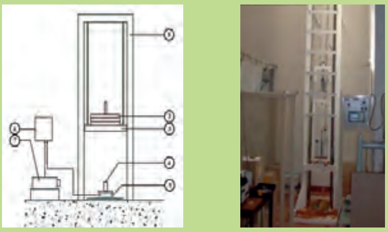


Numerical modelling of metal switch boxes subjected to blast loading

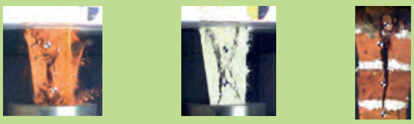


Estimation of the overpressure for the Buncefiel Major Incident

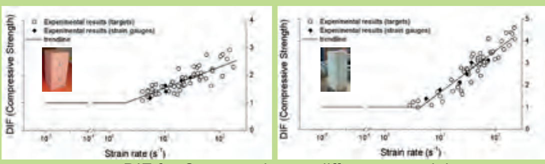
MECHANICAL CHARACTERIZATION OF MATERIALS



Drop Weight impact testing setup for Compression



High Speed Video for Compression tests

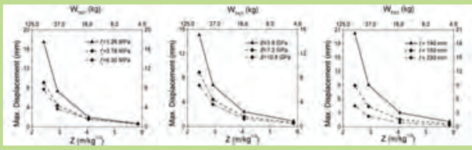


DIF for Compression on different materials

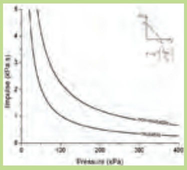
MASONRY INFILL WALLS UNDER BLAST LOADING

Out-of-plane setup for walls under blast loading

URM wall under WBWG loading



Parametric study on URM wall panel under blast loading



Pressure-Impulse diagram for URM wall panels

PROTECTING CRITICAL INFRASTRUCTURE

Public Transport element with high risk due to external explosions

Deformed shape for different explosion scenarios

University of Minho School of Engineering
CT2M Centre for Mechanical and Materials Technologies
Centre for Fire & Explosion Studies
REFER
bp
FCT Fundação para a Ciência e a Tecnologia

isise Institute for Sustainability and Innovation in Structural Engineering

João Ribeiro

Scientific supervision:
Aldina Santiago / Constança Rigueiro

INFLUENCE OF JOINT DUCTILITY IN THE ROBUSTNESS OF STEEL STRUCTURES

❑ SCOPE

- **This study focuses on the influence of bolted steel joints' (Fig. 1) behaviour on a structural steel frames' robustness; unlike common design situations, in which establishing the plastic strength of a joint usually suffices (Fig. 2), within a robustness analysis designers are asked to establish the structural over-strength provided by steel hardening and ensure that joints are able to cope with the required deformation to the development of new unloading paths.**
- **In order to achieve that, it is required to link the several scales represented in Fig. 3:**
  - **<u>Material scale</u> – study of the material fracture locus enabling the use of continuum damage mechanics approach to establish the rotation capacity of joints;**
  - **<u>Joint scale</u> - establishing accurately the behaviour of the steel joint, including over-strength, ductility and approximate fracture pattern;**
  - **<u>Structural scale</u> – Study of the full structural response and evaluation of elements relevant to avoid progressive collapse mechanisms to be developed.**

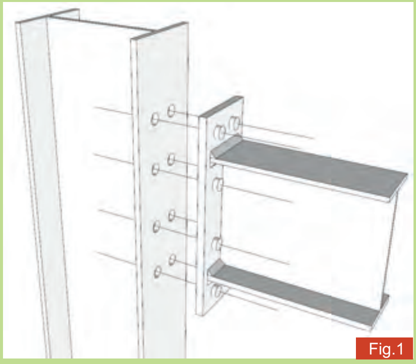


Fig.1

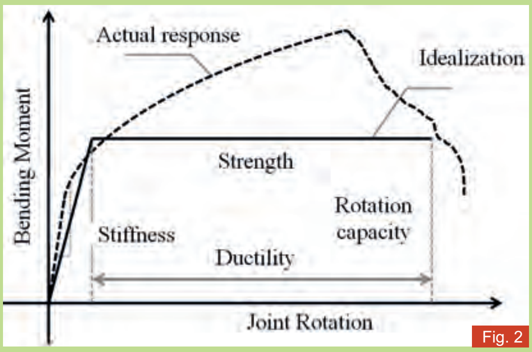


Fig. 2

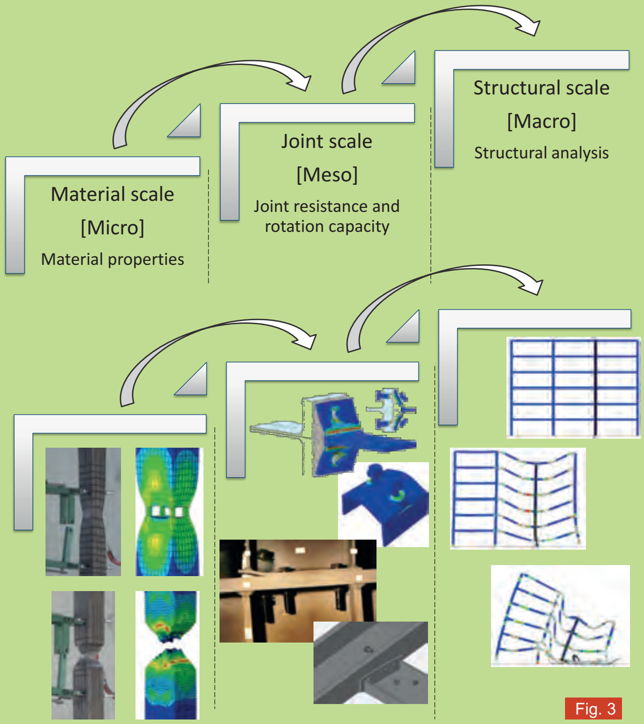


Fig. 3

University of Minho
School of Engineering

Instituto Politécnico de Castelo Branco
Escola Superior de Tecnologia

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Institute for Sustainability and Innovation in Structural Engineering

Jocelyn Erandi Reyes Nieto

Supervisors: Luís Simões da Silva / Vitor Murtinho / Constança Rigueiro

DEVELOPMENT OF SUSTAINABLE SOLUTIONS FOR URBAN REHABILITATION

❑ THESIS OUTLINE

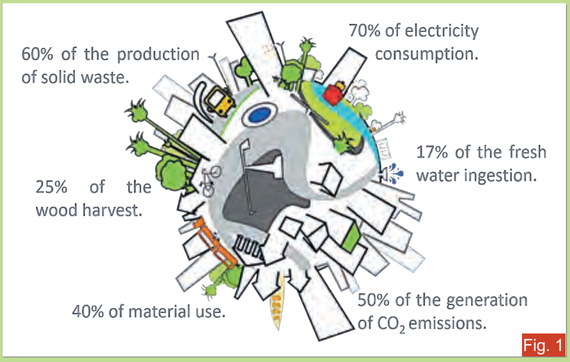


Fig. 1

- Currently, the construction sector represents the major single contribution to climate change (Fig. 1), so it is important the introduction of proposals that mitigates the environmental impacts of communities and construction activities. Looking to solve this problem, this work program presents an overview of two new innovative concepts in the field of Sustainable Construction. Two sustainable solutions that try to change lifestyles of the residents to develop a new healthy way of living our urban areas, creating vibrant residential spaces that can attract new inhabitants and which satisfies the necessities and priorities of the users by offering a better quality of life.

- These sustainable solutions, are developed in the scientific domain of the Sustainable Construction, and consist of:

1) The introduction of a new comprehensive approach of an urban sustainable assessment methodology, named "UISA" (Urban Integral Sustainable Assessment tool) (Fig. 2), which is a sustainability indexing model that offers a new focus of the important components that should be analyzed on an existing neighborhood and of the interactions between them.

Fig.2

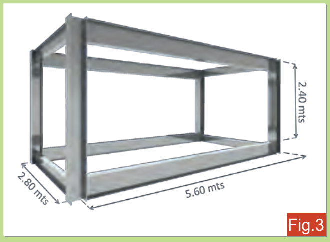


Fig.3

2) The development of a Conceptual Framework to improve the existing urban problems by a new model of city management on the basis of subdivide the inner neighborhoods in basic units (defined as subsectors) that share a common infrastructure (multipurpose building) which represents a living system that enables an urban community to control its spatial and social development itself through the centralization of services and insertion of facilities and amenities. Fig. 3 shows the modular system dimensions of the multipurpose building.

❑ IMPLEMENTATION OF SUSTAINABLE SOLUTIONS TO CASE STUDIES

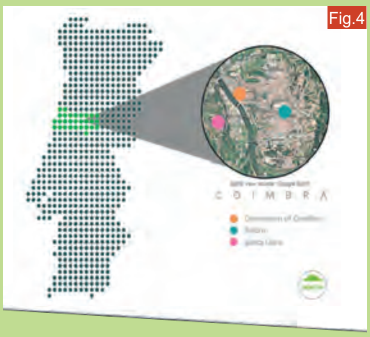


Fig.4

- To discuss the hypothesis that the UISA methodology and the conceptual framework will help in the promotion of sustainable development, three existing neighborhoods of different districts of the city of Coimbra (Fig. 4) were chosen as case studies, these are: Baixa, Solum and Santa Clara (Fig. 5).

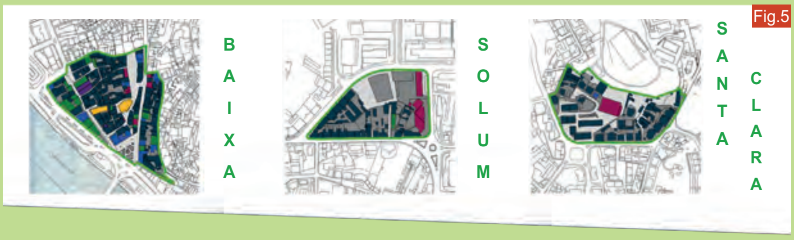


Fig.5

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

José Granja

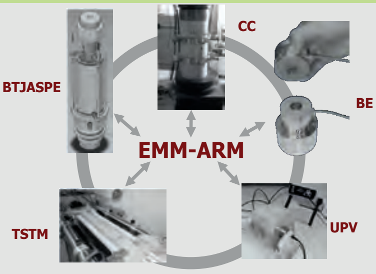
Supervisor: Miguel Azenha

Continuous characterization of stiffness of cement-based materials: experimental analysis and micro-mechanics modeling

❑ SCOPE OF THE WORK

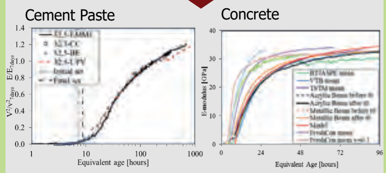
- Comprehensive validation of the methodology termed "Elasticity Modulus Monitoring through Ambient Response Method" (acronym: EMM-ARM).
- Introduce improvements to the EMM-ARM for overcoming the current limitations for systematic application in laboratory and in-situ.
- Optimization of the EMM-ARM for continuous monitoring of the modulus of elasticity of cementitious materials.
- Perform microstructural modeling of the stiffness evolution of cementitious materials by taking advantage of unprecedented quantitative experimental data that it will be possible to accumulate through the application of the EMM-ARM methodology.

❑ VALIDATION



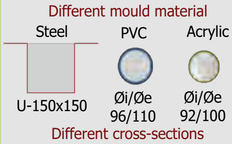
To validate the methodology is necessary to:

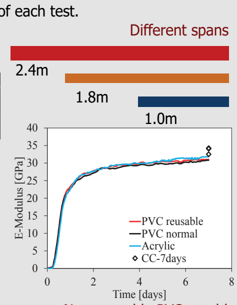
- Compare with other methodologies;
- Verify the robustness;
- Test the repeatability;
- Test the reproducibility.

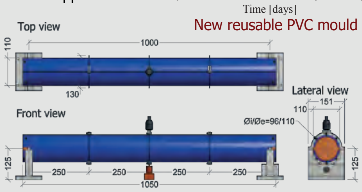


❑ OPTIMIZATION OF THE TESTING MOULD

Study and optimization of specimen geometry to increase the robustness and the reusability and to reduce the cost of each test.



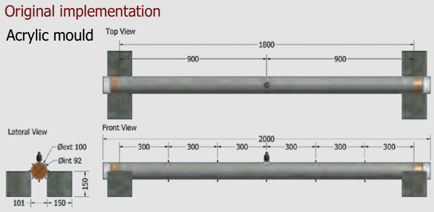




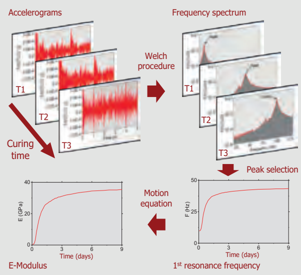
❑ EMM-ARM METHODOLOGY

Original implementation

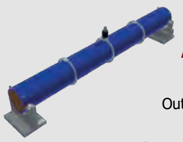
Acrylic mould



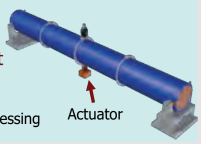
The EMM-ARM is a method that allows the automatic and continuous evaluation of the E-Modulus of cement based materials immediately after casting. This methodology is based on continuous modal identification of the first flexural resonant frequency of a composite beam. This beam is then placed horizontally, simply supported at both extremities, and vertical accelerations resulting from ambient vibration are measured at mid-span.

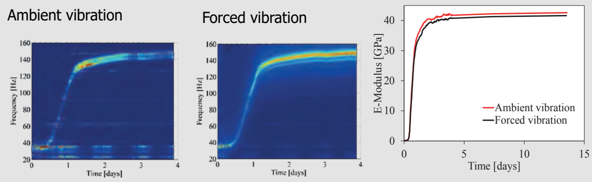


❑ SIGNAL PROCESSING



VS



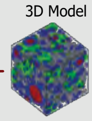


❑ NUMERICAL SIMULATIONS

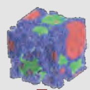
Cement Paste:

- Chemical composition
- w/c ratio
- PSD of the particles
- Reactions

3D Model



Meshing



Hydrated and anhydrated phases:

- Mechanical properties

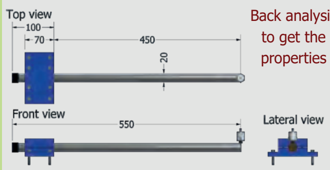
Several unknown properties!

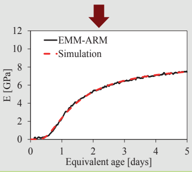
Mechanical test

Mechanical properties of the cement paste

Back analysis to get the properties

EMM-ARM for cement pastes





University of Minho
School of Engineering

FCT Fundação para a Ciência e a Tecnologia

QREN Quadro de Referência Estratégico Nacional

POPH

European Union
European Social Fund

Institute for Sustainability and Innovation in Structural Engineering

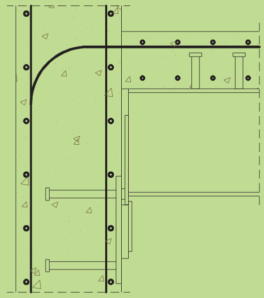
Behavior of joints: simple and efficient steel-to-concrete joints

José Henriques

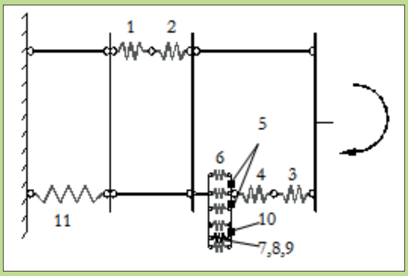
Supervisor(s): Luís Simões da Silva/ Isabel Valente

❑ Joint Configuration

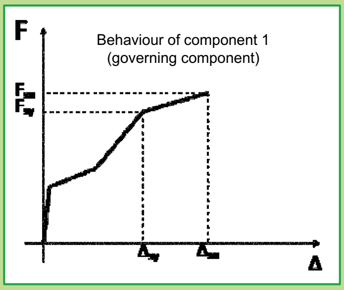
- Composite beam (IPE 300 + 16cm RC Slab) to RC Wall joint
- RC Slab and RC Wall concreting in separate stages → No Shear transfer
- Longitudinal Steel Reinforcement of Slab anchored in RC Wall
- Steel beam sits in Anchor Plate with steel bracket for shear
- Contact plate aligned with bottom flange of steel beam for compression



❑ Component model to bending moment

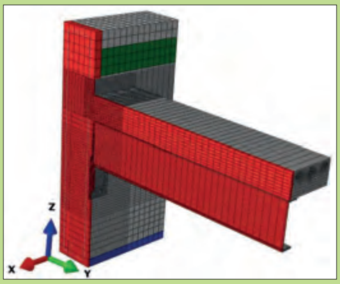


Component ID	Basic joint component
1	Longitudinal steel reinforcement bar in the slab
2	Slip of composite beam
3	Beam web and flange
4	Steel contact plate
5	Anchor plate in bending under compression
6	Concrete in compression
7	Headed anchor in tension
8	Concrete cone
9	Pull-out of anchor
10	Anchor plate in bending under tension
11	Joint link



❑ Numerical model

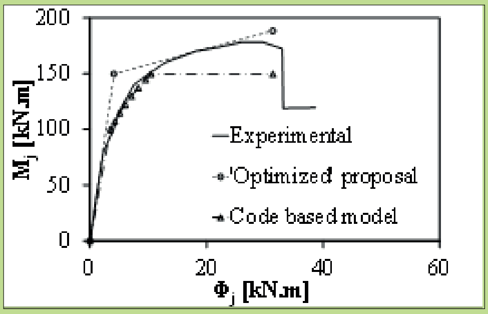
- Finite Element Software: ABAQUS
- Type of elements: Solid (C3D8/R)
- Contact: Surface to surface contact
- Concrete Constitutive Law: Concrete Damage Plasticity
- Wall and Slab normal reinforcement model using embedment option
- Longitudinal reinforcement (component 1) – concrete interaction modelled with bond model



❑ Experimental validation

Experimental tests performed at USTUTT within RFCS project "InFaSo"

Comparison with experimental tests



University of Minho
School of Engineering

SUSTAINABLE STEEL CONSTRUCTION

isise Institute for Sustainability and Innovation in Structural Engineering

Juan José Jiménez de Cisneros Fonfría

Supervisors: Luís Simões da Silva (UC) / Juan de Dios Carazo (UJA)

BEHAVIOUR OF ASSYMETRIC T-STUB COMPONENTS

❑ EXPERIMENTAL RESEARCH

- **This work program, in the scientific domain of the Steel Structures, consists in assessing the strength and the stiffness of T-stub components (Fig. 1). The approach followed will encompass experimental work as well as analytical and numerical developments.**
- **This component is considered in solutions of bolted moment end-plate connections where as a constructive exigence the profile faces have to be designed as aligned (see Fig. 1). The asymmetry has a great influence on the maximum resistance of the T-stub component.**

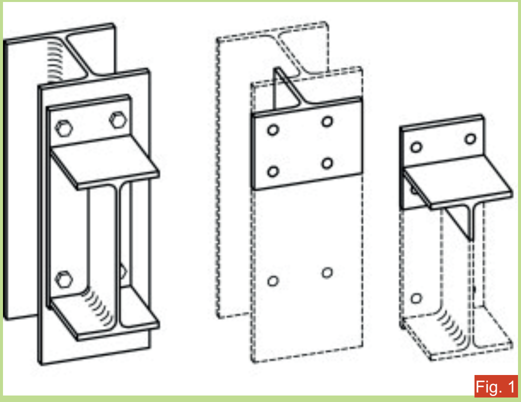


Fig. 1

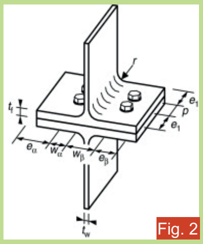


Fig. 2

❑ COMPONENT TESTS

- **A program of tests, on symmetric and asymmetric configuratioins, were performed at laboratories of the University of Coimbra. Characteristics momento-rotation curves were obtained to characterize the behavior (see Fig. 3)**

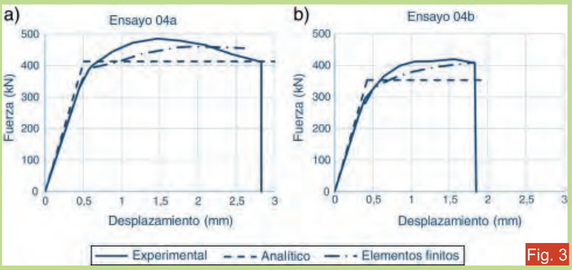


Fig. 3

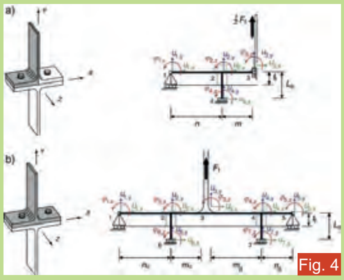


Fig. 4

❑ ANALYTICAL MODEL

- **A frame model was proposed and analyzed to define formulas in accordance to the Eurocodes methodologies**

❑ FINITE ELEMENT SIMULATIONS

- **Two 3d models were constructed, one symmetric and one asymmetric. They were analyzed by finite element simulations. The model considered contact between parts and material non-linearity. Results showed a good correlation with experimental evidences and with the analytical proposal.**

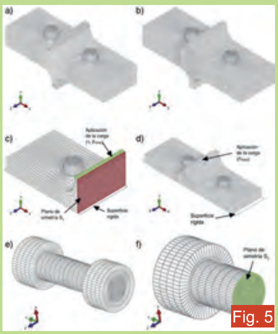


Fig. 5

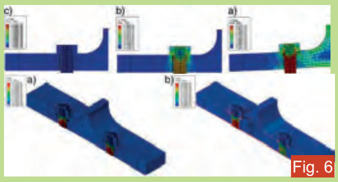


Fig. 6

University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

Leonardo Avila

Supervisors: Graça Vasconcelos/ Paulo Lourenço

SEISMIC BEHAVIOUR OF CONCRETE BLOCK MASONRY BUILDINGS

❑ INTRODUCTION

The comfort properties, simple construction, economy and durability given for masonry construction by using concrete block units make this construction technology suitable for its implementation in residential houses. A new construction system in which an innovative geometry block (Fig. 1) is used, is evaluated through shaking table tests of four residential houses.

❑ EXPERIMENTAL INVESTIGATION

- Four masonry buildings were planning for the identification of the seismic performance of the constructive system. Two symmetric and two asymmetric, in turn with and without steel reinforcement (Fig. 2).
- At the moment the experimental campaign for the symmetric buildings is done
- From results shown in Fig. 3 and Fig 4, in which damage of reinforced (a) and unreinforced (b) for symmetric and asymmetric buildings respectively are presented , it was found that in spite of the same inputs were applied to both models, the final state of unreinforced building lead to a considerable amplification of the damage and deformation. The use of reinforcement, clearly improves the seismic response of concrete block masonry buildings.

Fig. 1

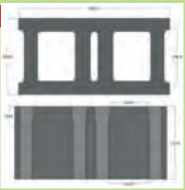


Fig. 2

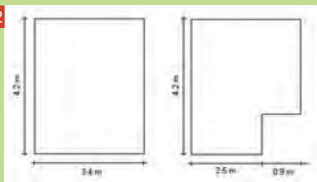
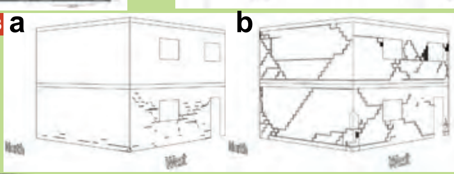


Fig. 3



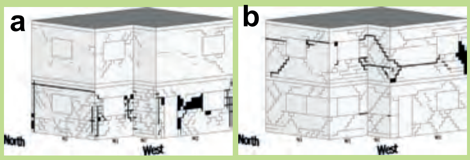


Fig. 4

❑ NUMERICAL SIMULATION

- A numerical model for the unreinforced solution was already calibrated based on the dynamic properties (mode shapes and frequencies) obtained during shaking table tests (Fig. 4). The finite element model was prepared using macro modelling methods .
- Static non-linear and full non-linear dynamic analysis with further parametric study to evaluate the influence of scale, reinforcement and material properties in the seismic behavior is under develop.
- The preliminary results obtained in the tests and in the numerical model allows the evaluation of the behaviour factor "*q*" (Fig. 5) for unreinforced masonry building . this parameter is implemented for design recommendations.
- Results from Table 1 shows that the behavior factors found for the unreinforced masonry fits the average value of the range provided in Eurocode 8 (1.5-2.5) for this construction typology, and it is controlled by damage limitation through ductility.

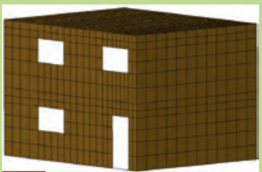


Fig. 4

Fig. 5

Table. 1	*q factor*	
Direction	**Force**	**Ductility**
Longitudinal	2.58	2.12
Transversal	2.56	2.03

· U C ·

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Leslie Edith Alejo Guerra

Supervisors: Paulo B. Lourenço / Nuno Mendes

EFFECT OF THE MASONRY MORPHOLOGY ON THE SEISMIC BEHAVIOR OF EXISTING MASONRY BUILDINGS

❑ INTRODUCTION

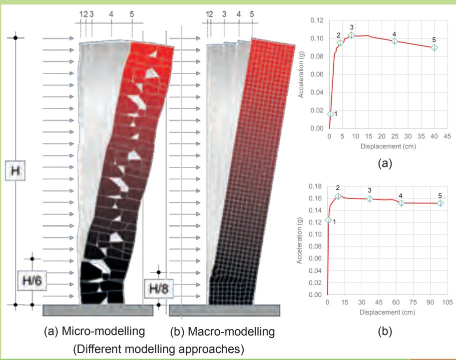
Ancient masonry buildings can present different types of damage due to earthquakes. Examples include local failures in masonry due to the loss of its integrity (Fig. 1), which can be also a consequence of a poor quality cross section arrangement (Fig. 2).

Local failures in masonry buildings[1] Fig. 1

The masonry morphology can have influence on the collapse mechanisms of structural elements and the global behavior of the structure.

Different cross section in masonry walls[2] Fig. 2

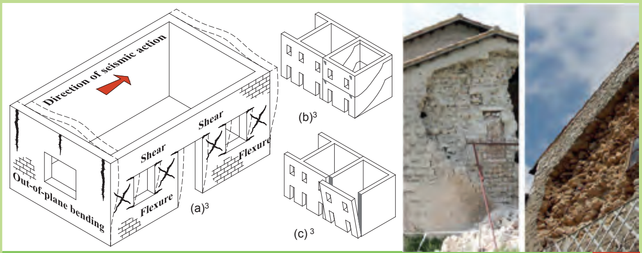
Moreover, some local failures of the masonry can be acceptable in the assessment of ancient masonry buildings (Fig. 3), since the global collapse of the building does not occur.



Assessment of ancient masonry Fig. 3

❑ MAIN OBJECTIVE

- The main objective of this thesis is to develop a hybrid analysis for the assessment of masonry structures, in which the local failures of structural elements (Fig. 1 and Fig. 2) due to the loss of the integrity of the masonry (poor quality of the masonry) are taken into account for the global behavior of the structure.



In-plane (b) and out-of-plane (c) masonry damage[3,4] Fig. 4

❑ METODOLOGY

❑ Study of the local failures due to the loss of integrity of the masonry

❑ Evaluation of the local behavior of masonry

❑ Develop of an hybrid analysis for assessment of ancient masonry buildings

❑ Application of the hybrid analysis for defining the fragility curves of ancient masonry buildings

This hybrid analysis will combine the global response obtained from global analyses of the structure (structure level) and the response of the structural elements obtained from different types of local analyses (material level). In order to evaluate the in-plane and out-of-plane seismic performance of existing masonry buildings based on a simple and quick global analysis with macro-block models.

1 N. Augenti and F. Parisi, "Learning from Construction Failures due to the 2009 L'Aquila, Italy, Earthquake," J. Perform. Constr. Facil., vol. 24, no. 6, pp. 536–555, 2010.

2 L. Binda, D. Penazzi, and A. Saisi, "Historic masonry buildings: necessity of a classification of structures and masonries for the adequate choice of analytical models," in Proceedings of the STRUMAS VI, 2003, pp. 168–173.

3 M. Tomaževič, Earthquake-Resistant Design of Masonry Buildings, vol. 1. Imperial College Press, 1999.

4 G. de Felice, "Out-of-Plane Seismic Capacity of Masonry Depending on Wall Section Morphology," Int. J. Archit. Herit., vol. 5, no. 4–5, pp. 466–482, 2011.

U C

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Luís Carlos Silva

Supervisors: Paulo B. Lourenço / Gabriele Milani

HOMOGENIZED DYNAMIC ANALYSIS OF OUT-OF-PLANE LOADED MASONRY WALLS AND EVALUATION OF FRAGILITY CURVES

SCOPE & MOTIVATION

Natural events had caused a considerable number of disasters in the last decades. The World Bank (IEG) [1] reported that the number of disasters increased, between 1975 and 2005, from an approximated number of 100 to more than 400 events. Earthquakes have a decisive role on this matter.

Bearing the latter, vulnerability assessments have a key role for authorities, decision makers, stakeholders (e.g. insurance companies) and to the community itself.

n = 100 | Natural disasters | n = 400

1975 | **Earthquakes** | 2005

Estimated +2.57±0.64 million fatalities until the end of the century + Cultural heritage buildings collapse (Fig. 1-3).

Fig. 1 Fig. 2 (c)

OBJECTIVES

The main goals of this research program are:

- Implementation of a novel discrete FE model for the two-way bending study of masonry walls through a homogenization approach;
- Validation of the model for quasi-static and dynamic purposes;
- The evaluation of fragility curves of structural elements.

RESEARCH STRATEGY

1st Year → 2nd Year → 3rd Year

MILESTONE 1	MILESTONE 2	MILESTONE 3
Develop a homogenized code for masonry in two-way bending.	Implement a novel discrete FE model in a commercial software. Perform numerical homogenized quasi-static and dynamic simulations at a structural scale.	Fragility curves evaluation through large scale Monte Carlo (MC) simulations.

The needed mathematical and physical backgrounds lead to a conceptualization process, a modelling formalization strategy.

RELEVANT RESULTS

MILESTONE 1

Homogenization (Meso-scale)

1. Define a Representative Volume Element (RVE) - figure 4.
2. Homogenization procedure (obtain in-plane homogenized stress-strain curves) - figure 5.
3. Integration over the thickness of the masonry Kirchhoff plate - figure 6.
4. Obtain the M–θ constitutive relation for each interface - figure 7.

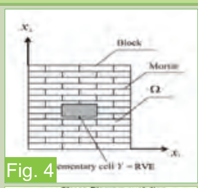


Fig. 4

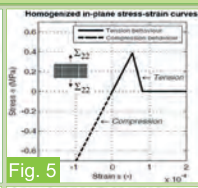


Fig. 5

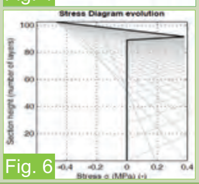


Fig. 6

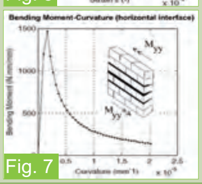
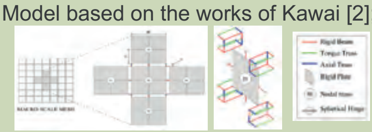


Fig. 7

MILESTONE 2

Structure-scale (macro-scale)

- Model based on the works of Kawai [2];



Quasi-Static validation

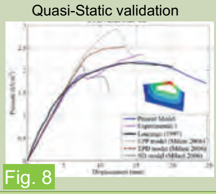


Fig. 8

Dynamic validation – Blast load

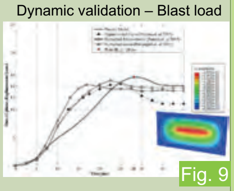


Fig. 9

CONCLUSIONS

- Milestone 1: the homogenization code was already implemented for running-bond and English-bond masonry patterns;
- Milestone 2: the novel discrete FE model was implemented in a commercial software. It was validated and thus oriented for non-linear quasi-static and dynamic purposes.

REFERENCES

[1] IEG, 2007. *Development Actions and the Rising Incidence of Disasters*, Washington, D.C.

[2] Kawai, T., *New discrete models and their application to seismic response analysis of structures*, Nuclear Engineering and Design, Volume 48, Issue 1, pp. 207-229, June 1978.

University of Minho School of Engineering

FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

isise Institute for Sustainability and Innovation in Structural Engineering

Luís Luciano Gouveia Correia

Supervisors: José Sena Cruz / Paulo França

DURABILITY AND LONG-TERM BEHAVIOR OF RC SLABS FLEXURALLY STRENGHTENED WITH PRESTRESSED CFRP LAMINATES

❑ EXPERIMENTAL RESEARCH

- This research work program intends to contribute for the knowledge on the durability and on the short and long-term structural behaviour of reinforced concrete elements flexurally strengthened with prestressed carbon fiber reinforced polymer (CFRP) laminate strips.
- In order to achieve this goal a wide experimental program will be executed using 17 full-scale slab specimens (Fig.1) under various specific application environments, load conditions and chemical degradation.

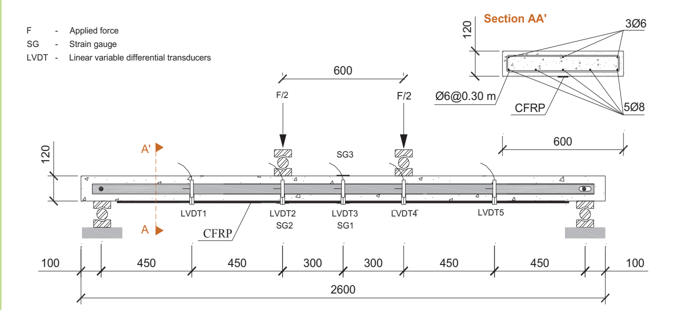
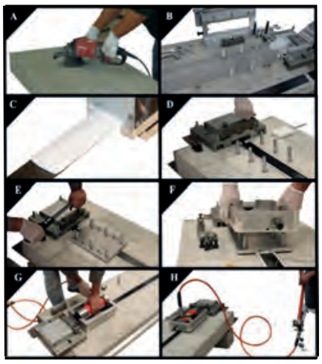


Fig. 1 Specimen's geometry and test configuration. Note: all units are in millimeters.

- The test results obtained from the experimental program will be used to predict the service life behaviour of prestressed slabs, as well as the ultimate strength supported in some numerical models. This PHD also intends to elaborate design recommendations using the results obtained in the experimental programs and derived from parametric studies performed by numeric simulations.

❑ STRENGTHENING PROCEDURES



- Firstly, the surface is prepared (A) and the anchor bolts are fixed. Then, the aluminium guides are placed in the right position to guide and fix the clamps units (B).
- The epoxy adhesive is prepared and applied to the CFRP strip (C). The clamps are closed (D) and the anchor plates are placed in the predefined location (E).
- The aluminium frames are placed on top of the anchor plates (F) in order to accommodate the hydraulic cylinder (G). Finally the prestress is applied with a manual hydraulic pump (H).

Fig. 2 Prestress procedure of the CFRP strip.

❑ OVERVIEW

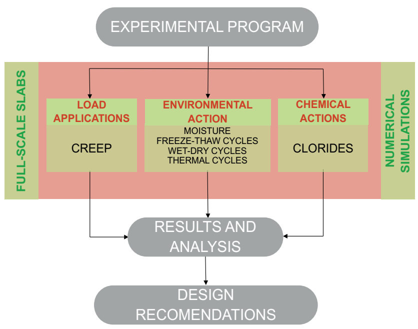


Fig. 3 Overview of the experimental program.

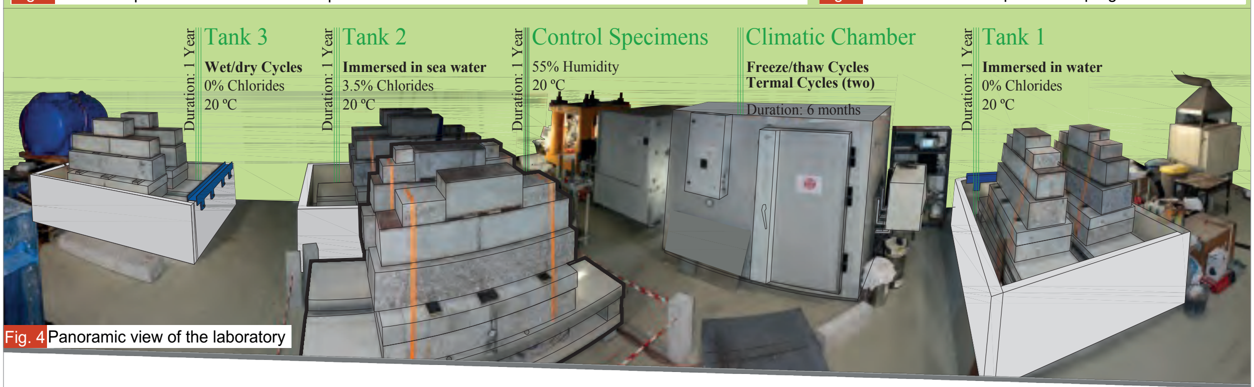


Fig. 4 Panoramic view of the laboratory

U C
University of Minho
School of Engineering
FCT Fundação para a Ciência e a Tecnologia
COMPETE
QREN

isise Institute for Sustainability and Innovation in Structural Engineering

Luís Miguel Magalhães

Supervisors: Carlos Rebelo / Sandra Jordão

BEHAVIOUR OF STEEL JOINTS BETWEEN I PROFILE BEAMS TO HOLLOW COLUMN WITH WELDED REVERSE CHANNEL

❑ EXPERIMENTAL RESEARCH

- This work program, in the scientific domain of the Steel Composite Structures, consists in assessing the nonlinear dynamic behaviour of steel joints between I profile beams to square section columns (Fig. 1), hollow or filled with concrete, with the welded reverse channel (Fig. 2). The approach followed will encompass experimental work associated with numerical modelling.
- Tubular columns show a privileged structural behaviour when compared with other steel shapes, due to their ability to withstand axial loads, bending in several directions and torsion, besides considerable advantages in terms of maintenance and aesthetics. The welded reverse channel connection is a good solution to overcome the joint problem in the case of I beam to hollow column since they have a reasonable construction cost, are easy to implement and possess large ductility through deformation of the web panel.

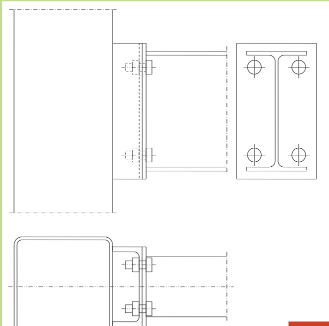


Fig. 1

❑ EXPERIMENTAL TESTS – BEHAVIOUR OF TUBULAR COLUMNS

Fig. 2

- The behaviour of the tubular columns main components (The chord face yielding in bending, the chord side wall yielding, crushing or instability, under the compression brace member and the chord in shear) is assessed by means of bending tests (monotonic and cyclic), calibrated with numerical models. Fig. 3 shows drawings of the elements to be used in the test layout, present in the photos of Fig. 4. The numerical models represent the real prototypes used in experimental tests (Fig. 5).
- The results of experimental tests allow correlate the parameters considered with the structural behaviour of the connection, defined by the resistance, the stiffness, and the rotation capability.

❑ PARAMETERS

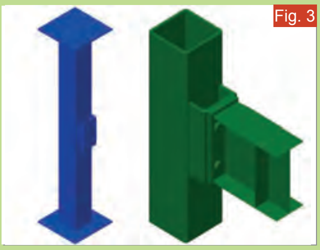


Fig. 3

- *Table with the prototypes characteristics*
- The parameters considered in the parametric variation are the thicknesses and the widths of the tubular columns faces, the filling or not with concrete and the axial load.

N.º	Profile	w_c [mm]	t_c [mm]	Concrete	Axial Load	Prototype (Reference)
1	SHS	220	8	No	No	S-021
2		250				S-051
3			10			S-052
4		220	8	Yes		S-121
5		250		No	Yes	S-251

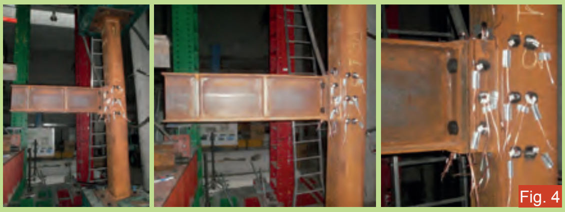
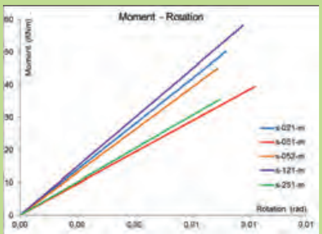
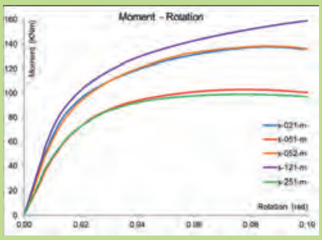


Fig. 4

❑ RESULTS

- Results expressed in terms of moment-rotation curves:





- Results in terms of deformations and V-M stresses:

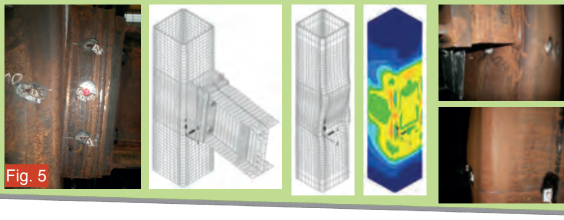


Fig. 5

University of Minho
School of Engineering

Instituto Politécnico de Castelo Branco
Escola Superior de Tecnologia

Institute for Sustainability and Innovation in Structural Engineering

Luís Miguel Silva

Supervisors: Graça Vasconcelos / Paulo Lourenço

INNOVATIVE SYSTEMS FOR EARTHQUAKE RESISTANT MASONRY ENCLOSURES IN RC BUILDINGS

❑ MOTIVATION

The recent earthquakes in L'Aquila (Italy, 2009, Mw = 6.3), Van (Turkey, 2011, Mw = 7.1) and Emilia Romagna (Italy 2012, Mw = 6.0), among others, have shown that the behaviour of masonry enclosures walls, it is not appropriate, existing different situations of collapse, in-plane and out-of-plane, with loss of life and huge economic losses for repairs and replacements.

In the past the investigation in this topic was unable to produce solutions, with appropriate behaviour to earthquakes and clear design rules to include in European design codes.

❑ OBJECTIVES

The main objectives of this work program are:

- Developing new systems for construction of masonry infill walls;
- Validate their behaviour experimentally and numerically;
- Providing recommendations to improve the construction technology in this type of walls;
- Provide design recommendations for seismic actions to prevent excessive damage and the fragile collapse of the walls.

❑ PROPOSED SOLUTIONS

To accomplish the objectives were proposed two masonry infill systems, which was subject to experimental and numerical validation.

➢ Térmico system uses the concept of maintain the infill rigidly attached to the frame, using internal reinforcement and connectors. This system is a single leaf clay infill with 140mm of thickness.

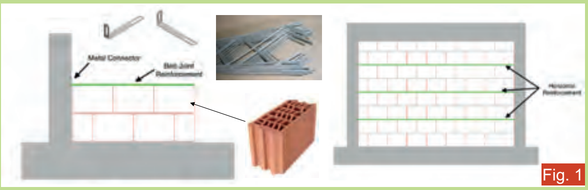


Fig. 1

➢ Uniko system use the concept of allow internal deformation of the wall, in the continuous vertical joints but it is also rigidly attached to the RC frame.

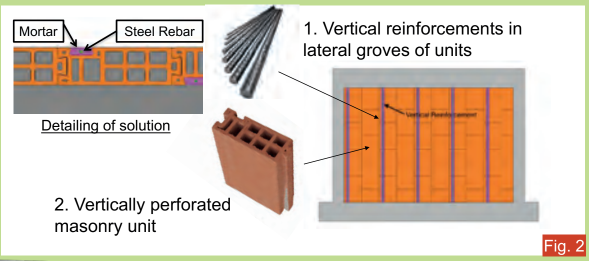


Fig. 2

❑ RESEARCH STRATEGY

The proposed solutions, has been studied experimentally for cyclic loads in the plane and out of the plane directions. Due to laboratory limitations RC frames were sized to small-scale (1:1,5). The final geometry and the reinforcement scheme was obtained using Cauchy's law of similarity

In-Plane and Out-of-Plane tests are performed in displacement control according to a load pattern defined based on the FEMA 461 recommendations.

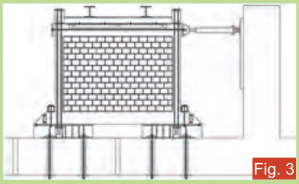


Fig. 3

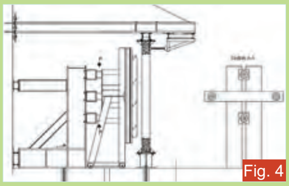
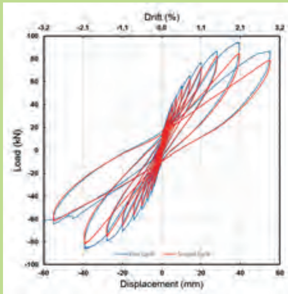
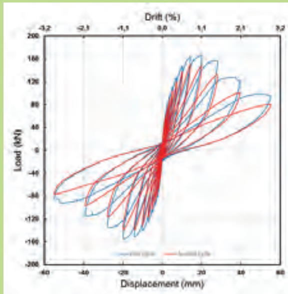


Fig. 4

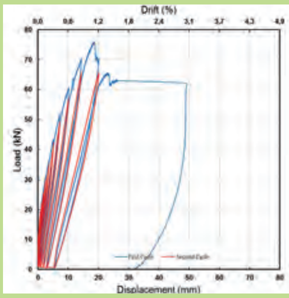
❑ RESULTS



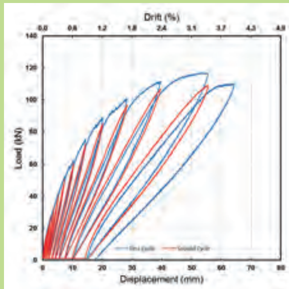
Uniko System In-Plane Test:
Max. Force: 94,54kN (39,69mm)
Max. Disp.: 55,56mm (80kN)



Térmico System In-Plane Test:
Max. Force: 167kN (20mm)
Max. Disp.: 55,56mm (95kN)



Uniko System Out-of-Plane Test:
Max. Force: 76kN (18,81mm)
Max. Disp.: 26,98mm (62,94kN)



Térmico System Out-of-Plane Test:
Max. Force: 117,05kN (53,65mm)
Max. Disp.: 64,37mm (107,86kN)

❑ CONCLUSIONS

From the results presented it is possible to conclude that Térmico System presents better behaviour both for In-Plane and Out-of-Plane direction. The numerical validation and design recommendations will be made for this system.

University of Minho
School of Engineering

INSYSME

isise Institute for Sustainability and Innovation in Structural Engineering

Mahsa Taheri

Supervisor: Joaquim Barros

A Model to Predict the Crack Width of FRC Members Reinforced with Longitudinal Bars

❑ Motivation

- A hybrid analytical/numerical approach for the evaluation of the moment-rotation behavior of a cross section of fiber reinforced concrete (FRC) elements flexurally reinforced with longitudinal bars is developed.
- This model is applied to FRC elements failing in bending, and considers the constitutive laws of the constituent materials, where a special focus on the simulation of the post-cracking tensile behavior of FRC is given, as well as the bond behavior between flexural reinforcement and surrounding FRC.

❑ NUMERICAL/ANALYTICAL MODEL

- The overall deformational response of the beam can be obtained by using the moment-rotation response of each prism depicted in Fig. 1. A symmetric cross section that can have a width varying along its depth and a height *h*, is discretized in n layers in order to take into account the appropriate constitutive law for each concrete layer during the loading procedure.

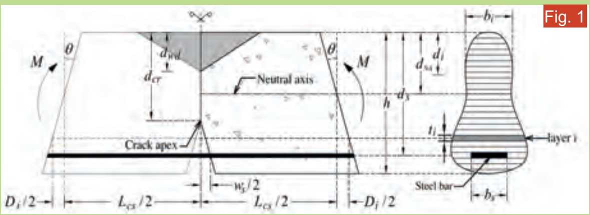


Fig. 1

❑ CONSTITUTIVE LAWS

- The constitutive laws adopted to simulate the tensile and compressive behavior of FRC are depicted in Fig. 2 and 3, respectively.

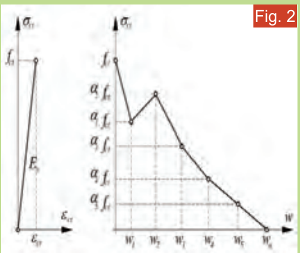


Fig. 2

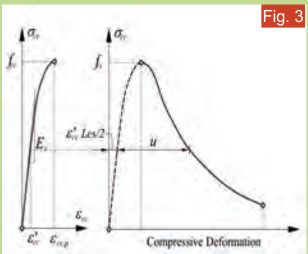


Fig. 3

❑ MODEL ASSESSMENT

- The predictive performance of the proposed model was evaluated by simulating the moment-crack width of three R/FRC beams tested in four point bending configuration (Fig. 4).

Fig. 4

- The model has predicted with good accuracy the relationship between the bending moment vs crack width. This predictive performance is better than the ones obtained by applying the recommendations of RILEM TC 162-TDF and fib Model Code 2010 (Fig. 5).

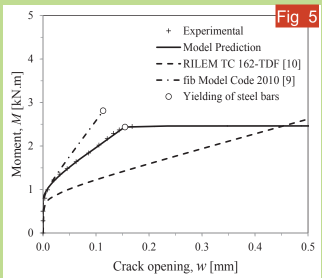


Fig 5

❑ PARAMETRIC STUDY

- By using the developed model, a parametric study was carried out.
- It was verified that in R/FRC elements of a longitudinal reinforcement ratio of 0.5% the flexural capacity for crack width for the serviceability limit states has increased significantly with the increase of the residual flexural tensile strength parameter for a CMOD=0.5 mm (f_{R1}).
- It was observed that the bond stiffness has a quite favorable effect on the flexural capacity and on the arrestment of the crack opening up to the yield initiation of the longitudinal reinforcement.

· U C ·

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Manuel Parente

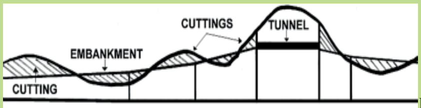
Supervisors: A. Gomes Correia/ Paulo Cortez

DEVELOPMENT OF AN INTELLIGENT EARTHWORKS OPTIMIZATION SYSTEM

Background

Prior to the construction of any structural element in Civil Engineering, conditions for its foundation must be created. This is mainly achieved by excavating geomaterials from areas above the target height (cuttings) and transporting them to areas below target height, where they are spread into layers and compacted (embankments) – this process is known as **earthworks**:

- High costs and construction durations in transportation infrastructure projects;
- Involve repetitive sets of sequential and interdependent tasks, strongly based on mechanical equipment (one type for each task: excavators, trucks, bulldozers, rollers);
- Highly susceptible to being optimized, even though there are few attempts, due to the complex and dynamic nature inherent to earthworks.



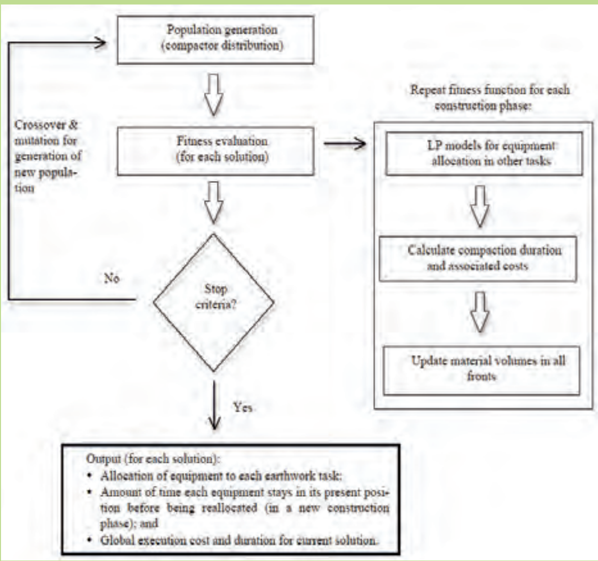
Earthwork tasks schema

Recent developments in the area of artificial intelligence enhance its use in earthwork optimization, resorting to tools such as **Evolutionary Computation**:

- Robust search of solutions within reasonable time and computational effort;
- Optimization capabilities and flexibility to deal with dynamic and complex environments (i.e., earthworks).

Objective

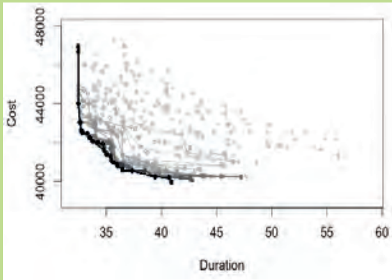
In this framework, the expected outcome consists of an intelligent optimization system for selection and allocation of mechanical equipment in an earthwork construction, minimizing both final project costs and duration using a multi-objective optimization approach.



Implementation results

Implementation of the system has been successfully achieved, including validation with real construction data from a Portuguese construction site.

Assessment of algorithm convergence towards optimal solutions:



Algorithm convergence

Comparison between an optimized solution for one work front and the original manual solution adopted by the designer:

Parameter	Conventional allocation	Optimized allocation
Approximate distance to excavation front (m)	500	
Number of compactors	1	1
Compactor work rate (m^3/h)	683	683
Number of spreaders	1	1
Spreader work rate (m^3/h)	675	820
Number of dumper trucks	3	2
Dumper truck work rate (m^3/h)	1280	880
Number of excavators	1	2
Excavator work rate (m^3/h)	540	743

Conclusions

Experiments using real-word data from a Portuguese construction site have been carried out, indicating:

- Evolutionary computation techniques are powerful and versatile tools, suitable for modelling real problems;
- The system has shown promise regarding the optimization of the earthworks process, especially in terms of managing the available resources in order to achieve feasible solutions with minimal construction costs and durations.

Overall, competitive results were achieved by the proposed system (reduction of 20-50% in project cost and duration when compared with solution adopted by conventional design methodologies), stressing the advantages of intelligent optimization tools in the design of earthworks.

· U C ·

University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

EFFECT OF TIMBER FLOOR DIAPHRAGMS ON THE SEISMIC BEHAVIOUR AND ANALYSIS OF EXISTING MASONRY BUILDINGS

Maria Pia Ciocci

Supervisors: Paulo B. Lourenço / Rui Marques

❑ BACKGROUND

- **Unreinforced masonry (URM) buildings with timber floors is a very frequent structural typology in ancient constructions. Besides the material and geometrical properties of the masonry fabric, the seismic performance of these buildings is significantly dependent on the characteristics of their wooden floors.**
- **International guidelines (e.g. ASCE/SEI 41-13:2014, NZS 1170.5:2004, IBC 2008) recognize that adequate in-plane stiffness and proper wall-to-floor connections allow to improve the global seismic behaviour of URM buildings, and to obtain a better distribution and transfer of forces to the lateral load resisting walls (Fig. 1).**
- **Post-earthquake damage observations demonstrate that inappropriate and invasive retrofitting techniques can have dramatic consequences, such as the case of excessively stiff floors with inadequate connection to the walls, as shown in Figs. 2-3.**

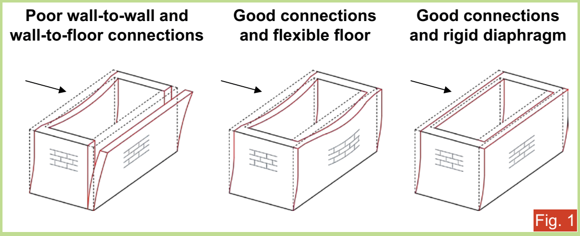


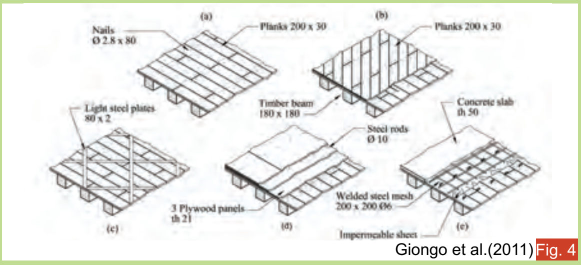
Fig. 1

Brignola et al.(2009) Fig. 2

Brignola et al.(2009) Fig. 3

❑ AIM AND METHODOLOGY

- **The aim of this work is to investigate the effect of timber floor diaphragms on the seismic behaviour of URM buildings, before and after retrofitting.**
- **The methodology to be applied in this work consists of the following main steps:**
  1. **Characterization of existing URM building typologies and floor diaphragms, as well as idealization of possible retrofitting techniques for floors, e.g. Fig. 4;**
  2. **Laboratory and in-situ tests of floor connections and retrofits, to complement previous experimental programs, see Figs. 5-6;**
  3. **Numerical modelling at the wall-to-floor connection and building scales to simulate and investigate typical behavioural response and failure mechanisms;**
  4. **Development and validation of analytical models for floors and wall-to-floor connections;**
  5. **Cost-benefit analysis to establish optimal intervention strategies.**



Giongo et al.(2011) Fig. 4

Senaldi et al.(2014) Fig. 5

Mendes et al.(2014) Fig. 6

REFERENCES

- Brignola A, Pampanin S, Podestà S (2009) Evaluation and control of the in-plane stiffness of timber floors for the performance-based retrofit of URM buildings, Bulletin of the New Zealand Society for Earthquake Engineering, 42(3):204-221.
- Giongo I, Piazza M, Tomasi R (2011) Pushover analysis of traditional masonry buildings: influence of refurbished timber-floor stiffness, Proceedings of the International Conference on Structural Health Assessment of Timber Structures, Lisbon.
- Mendes N, Lourenço PB, Campos-Costa A (2014) Shaking table testing of an existing masonry building: assessment and improvement of the seismic performance, Earthquake Engineering & Structural Dynamics, 43(2):247-266.
- Senaldi I, Magenes G, Penna A, Galasco A, Rota M (2014) The effect of stiffened floor and roof diaphragms on the experimental seismic response of a full-scale unreinforced stone masonry building, Journal of Earthquake Engineering, 18(3):407-443.

U C · TÉCNICO LISBOA · U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO · universidade de aveiro · LNEC LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL · ICIST

University of Minho School of Engineering · FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR · POCH · PORTUGAL 2020

isise Institute for Sustainability and Innovation in Structural Engineering

Maria Giovanna Masciotta

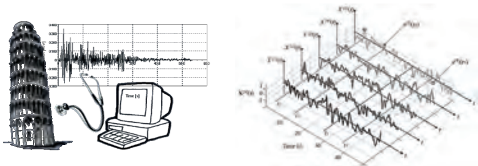
Supervisors: Paulo Lourenço / Luís Ramos

DAMAGE IDENTIFICATION OF STRUCTURES BASED ON SPECTRAL OUTPUT SIGNALS

❑ SCOPE AND FOCUS OF THE RESERCH

- **This work investigates upgraded spectral analysis methods for early-stage damage identification of structures.**
- **The main goal is the development and evaluation of a damage localization spectral index based on a robust formulation, insensitive to user choices, applicable to any type of structure, and suitable for both output-only (OMA) and input-output (EMA) identification techniques.**
- **Changes in the structural stiffness caused by evolutionary damage scenarios lead to changes in the response power spectral density (PSD) matrix of the system. Thus, given two structural scenarios (e.g. undamaged & damaged), the analysis of the relevant spectral parameters, extracted from the response PSD matrices through their eigenvalue decomposition, does enable to detect and locate structural damage. The spectral procedure consists of 3 main steps.**

Step 1. Output signals acquisition and spectral densities estimation



Auto Correlation Function

$$R_{XX}(\tau)=\lim_{T\to\infty}\frac{1}{T}\int_0^T x(t)x(t+\tau)dt$$

F ⟶

Direct Power Spectral Density

$$S_{XX}(\omega)=\frac{1}{2\pi}\int_{-\infty}^{+\infty}R_{XX}(\tau)\cdot e^{-i\omega\cdot t}d\tau$$

Cross Correlation Function

$$R_{xy}(\tau)=\lim_{T\to\infty}\frac{1}{T}\int_0^T x(t)y(t+\tau)dt$$

F ⟶

Cross Power Spectral Density

$$S_{XY}(\omega)=\frac{1}{2\pi}\int_{-\infty}^{+\infty}R_{xy}(\tau)\cdot e^{-i\omega\cdot t}d\tau$$

Step 2. Eigenvalue decomposition of the output power spectrum matrix

$$\mathbf{S}_X(\omega)=\begin{bmatrix} S_{X_1X_1}(\omega) & S_{X_1X_2}(\omega) & \dots & S_{X_1X_m}(\omega) \\ S_{X_2X_1}(\omega) & S_{X_2X_2}(\omega) & \dots & S_{X_2X_m}(\omega) \\ \vdots & \vdots & \ddots & \vdots \\ S_{X_mX_1}(\omega) & S_{X_mX_2}(\omega) & \dots & S_{X_mX_m}(\omega) \end{bmatrix}$$

Eigenvalue Decomposition

$$\mathbf{S}_X(\omega)=\mathbf{\Psi}_X(\omega)\mathbf{\Lambda}(\omega)\mathbf{\Psi}_X^H(\omega)$$

Eigenvalues Matrix

$$\Lambda_X(\omega)=diag\{\lambda_1, \lambda_2, \dots, \lambda_j, \dots, \lambda_n\}$$

λ_n: energy of the vibration mode (frequency-dependent)

Eigenvectors Matrix

$$\Psi_X(\omega)=[\psi_1\ \psi_2\ \dots\ \psi_j\ \dots\ \psi_n]$$

ψ_n: mode shape estimation (coordinate-dependent)

Step 3. Computation of the damage localization spectral index

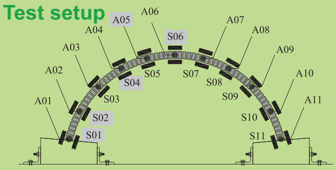
$$\Delta\psi=\sum_{j=1}^{n}\left\|\underbrace{\sum_{i=1}^{m}\left[\psi_j^d(\omega_i)\cdot\sqrt{\lambda_j^d(\omega_i)}\right]}_{\text{Spectral Mode Damage Scenario}}-\underbrace{\sum_{i=1}^{m}\left[\psi_j^u(\omega_i)\cdot\sqrt{\lambda_j^u(\omega_i)}\right]}_{\text{Spectral Mode Reference Scenario}}\right\|$$

Number of Modes: n; Frequency Range: m

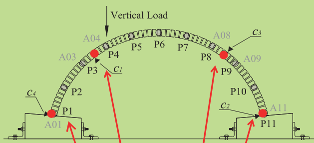
❑ EXPERIMENTAL VALIDATION

- **The method is validated through the comparison of the results predicted by the spectral-based damage analysis with the results from diverse experimental campaigns. Here, the experimental validation on a masonry arch replica is presented as an example.**

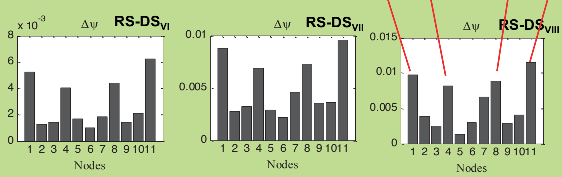
Test setup



Crack pattern



- **The results of the spectral index are consistent with the experimental evidence: damage is detected at a very early stage and localized exactly in the nodes where the actual cracks occurred during the experimental test.**



University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Marialuigia Sangirardi

Supervisors: Paulo B. Lourenço/ Giuseppina Uva

SEISMIC ASSESSMENT OF MIXED MASONRY - REINFORCED CONCRETE BUILDINGS. AN INSIGHT INTO MODELLING APPROACHES

❑ MOTIVATIONS AND OBJECTIVES

In the framework of the seismic assessment of existing historical buildings, this thesis has focused on mixed masonry-reinforced concrete structures (not in adherence), whose diffusion is largely testified (Fig.1). Motivations lie on the lack or inadequacy of experimental data, scarcity of numerical simulations, insufficient Code indications and on the fact that results of numerical simulations are sensitive to modelling approaches.

The aims of this research work have been to provide insights concerning the criteria for repartition of the seismic actions between elements, evaluate the reliability of code prescriptions, assess the performance of different building types.

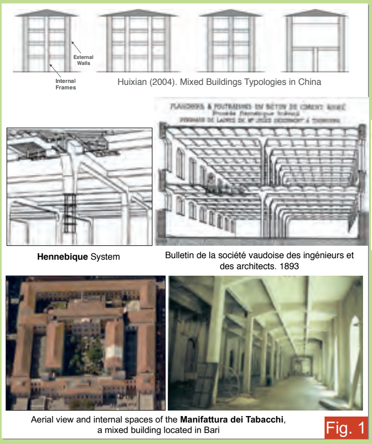


Fig. 1

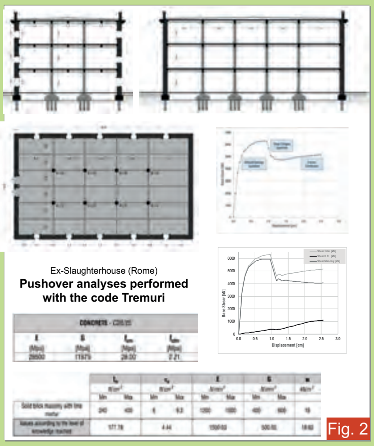


Fig. 2

❑ CASE STUDIES AND PERFORMED ANALYSES

- **Two buildings, the Ex-Slaughterhouse in Rome (Fig.2) and an literature case-study, have been analysed with equivalent frame approach, using the code Tremuri, and for the latter also a more refined finite element model has been studied (Fig.3).**
- **A series of hypotheses on the dimensions of the reinforced concrete elements in the ideal case has allowed to estimate their contribution on the overall horizontal strength.**

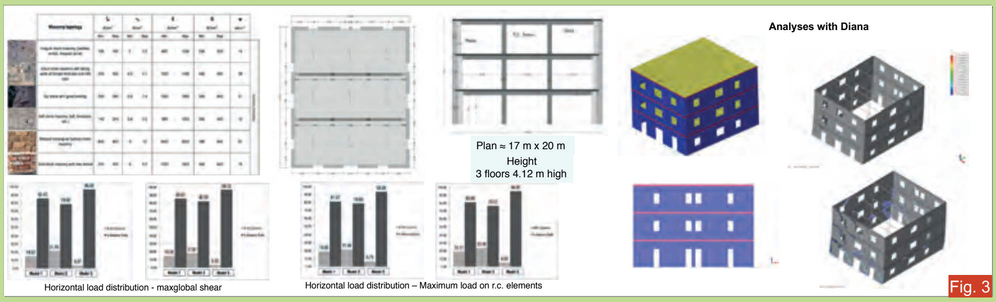


Fig. 3

❑ RESULTS

- **For mixed masonry-reinforced concrete buildings in which frames have dimensions typical of seismically designed r.c. structures, neglecting their contribution withstanding horizontal actions would lead to overestimate the actual portions acting on masonry walls. Indeed, the relative percentages shared between masonry and RC elements should be assessed by means of a nonlinear static analysis.**
- **In case of existing buildings it's always necessary to perform non-linear analyses in order to evaluate the entity of load repartition among the structural elements; in fact load distribution can vary significantly passing from linear to non-linear field.**
- **In case of new buildings the contribution of reinforced concrete elements should be evaluated in the non-linear field.**
- **The role of connections between r.c. elements and masonry panels is a crucial aspect, together with the in-plane stiffness of the floors.**

· U C ·

University of Minho
School of Engineering

Politecnico di Bari
Dipartimento di Ingegneria Civile, Ambientale, del Territorio, Edile e di Chimica

isise
Institute for Sustainability and Innovation in Structural Engineering

Mário Rui Freitas Coelho

Supervisors: José Sena Cruz / Luís Neves

BOND BEHAVIOR OF FRP NSM SYSTEMS IN CONCRETE

❑ THESIS OBJECTIVE

- Development of a design methodology for the bond behavior of concrete structures strengthened with fiber reinforced polymers (FRP) using the Near-Surface Mounted (NSM) strengthening technique.

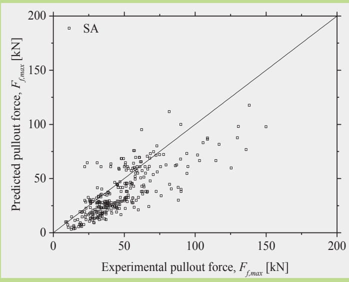
❑ BIBLIOGRAPHIC COMPONENT

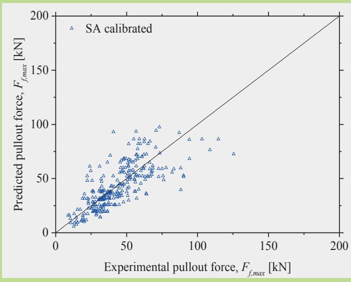
- Compilation of the available works on FRP NSM systems, focusing: (i) experimental bond tests; (ii) proposal of analytical models; (iii) use of numerical models to study the bond behavior in FRP NSM systems in concrete.
- A data-base-web-tool was built in order to gather in a single place the bond tests collected. Already includes 363 Direct and 68 Beam Pullout Tests. Allows registered Users to apply the design formulations of ACI 440.2R-08 and SA HB305-08, as well as, formulations based on data mining (DM) algorithms.

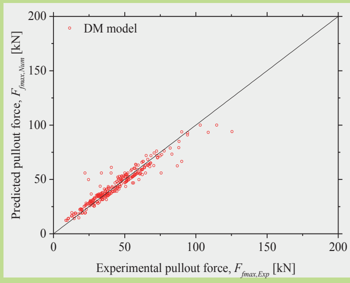
Available at www.bfn.civil.uminho.pt

❑ ANALYTICAL COMPONENT

- ACI and SA guidelines' formulations: accuracy evaluation, recalibration and using DM models adopting the same input variables as the corresponding guidelines.



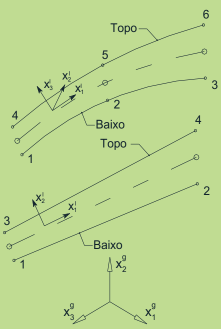




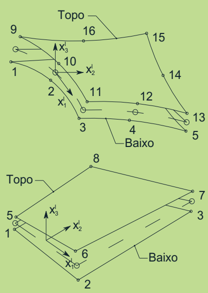
❑ NUMERICAL COMPONENT

- Implementation in FEMIX 4.0 software of a constitutive model for zero-thickness interface elements. The model is based on the theory of plasticity, allows 2D and 3D nonlinear FEM simulations considering fracture modes I and II.

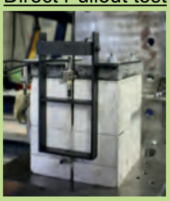
Interface Line 2D/3D



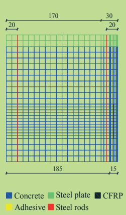
Interface Surface



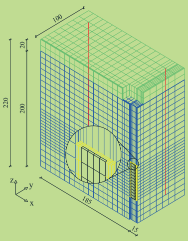
Direct Pullout test

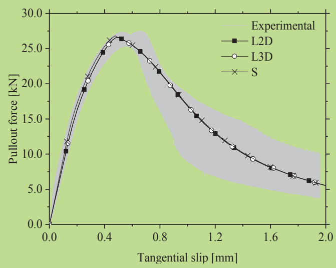


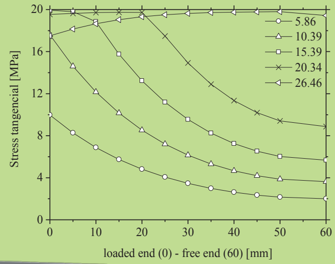
FEM 2D



FEM 3D







University of Minho
School of Engineering
The University of Nottingham
FCT
Fundação para a Ciência e a Tecnologia
COMPETE
QREN
SFRH/BD/87443/2012

isise Institute for Sustainability and Innovation in Structural Engineering

Marisa Mota Pinheiro

Supervisors: Tiago Miranda/ Luís Lamas

NUMERICAL METHODOLOGY TO MODEL HETERGOENEOUS ROCK MASSES

❑ OBJECTIVE

This work program, in the scientific domain of Geomechanics and Geotechnical Engineering, consists in the development of a numerical methodology to use in the characterization of heterogeneous rock masses. The aim is to integrate the uncertainty related to the spatial variability and heterogeneous naturally present in this type of rocks. Therefore, geostatistics was the main technique used to perform the geomechanical parameters simulation and, consequently built an heterogeneous model of the rock mass.

❑ METHODOLOGY

Using the information of geotechnical surveys and *in situ* tests it is possible to simulate the parameters and build *2D* or *3D* models with explicit representation of heterogeneities of the rock mass. Those parameters are mainly empirical systems such as the *RMR* (Bieniawski, 1989), the *Q* (Barton, 1974) and *GSI* (Hoek et al.,1995). Since a wide range of "realities" (realizations) is obtained as output of the geostatistical simulation (Fig. 1:step 3), a scenario reduction methodology had to be adapted in order to select a smaller set of realization (that statistically represent the full realization set (Fig. 1:step4)). As final step, the geomechanical information simulated is imported to a finite difference software (Flac^{3D}) to perform a mechanical behaviour analysis of the geotechnical structure and compare the result with a deterministic approach.

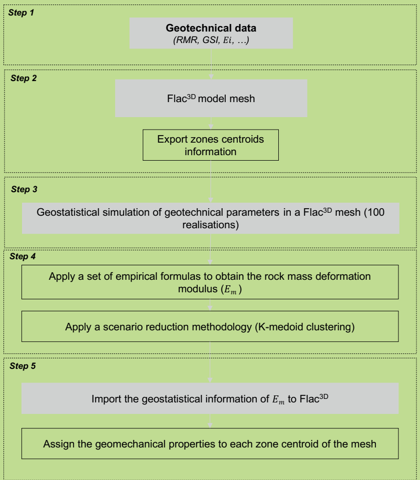


Fig. 2 General workflow containing the general steps of the characterisation methodology.

❑ REAPROVEITAMENTO HIDROELÉTRICO DE SALAMONDE (SALAMONDE II) – CASE STUDY

The proposed methodology was applied using as case study the geotechnical information recovered from the powerhouse complex of Salamonde II, located in a cavern built in a depth of 200 m in the left side of the Salamonde dam (north of Portugal). The Flac^{3D} numerical model is composed by a total of 664,022 grid points and 642,086 elements.

The goal of this study was analyse the differences in terms of displacements and stresses when the rock mass is modelled as and homogeneous or as an heterogeneous medium. As result, was possible to observe (Fig. 2 and Fig. 3) some significant differences in the displacement magnitude of value between both models, having the heterogeneous one achieved a maximum displacement value of 11.8 mm in the tunnel invert (Fig. 4), while the homogenous resulted in smaller values (5.7 mm).

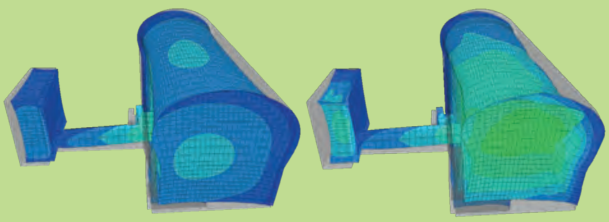


Fig. 2 *3D* contours of the displacements magnitude (in m) with a deformed factor equal to 1000 in the last excavation stage, for: a) the Homogeneous model; and b) Heterogeneous model.

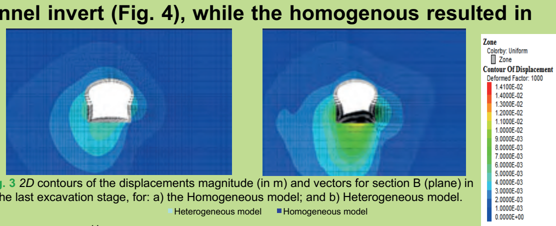


Fig. 3 *2D* contours of the displacements magnitude (in m) and vectors for section B (plane) in the last excavation stage, for: a) the Homogeneous model; and b) Heterogeneous model.

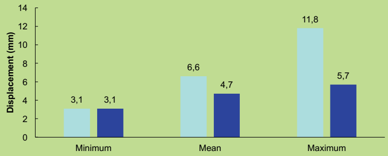


Fig. 5 Graphical representation of the minimum, mean and maximum values of the maximum displacements registered in each analysed numerical model (Homogeneous and Heterogeneous).

· U C ·

University of Minho
School of Engineering

FCT Fundação para a Ciência e a Tecnologia

isise Institute for Sustainability and Innovation in Structural Engineering

Mateus Antônio Nogueira Oliveira
Supervisors: Paulo B. Lourenço / Miguel Azenha

A MULTI–PHYSICS APPROACH APPLIED TO MASONRY STRUCTURES WITH NON–HYDRAULIC LIME MORTARS

KEYWORDS
Historical constructions, masonry, aerial lime, carbonation, numerical simulation, experiments and multi-physics problems

INTRODUCTION AND OBJECTIVES

This PhD thesis aimed to establish a multi-physics approach with numerical simulations and experiments to study the structural behavior of historic buildings comprised of masonry with non-hydraulic lime.

Coupled Model (Multi-physics Model)
Complex behavior

Model 1D/2D
Finite Difference Method

Model 3D
Finite Element Method

Experiments

Thermic
Diffusion
Thermal Effects
Microstructural changes
Humidity
Reactions Velocity
Mechanical Behavior
Water Consumption
Carbon Dioxide Diffusion and Carbonation
Stiffness

• Moisture field

Drying process
Humidity diffusion
Interaction with other fields

$$\frac{\partial h}{\partial t} = \nabla \cdot (C\,\nabla h) + \alpha_2 \frac{\partial \Re}{\partial t}$$

• Carbon dioxide field

Diffusion process
Carbonation
Interaction with other fields

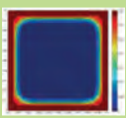
$$\frac{\partial c}{\partial t} = \nabla \cdot (D_c \nabla_c) - \alpha_3 \frac{\partial \Re}{\partial t}$$

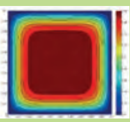
• Reaction field

Carbonation depth

$$\frac{\partial \Re}{\partial t} = v = \alpha_4 \cdot f_1(h) \cdot f_2(c) \cdot f_3(\Re) \cdot f_4(T)$$

• Example of results 2D - FDM code


Carbon dioxide


Humidity


Reaction

• Experimental Campaign

Humidity profile

Phenolphthalein

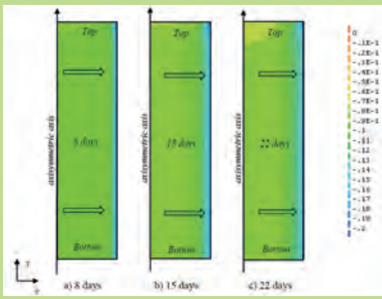
TGA discs

TGA + Phenolphthalein

Compressive strength

Elastic modulus

• Mechanical behavior - Axisymmetric condition
Matlab ® + Experiments + TNO Diana®



University of Minho
School of Engineering

CIÊNCIA SEM FRONTEIRAS

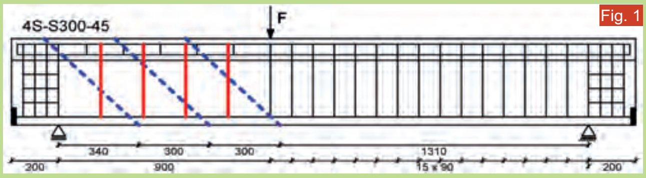
CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

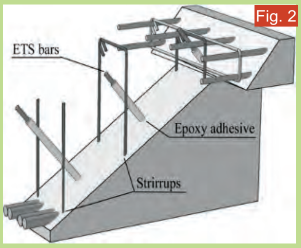
isise
Institute for Sustainability and Innovation in Structural Engineering
Matteo Breveglieri
Supervisors: Joaquim Barros (University of Minho)/ Alessandra Aprile (University of Ferrara)

SHEAR STRENGTHENING OF RC BEAMS USING THE EMBEDDED THROUGH-SECTION TECHNIQUE

❑ EXPERIMENTAL RESEARCH

The Embedded Through-Section (ETS) technique is a promising technique for the shear strengthening of existing RC elements. According to this technique, holes are drilled through the beam section, and bars of steel or FRP material are introduced into these holes and bonded to the concrete with adhesive materials. An experimental program was carried out with RC T-cross section beams strengthened in shear using the ETS steel bars and ETS CFRP rods (Figs. 1 and 2). The research was focused on the evaluation of the ETS efficiency on beams with different percentage of existing internal transverse reinforcement (ρ_{sw}=0.0, 0.1, 0.17%). The effectiveness of different ETS strengthening configurations was also investigated. The good bond between the strengthening ETS bars and the surrounding concrete allowed the yield initiation of the ETS steel bars and the attainment of high tensile strains in the CFPR rods, leading to significant increase of shear capacity (in the interval of 5% to 136%), whose level was strongly influenced by the inclination of the ETS bars and the percentage of internal transverse reinforcement. The strengthening configurations of the tested beams are listed in Table 1 and the load-deflection for 2S-Series is presented in Fig. 3.





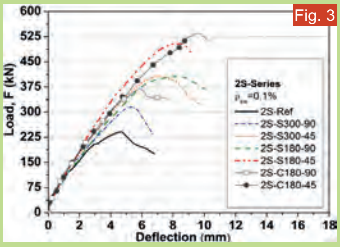
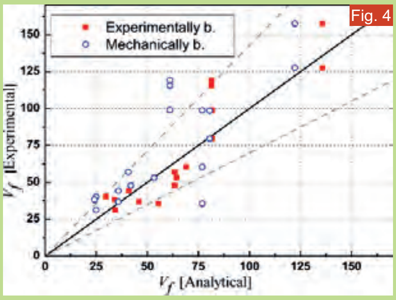


Table 1

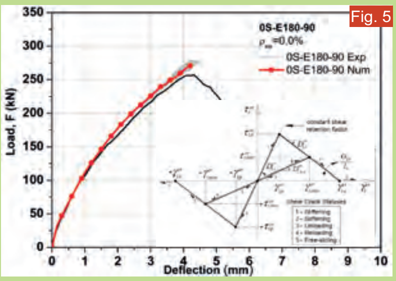
Angle [θ_{fw}]	ETS bar spacing [s_{fw}]	ETS Reinforcing ratio [ρ_{fw}]	0S-Series	2S-Series	4S-Series
[°][a]	(mm)	[%][b]	(ρ_{sw}=0.0%)	(ρ_{sw}=0.10%)	(ρ_{sw}=0.17%)
90	300	0.15	0S-S300-90	2S-S300-90	4S-S300-90
45	300	0.21	0S-S300-45	2S-S300-45	4S-S300-45
90	180	0.24	0S-S180-90	2S-S180-90	4S-S180-90
45	180	0.34	0S-S180-45	2S-S180-45	4S-S180-45
90	180	0.16	--	2S-C180-90	4S-C180-90
45	180	0.22	--	2S-C180-45	4S-C180-45

S - steel ETS bars, C – CFRP ETS bars



❑ ANALYTICAL RESEARCH

The predicted performance of two different analytical models developed to calculate the contribution of ETS to shear resistance was assessed by using the experimental results. The first model follows an empirical approach (experimental-based approach), while the second model takes into account the physical and mechanical principles of the technique (mechanical-based approach). Fig. 4 presents the comparison between the experimental and analytical values. The two approaches have predicted values with similar level of accuracy, and were able to evidence the different shear strengthening effectiveness between vertical and inclined ETS strengthening.



❑ NUMERICAL RESEARCH

An alternative strategy to the shear retention factor based on the adoption of a diagram describing the shear stress-shear strain Fig 5, for modelling the shear fracture energy diagram was investigated. The predictive performance was evaluated simulating the tested ETS strengthened beams. The parameters influencing the diagram are individually investigated and analyzed as a function of the mechanical and geometrical properties of the tested beams. A simple rule to estimate these values is provided and its predictive performance is assessed. Fig. 5 presents the comparison between the experimental and numerical load- displacement relationship for beam 0S-180-90.

U C
University of Minho
School of Engineering
Università degli Studi di Ferrara
Ex labore fructus

isise Institute for Sustainability and Innovation in Structural Engineering

Maxime Paul A. Verbist

Supervisor: Jorge Manuel G. Branco (UM)

Co-supervisor: Lina Maria R. Nunes (LNEC)

Mechanical Behaviour of Traditional Timber Carpentry Connections

Step Joints Design and Damage Assessment

❑ DESCRIPTION AND OBJECTIVES

In the field of Built Heritage Restoration, the present work program deals with the design and assessment of Step Joints inside traditional timber carpentries badly preserved. Two kinds of damage can be encountered: structural damage (Figures 1 and 2), and natural damage (Figures 3 and 4). The proposed work approach will encompass theoretical and experimental campaigns by achieving the objectives below:

- **Assessing the mechanical behaviour of sound Step Joints and decayed Single Step Joints by focusing on the shear crack appearance.**
- **Simulating the development of biological degradations inside Step Joints over time.**
- **Checking the reliability of Non-Destructive Tests (NDT) in determining the impact of decay on the mechanical behaviour of Step Joints.**

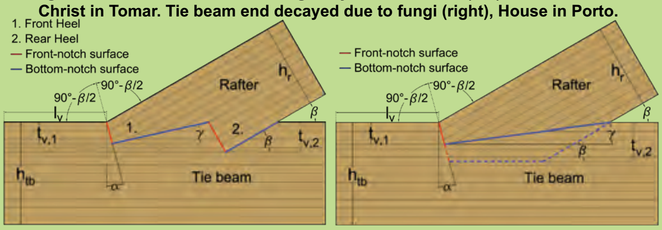
Figures 1 and 2: Failure modes in the Single Step Joint – Shear crack in the tie beam (left), crushing at the front-notch surface (right).

Figures 3 and 4: Floor beam damaged by insect attacks (left), Convent of the Christ in Tomar. Tie beam end decayed due to fungi (right), House in Porto.

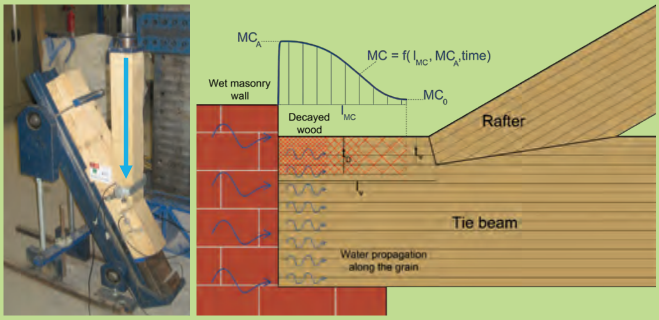
❑ THEORIES AND EXPERIMENTS

Theoretical design models must firstly be determined for each sound Step Joint according to their geometrical parameters (Figures 5 and 6) in order to condition the emergence of both failure modes (Figures 1 and 2) and to predict their mechanical behaviour. By modifying the geometrical parameters, lab tests will then be performed under monotonic compression tests (Figure 7) on the selected specimens of sound Step Joints to check the reliability of the defined design equations.

Within the proposed design models (Figure 8), the evolution of biological degradations (i.e. insect attacks, fungi) inside the Single Step Joint must be assessed over time by pointing out the influence of environmental factors (e.g. moisture content). To this end, experimental simulations on the development of natural damage will be carried out over time, by measuring their impact on the mechanical behaviour of the Single Step Joint with Non-Destructive Tests (NDT) and under monotonic compression (destructive) tests.



Figures 5 and 6: Geometrical configurations of the Double Step Joint (left) and of the Single Step Joint with Tenon-Mortise (right).



Figures 7 and 8: Setup for the monotonic compression test (left). Design model for the Single Step Joint damaged by biological degradations (right).

❑ ACKNOWLEDGEMENTS

This work was partly financed by FEDER funds through the Competitivity and Internationalization Operational Programme - COMPETE and by national funds through FCT – Foundation for Science and Technology within the scope of the project POCI-01-0145-FEDER-016843.

· U C ·

University of Minho
School of Engineering

LNEC
Laboratório Nacional de Engenharia Civil

FEDER

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

isise Institute for Sustainability and Innovation in Structural Engineering

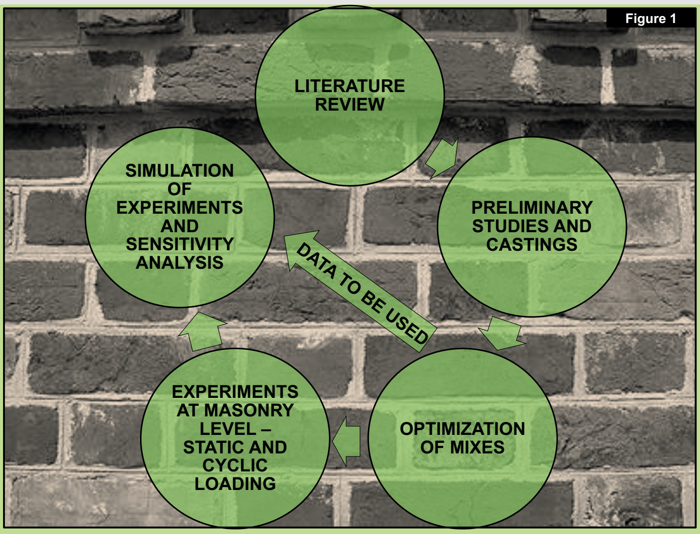
A MULTI-SCALE APROACH TO THE STUDY OF THE EFFECTS OF ADDING LIME TO CEMENT IN MASONRY MORTARS: FROM THE MICRO-SCALE TO THE STRUCTURAL LEVEL

Meera Ramesh

Supervisors: Miguel Azenha / Paulo B. Lourenco

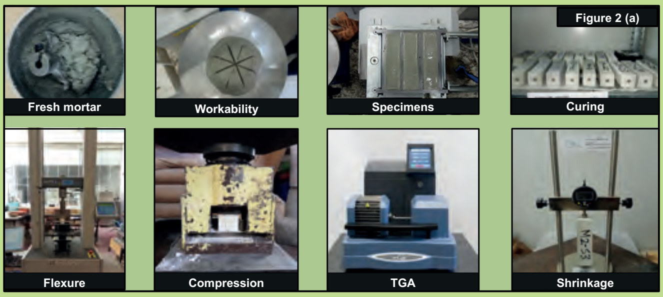
❑ FRAMEWORK OF PROJECT

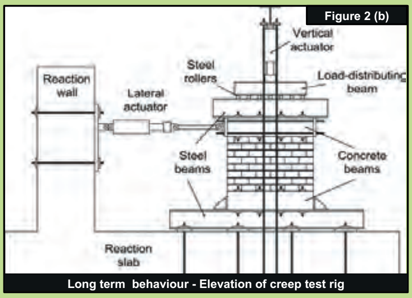
- The main objective of this work is to quantitatively establish the benefits that can be harvested from adding hydrated lime to cement-based mortars to be used in masonry.
- The research is intended to encompass a wide spectrum of analyses, from micro-scale characterization of the material, to evaluation of performance within masonry elements in real scale, with a focus on long term behaviour as well (Figure 1).
- Data from micro characterization and mortar level tests will be used in multi-physics models, to validate the outcomes of macro level experimental setup.
- The framework will be deployed for sensitivity analyses to assist the development of guidelines and recommendations for practitioners.



❑ EXPERIMENTS AT MORTAR AND MASONRY LEVEL

- Preliminary studies involving assessment of mechanical behaviour to be carried out with numerous mix proportions (Figure 2, a), based on which some mixes will be chosen for advanced studies of physical chemistry and interaction with masonry in long terms tests such as creep (Figure 2, b).

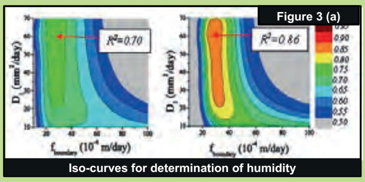




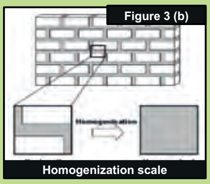
Long term behaviour - Elevation of creep test rig

❑ MULTI PHYSICS SIMULATION

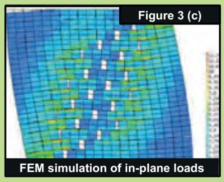
- COMSOL or ANSYS will be used to create a thermo-hygro-carbo coupled mechanical model which will simulate and predict experimental behaviour. This stage will also involve factorial plans and multiple regression plots (Figure 3).



Iso-curves for determination of humidity



Homogenization scale



FEM simulation of in-plane loads

University of Minho School of Engineering

EuLA European Lime Association

European Lime Association

Institute for Sustainability and Innovation in Structural Engineering

Miguel Pereira

Supervisor: Rui Simões

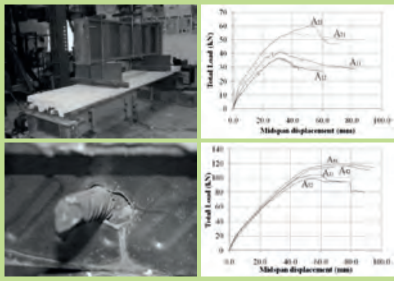
Development of a new reinforcing system and evaluation of the existing models for composite slabs

❑ ABSTRACT

Composite steel-concrete slabs with profiled steel sheeting are the most common solution applied on floor systems in steel framed buildings. Usually, the design of composite slabs with current spans is governed by the longitudinal shear resistance, so not taking advantage of the high bending capacity of these ones.

Based on previous studies performed in the University of Coimbra (Fonseca, Marques and Simões, 2015), it was verified that it is possible to increase the resistance of slabs reinforced with transversal bars, acting like an end anchorage device. Additionally, it was verified that the design model for shear resistance prescribed in Eurocode 4 – the *m-k* method, that can't take account the acquired resistance of end anchorage systems and does not consider adequately the steel sheeting contribution – tends to conduct to an overdesign of composite slabs, comparably to the partial shear connection method. In this research these concepts will be restudied and reinforced.

The main objectives of current thesis are (i) develop and prove the effectiveness of new reinforcement systems which increases the longitudinal shear resistance, (ii) calibrate design equations to predict the resistance of proposed reinforcement systems, (iii) improve the design analytical models available to predict the vertical shear resistance and (iv) develop the design analytical models available to predict the shear resistance.



Fonseca, A., Marques, B. e Simões, R. (2015). *Improvement of the behavior of composite slabs: A new type of end anchorage.* Steel and Composite Structures, *Vol. 19, No. 6 (2015) 1381-1402*

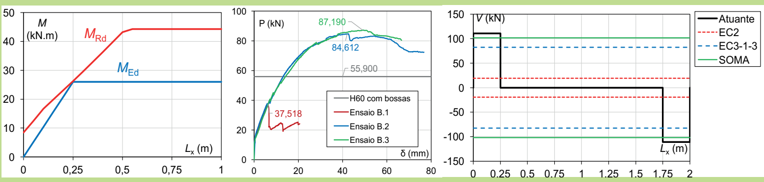
❑ EXPERIMENTAL APPROACH

EXPERIMENTAL APPROACH I

Several specimens of composite slabs with profiled steel sheet with usual height (60 mm) are being experimentally tested with and without the reinforcing devices to prove the efficacy of those proposed systems and to evaluate the vertical shear resistance in composite slabs compared to the design rules defined in Eurocode 4.

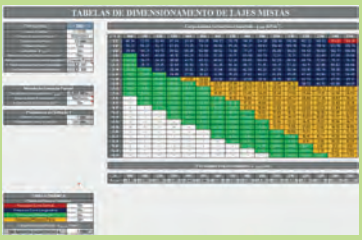
EXPERIMENTAL APPROACH II

Several specimens of composite slabs with profiled steel sheet with usual and high height (60 and 120 mm) are being experimentally tested to define analytical models to consider the reached capacity of the proposed reinforcing systems and define the real resistance of composite slabs to vertical shear.



❑ PRELIMINARY DESIGN TABLES

A dynamic table was developed to define the pre-design tables in order of the geometry and material's properties adopted. A preliminary design table defines the ultimate characteristic bearing capacity of the slab. This tables also includes the option to consider one of several reinforcing systems, like end anchorage devices and the one developed in this thesis.



❑ NUMERICAL SIMULATION

The specimens experimentally tested will be numerically calibrated using the software ABAQUS to perform the results achieved in laboratory. After that, several models will be developed to perform a parametric study to develop an analytical approach to simulate the resistance achieved with the new reinforcing system.

University of Minho
School of Engineering

PORTUGAL 2020
UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional

O FELIZ

Institute for Sustainability and Innovation in Structural Engineering

INCORPORATION OF HYBRID PHASE CHANGE MATERIALS IN PLASTERING MORTARS FOR INCREASED ENERGY EFFICIENCY IN BUILDINGS

Mohammad Kheradmand

Supervisors: Jose B. Aguiar/ Miguel Azenha

❑ EXPERIMENTAL RESEARCH

- This work program initially encompassed the evaluation of several mortars with and without microencapsulated PCM. Hardened mortar samples were assessed through SEM, and also through DSC. An example of SEM investigation of mortar with hybrid PCM and corresponding DSC testing of the specimen are given in Fig.1.
- This program also has the purpose of assessing the thermal behavior of small envelopes (testable at laboratory scale) with incorporation of hybrid PCM (HPCMM) throughout passive and active systems, and compare thermal behavior in regard to reference mortars without PCM (REFM). The test setup configuration is shown in Fig.2. The obtained experimental results are providing solid grounds for the numerical simulations.

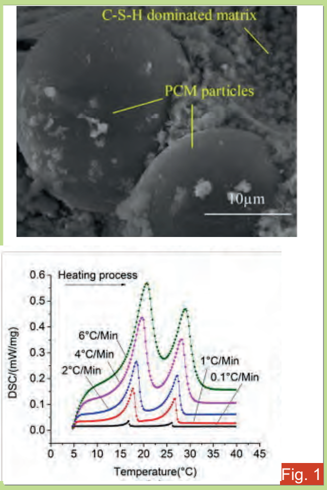


Fig. 1

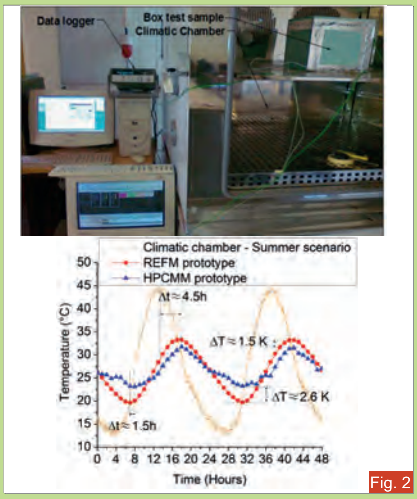


Fig. 2

❑ NUMERICAL SIMULATIONS

- The problem of predicting the behavior of phase change systems resides is the fact that a sudden change occurs in the simulation model upon a phase change: consumption or liberation of energy. The non-linear material behavior demands for specialized solution algorithms in the numerical simulation, which was tackled with existing strategies, such as the enthalpy method (within the framework of a finite volume simulation tool, incorporating computational fluid dynamics (CFD) simulation tools). (see generated mesh and an example of corresponding numerical results compared with experimental in Fig.3,4).

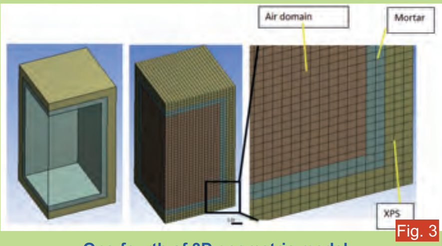


Fig. 3

One-fourth of 3D geometric model (small scale prototype); and model mesh

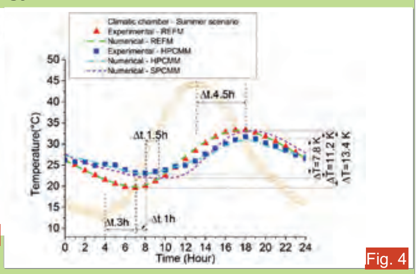
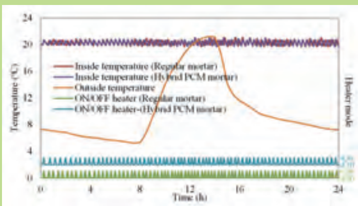


Fig. 4

❑ REAL SCALE SIMULATIONS

▪The performance of the proposed hybrid PCM system in real-scale building enclosures was numerically simulated in view of internal comfort level winter days under realistic environmental conditions. Hybrid PCMs are embedded in inner surface linings of four walls (see Fig.5 with detailed mesh and heating system).



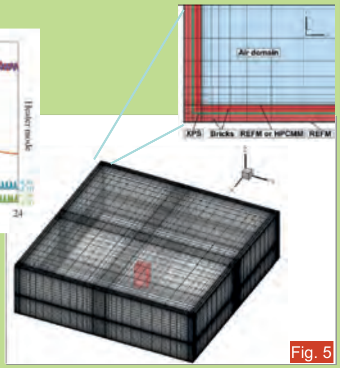


Fig. 5

❑ COST EFFECTIVNESS STUDIES

▪An economic study will be performed in order to determine the range of percentage volume of hybrid PCM needed for the thermal comfort, which is cost-competitive in regard to existing conventional solutions.

University of Minho
School of Engineering

CTAC
Centre for Territory, Environment and Construction

isise Institute for Sustainability and Innovation in Structural Engineering

Mohammadali Rezazadeh

Supervisor: Joaquim Barros

INNOVATIVE METHODOLOGIES FOR THE ENHANCEMENT OF THE FLEXURAL STRENGTHENING PERFORMANCE OF NSM CFRP TECHNIQUE FOR RC BEAMS

❑ EXPERIMENTAL RESEARCH

- **The main purpose of this research is to experimentally evaluate the efficiency of NSM CFRP strengthening techniques to enhance not only the load capacity at service and ultimate conditions, but also the ultimate deflection capacity when compared to the use of non-prestressed NSM CFRP technique.**
- **Hence, two experimental programs were organized to assess first, the influence of the prestress level on the flexural behavior of NSM CFRP strengthened beams and then, the potentialities of a new NSM hybrid methodology combining non-prestressed and prestressed CFRP laminates in the same application for the flexural strengthening of RC beams (Fig. 1).**
- **Moreover, the distribution of tensile strain and bond shear stress after the release of prestress force along the prestressed NSM CFRP reinforcement was experimentally evaluated.**

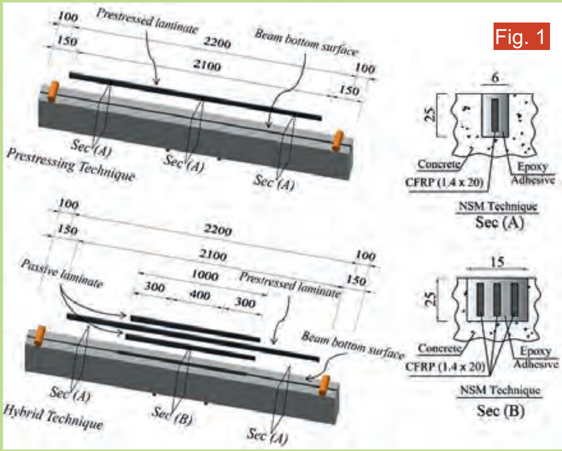


Fig. 1

❑ NUMERICAL ANALYSIS

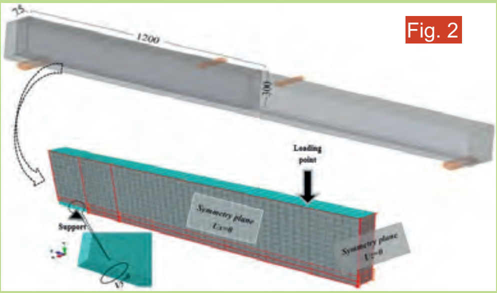


Fig. 2

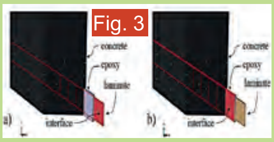


Fig. 3

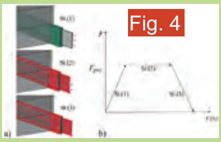


Fig. 4

- **The experimental tests were simulated using a nonlinear FE model (Fig. 2), which considers:**

  a) the nonlinear behavior of the constituent materials;

  b) the bond behavior between CFRP-epoxy adhesive and concrete-epoxy adhesive surfaces (Fig. 3);

  c) modeling the prestress process of the CFRP elements adopted in the experimental tests (Fig. 4).

❑ ANALYTICAL APPROACHES

- **A simplified analytical approach was proposed to predict the flexural behavior of simply supported RC beams flexurally strengthened with prestressed CFRP reinforcements using either EBR or NSM techniques.**
- **This design methodology also considers the ultimate flexural capacity of NSM CFRP strengthened beams when concrete cover delamination is the governing failure mode (Fig. 5).**
- **An analytical formulation, with a design framework, was developed for the prediction of the distribution of CFRP tensile strain and bond shear stress and, additionally, the prestress transfer length (Fig. 6).**

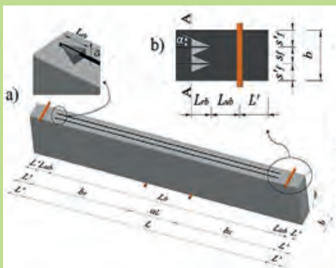


Fig. 5

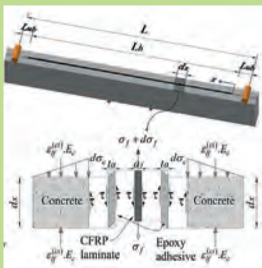


Fig. 6

University of Minho
School of Engineering

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

S&P Clever Reinforcement Company

Institute for Sustainability and Innovation in Structural Engineering

Hybrid High-Rise Wind Turbine Tower: Aeroelastic Load, Dynamic Response, and Fatigue Assessment

Mohammad Reza Shah Mohammadi

Supervisors: Carlos Rebelo / Milan Veljković/ Luís Simões da Silva

❑ Conceptual Design and Analysis

- This project, in the scientific domain of the Steel Composite Structures, consists of design and assessing a new hybrid high-rise wind turbine tower (Fig. 1).
- The work is divided into the design of the different hybrid tower components e.g. lattice structure and the transition piece.
- In order to remove the fatigue prone welds, free-maintenance bolted connections are considered in the lattice and transition piece.(Fig. 2)
- Moreover, a new erection process is proposed to reduce the installation cost of high-rise tower. (Fig. 3)

Fig. 1

Fig. 2

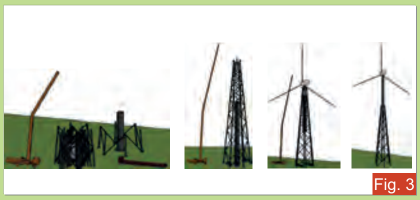


Fig. 3

❑ Design Assessment– Load Analysis and Fatigue Calculation

- The dynamic behavior and the loads on the supporting structure are investigated using servo-aero-elastic code (ASHES). The most critical load cases are identified and the forces and moments are calculated in several level of the supporting structure (Fig.4).
- The damage equivalent load is calculated for the transition piece level using “rain flow counting” method. 20 years life time design using simulation of all operations and special events of the wind turbine.

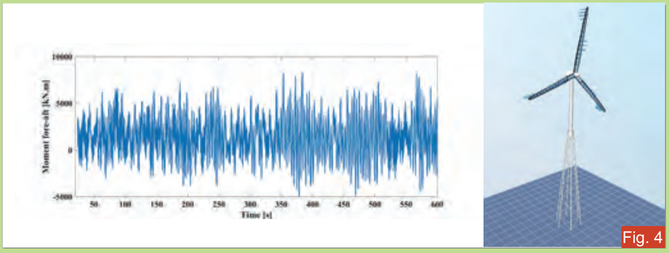


Fig. 4

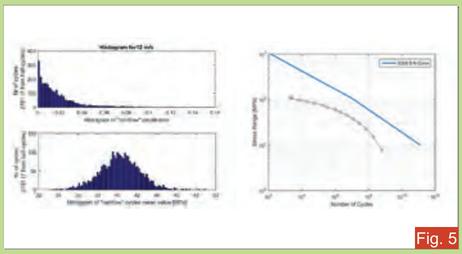


Fig. 5

❑ Experimental Tests

- The multi-axial fatigue test are done on specific S355 and S690 steel specimen to characterize the crack initiation and propagation.
- The main objective of the fatigue tests are to assess the material’s fatigue behaviour and capacity of the main components.
- The scaled lifting process is designed and tested to prove the feasibility of the erection process.

❑ Conclusion

- The limitation of tubular tower height leads to higher base diameter and transportation difficulties, also the limitation of hub height limits the power capacity of the wind turbine. Therefore, the hybrid high rise structure with adequate erection process was presented and validated by international standards.

University of Minho
School of Engineering

Research Fund for Coal & Steel

Aeolus future European Commission

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 643167

Institute for Sustainability and Innovation in Structural Engineering

Mohammadreza Mostakhdemin Hosseini

Supervisors: Salvador Dias / Joaquim Barros

Behavior of RC Slabs Flexurally Strengthened with Prestressed NSM CFRP Laminates

❑ EXPERIMENTAL RESEARCH

- **The thesis aims to study flexural strengthening of RC slabs using prestressed CFRP laminates applied according to the NSM technique. For this purpose, an extensive experimental research was executed and the influence of the level of prestress; percentage of existing steel reinforcement; concrete quality and level of damage in the RC slabs prior to the strengthening (pre-crack) on the behavior of strengthened RC slabs with prestressed NSM CFRP laminates was determined. Strengthening RC slabs with the presented method resulted in a significant increase of load carrying capacity at serviceability limit states but had a detrimental effect on the deflection at the maximum load of the slabs.**

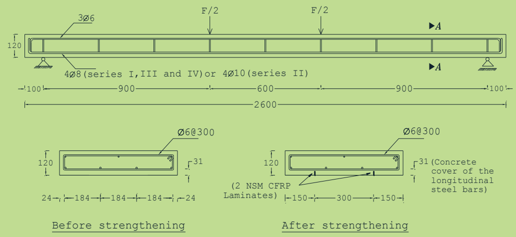


Fig. 1 General information about extensive experimental research.

Table 1 General information about extensive experimental research.

Series	Test configuration	Percentage of steel reinforcement (%)	Percentage of CFRP (%)	Compressive strength, f_{cm} (MPa)	Damage	Number of specimens
I	Fig. 2b	0.394 (4ϕ8)	0.085	40	No	6
II	Fig. 2b	0.623 (4ϕ10)	0.085	40	No	4
III	Fig. 2b	0.394 (4ϕ8)	0.085	15	No	4
IV	Fig. 2b	0.394 (4ϕ8)	0.085	40	Yes	6

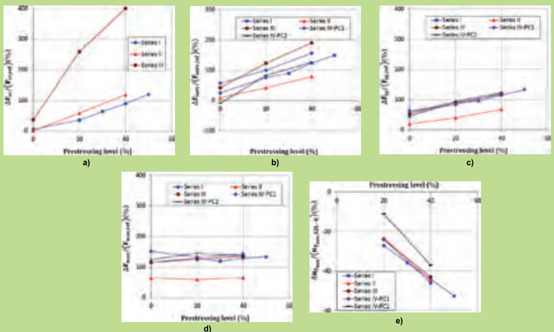


Fig. 3 Effect of the prestress level on: a) cracking load; b) service load; c) yielding load; d) ultimate load; and e) maximum deflection.

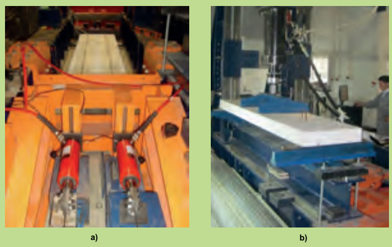


Fig. 2 a) Prestressed system and b) Test setup.

❑ NUMERICAL SIMULATION AND PARAMETRIC STUDY

- **The flexural behavior of the tested RC slabs strengthened with prestressed NSM CFRP laminates was simulated numerically.**

- **The numerical strategy, whose good predictive performance for the simulation of the structural behavior of the RC slabs flexurally strengthened using prestressed NSM CFRP laminates, was adopted to execute a parametric study.**

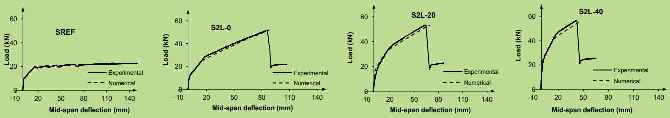


Fig. 4 Experimental vs. numerical load-deflection at mid-span for four tested RC slabs (Reference slab without CFRP (SREF); slabs with NSM CFRP laminates with different level of prestress: 0% (S2L-0), 20% (S2L-20) and 40% (S2L-40)).

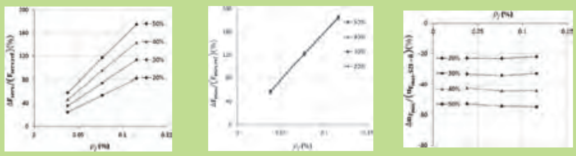


Fig. 5 Parametric study: effectiveness of NSM technique with prestressed CFRP laminates vs. percentage of the CFRP (Series I).

❑ ANALYTICAL APPROACH

- **The bending moment at some critical points (crack initiation, yield initiation and failure) were calculated with analytical approaches and were compared with the experimental results.**

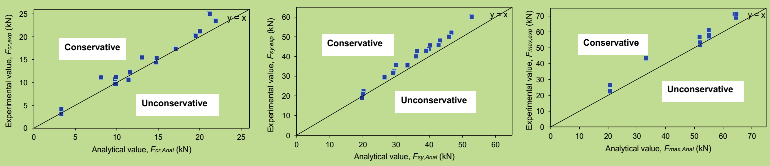


Fig. 6 Experimental vs. Analytical results of cracking, yielding and ultimate loads of the RC slabs.

University of Minho
School of Engineering

S&P Clever Reinforcement Ibérica

COMPETE

UNIÃO EUROPEIA

FCT Fundação para a Ciência e a Tecnologia

isise Institute for Sustainability and Innovation in Structural Engineering

Neda H. Sadeghi

Supervisors: Daniel V. Oliveira / Mariana Correia

CONSERVATION AND SAFETY ASSESSMENT OF ADOBE VAULTED ARCHITECTURE IN YAZD, IRAN

❑ INTRODUCTION

Past earthquakes have demonstrated that historical vaulted adobe buildings are vulnerable to seismic actions. Besides the human losses as the most important issue, in the case of adobe heritage, destruction of cultural heritage makes the earthquake more catastrophic. Hence, it is crucial for such building typology to be evaluated in terms of seismic capacity. To this end, this research deals with the preventive conservation and seismic safety assessment of historical vaulted adobe houses (Fig. 1) from the city of Yazd, Iran, as one of the seismically active areas of the world.

Fig. 1

❑ OBJECTIVE

The main research objective is: To increase the life of historical vaulted adobe houses in Yazd and evaluate their safety, to guarantee the human safety during an earthquake, considering the relevant principles and criteria for conservation of cultural heritage.

Fig. 2

Fig. 3

❑ MAIN PHASES

- **To define a comprehensive conservation procedure related to prevention of casualties and damage to historical adobe houses in Yazd, Iran**
- **To assess numerically the safety of vaulted adobe structures and also the structural performance of them against future earthquake. To this end, a geometrical survey on several vaulted adobe houses, a simplified geometric-based analysis and a numerical parametric study based on limit analysis theory implemented in Block2D software has been conducted to compute the seismic safety of vaulted adobe structures (Fig. 2, Fig. 3 and Fig. 4).**
- **To evaluate the experimental behavior of unreinforced and reinforced adobe vaults. To this end, six 1:3 scaled adobe vaults were analyzed experimentally. The tests were performed in loading-unloading steps of increasing amplitude of an imposed vertical displacement at 30% of span (Fig. 5 and Fig. 6). The tests were carried out in two unstrengthened and four strengthened adobe vaults. Vaults were strengthened with a low cost textile reinforced mortar (LC-TRM), where a low cost fiber-glass mesh is covered with an earth-based mortar.**
- **To improve the seismic behavior of vulnerable vaulted adobe architecture by proposing an appropriate intervention technique and establishing a relevant recommendation for preventive conservation process.**

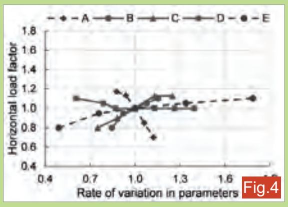


Fig.4

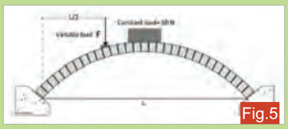


Fig.5

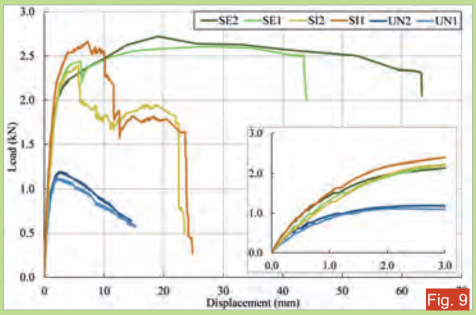


Fig. 9

Fig. 7

Fig. 8

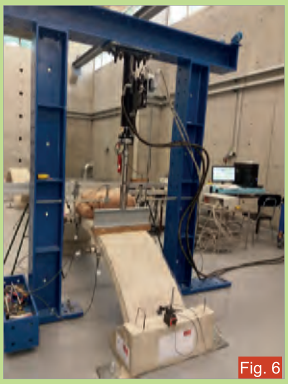


Fig. 6

U C

University of Minho
School of Engineering

Yazd University

Institute for Sustainability and Innovation in Structural Engineering

Nelson Soares

Supervisors: José Costa (DEM-UC)/ Adélio Gaspar and Paulo Santos (DEC-UC)

THERMAL ENERGY STORAGE WITH PHASE CHANGE MATERIALS (PCMs) TOWARDS BUILDINGS' ENERGY EFFICIENCY

❑ MAIN GOALS

- **To evaluate how PCMs can be used to improve the energy efficiency of different typologies of residential buildings (lightweight steel-framed and heavyweight constructions) in different climates;**
- **To develop a methodology for the dynamic simulation of energy in buildings considering the influence of latent heat loads from the phase change processes;**
- **To develop a methodology for the assessment of the heat transfer through small thermal energy storage (TES) units to be used in the design of new construction solutions.**

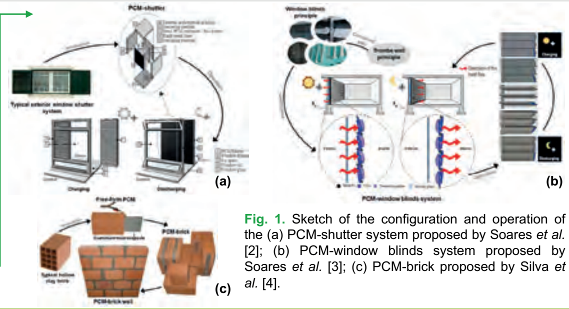


Fig. 1. Sketch of the configuration and operation of the (a) PCM-shutter system proposed by Soares *et al.* [2]; (b) PCM-window blinds system proposed by Soares *et al.* [3]; (c) PCM-brick proposed by Silva *et al.* [4].

❑ PART A – HEAT TRANSFER WITH PHASE CHANGE

❑ Experimental study of the heat transfer through a vertical stack of rectangular cavities filled with different PCMs (the free-form PCM – Rubitherm® RT 28 HC and the microencapsulated PCM – Micronal® DS 5001 X) [5].

Goals:

- To evaluate the melting and solidification processes;
- To discuss which PCM type is better for different buildings applications.

Methodology:

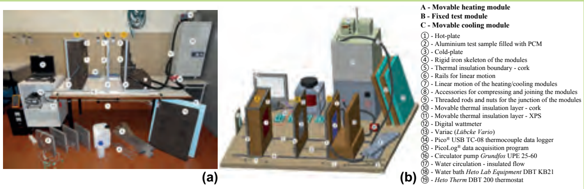


Fig. 2. (a) Photographic view and (b) 3D sketch of the experimental setup described by Soares *et al.* [5].

Results:

- Data for benchmarking and validation of numerical models;
- Assessment of the influence of natural convection and subcooling phenomena during charging and discharging.

❑ Heat transfer through small TES units filled with PCMs for vertical buildings applications: experimental and parametric analysis [6].

Goals:

- To evaluate the thermal performance of several TES units by considering 3 test samples filled with different cavity aspect ratios (*A*); 2 types of PCMs (free-form and microencapsulated PCMs); 2 input power levels during charging; and 4 temperatures of the cooling water flow during discharging.

Methodology:

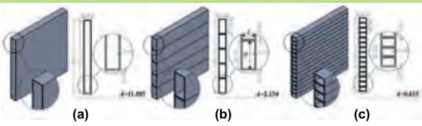


Fig. 3. Sketch of the 3 aluminum test samples used as PCM containers [6]: (a) 1 single rectangular cavity; (b) 5 cavities; (c) 15 cavities.

Results:

- The results allow discussing which arrangement is better for specific buildings applications considering the thermal regulation effect of the TES unit during charging; the influence of subcooling during discharging, and the influence of natural convection during both processes.

Nelson Soares acknowledges the support provided by FCT - PhD scholarship SFRH/BD/51640/2011.

University of Minho School of Engineering

Energy for Sustainability • EfS | UC

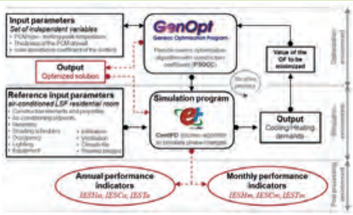
❑ PART B – DYNAMIC SIMULATION OF ENERGY IN BUILDINGS

❑ Multi-dimensional optimization of the incorporation of PCM-drywalls in lightweight steel-framed (LSF) residential buildings in different European climates [7].

Goals:

- To optimize the impact of PCM-drywalls in the annual heating and cooling energy-saving of an air-conditioned LSF residential single-zone building, considering real-life conditions and 7 European climates (Köppen-Geiger climate classification).

Methodology:



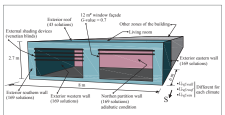


Fig. 4. Sketch of the room model described by Soares *et al.* [7].

Fig. 5. Sketch of the methodology carried out and described by Soares *et al.* [7].

Results:

- An optimum PCM-drywall solution was found for each climate leading to significant annual energy savings.

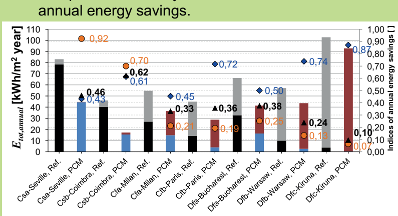


Fig. 6. Heating and cooling energy demand for both the reference and the PCM-enhanced rooms for each climate. Indices of annual energy savings for each climate considering the optimized solution.

❑ PCM-drywalls for reducing cooling demand and cooling peak loads in residential heavyweight buildings in Kuwait in the framework of the ongoing MIT-Kuwait Signature Project called "Sustainability of Kuwait's Built Environment" [8].

Goals:

- To discuss the existence of a fully-customized PCM-drywall solution regarding its thickness and the melting-peak temperature of the PCM; to evaluate the impact of PCM-drywalls in the reduction of both the cooling demand and the cooling peak loads; to provide some guidelines for incorporating PCM-drywalls in Kuwait, and to evaluate if they can contribute for improving the resilience of the electricity-grid during the summer peak-hours.

References

[1] Soares N, Costa JJ, Gaspar AR, Santos P. Review of passive PCM latent heat thermal energy storage systems towards buildings' energy efficiency. Energy and Buildings 2013;59:82–103.

[2] Soares N, Costa JJ, Samagaio A, Vicente R. Numerical evaluation of a phase change material-shutter using solar energy for winter nighttime indoor heating. Journal of Building Physics 2014;37(4):367–394.

[3] Soares N, Costa JJ, Vicente R. PCM_WindoWall – storage of solar thermal energy for buildings heating. in: 1st edition of the 'Prémio Ramos Catarino Inovação' Innovation Award, Coimbra, Portugal, February 4, 2012.

[4] Silva T, Vicente R, Soares N, Ferreira V. Experimental testing and numerical modelling of masonry wall solution with PCM incorporation: A passive construction solution. Energy and Buildings 2012;49:235–245.

[5] Soares N, Gaspar AR, Santos P, Costa JJ. Experimental study of the heat transfer through a vertical stack of rectangular cavities filled with phase change materials. Applied Energy 2015;142:192–205.

[6] Soares N, Costa JJ, Gaspar AR, Santos P. Heat transfer through small thermal energy storage units filled with phase change materials for vertical buildings applications: experimental study and parametric analysis. (submitted)

[7] Soares N, Costa JJ, Gaspar AR, Santos P. Multi-dimensional optimization of the incorporation of PCM-drywalls in lightweight steel-framed residential buildings in different climates. Energy and Buildings 2014;70:411–421.

[8] Soares N, Reinhart CF. PCM-drywalls for reducing cooling demand and cooling peak loads in residential buildings in Kuwait. (in preparation).

Institute for Sustainability and Innovation in Structural Engineering

STRUCTURAL AND THERMAL PERFORMANCE OF LSF MODULAR CONSTRUCTION

Nuno Cláudio Ferreira Rosa

Supervisors: Paulo Santos/ Helena Gervásio/ José Costa

❑ STRUCTURAL PERFORMANCE OF LSF PANELS SUBJECTED TO LATERAL LOADING

- **In Light Steel Framing (LSF) construction screws are often used to perform the connections between structural and non-structural elements due to its efficiency. This connections have an important role in the performance of such structural systems. In this work the behaviour of LSF panels using screw connections subject to lateral load is investigated by experimental tests and numerical analysis.**
- **This work comprises three tasks: (Task 1) the behaviour of steel-to-steel screw connections between cold-formed elements; (Task 2) the behaviour of Oriented Strand-Board (OSB) to steel screw connections; and (Task 3) the behaviour of braced and unbraced LSF panels to lateral loading.**

Fig. 1 - Experimental layout.

Fig. 2 – Test Specimen.

❑ MODELLING AND PERFORMANCE ANALYSIS OF AN EARTH-TO-AIR HEAT EXCHANGER

- **Earth-to-air heat exchangers (EAHE) are a suitable and efficient alternative to conventional space heating and cooling systems. The performance of an EAHE installed in a LSF residential building located in Coimbra, Portugal, will be analyzed. An analytical and numerical model will be developed and validated to predict the thermal performance of the EAHE system.**

Fig. 3 - EAHE System.

❑ MODELLING AND PERFORMANCE ANALYSIS OF A WATER TROMBE WALL SYSTEM

- **Passive solar technologies are known as a way to use solar energy as heating source for buildings space heating. The Trombe wall system can convert the solar radiation into thermal energy that can be conserved and used when the occupants of the building desire.**
- **The main objective of this study is the development of a Water Trombe Wall solution that could be implemented in LSF constructions, using experimental, analytical and numerical approaches. This wall absorbs diffused and direct radiation during the day and transfer the heat to the building interior by controlled convection during the night. This Trombe Wall could be work as a hybrid system to produce or pre-heat domestic hot water. Another objective is the mitigation of heat losses mainly at night and increase buildings thermal inertia.**

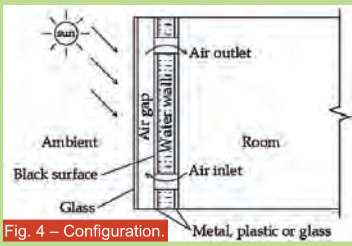


Fig. 4 – Configuration.

Fig. 5 – Water Trombe Wall in a LSF house.

Fig. 6 – Experimental layout.

Fig. 7 – Prototype design.

· U C ·

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Onur ONAT

Supervisors: Paulo Lourenço / Ali Koçak (TR)

INVESTIGATION of SEISMIC BEHAVIOR of INFILL WALLSURROUNDED by REINFORCED CONCRETE FRAME

❑ EXPERIMENTAL RESEARCH

- The purpose of this work was to assess out-of-plane behaviour of infill wall subjected to bidirectional earthquake load. Two specimens were tested using an innovative test set-up. One of them is Unreinforced Masonry Infill wall as seen in Figure 1, other of them is infill wall with Bed Joint Reinforcement as seen in Figure 2.
- Earthquake load is applied in six steps according to reference earthquake load. Reference earthquake load is selected according to return period. Return period of reference earthquake load is 475 years. Possibility in 50 years is 10 %.

Fig. 1

Fig. 2

❑ TEST SETUP & SHAKE TABLE TEST

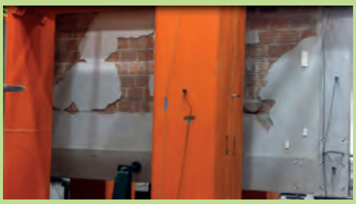
- For this purpose, special test setup was produced to supply adequate boundary condition. The steel work and struts can be seen in Figure 3. Subsequently, an extensive numerical modelling campaign was carried out.

Fig. 3

STRUT MECHANISM

❑ TEST RESULT of URM

- First specimen was imposed to earthquake load. After first test, applied drift in longitudinal direction at last stage is 1.5 %. In addition, applied drift level in transversal direction is 0.6 %



- Motivation of this study was Angel (1994) and Komaraneni (2009)

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Patrícia Moreira da Silva

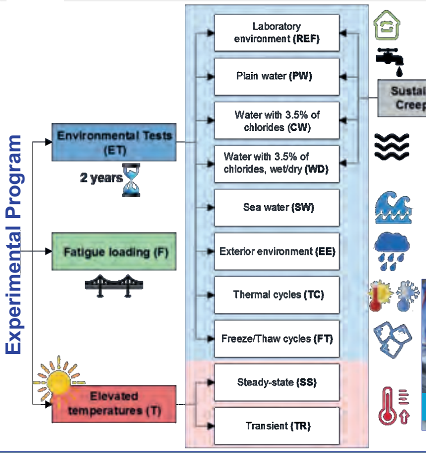
Supervisors: José Sena-Cruz / Miguel Azenha

TIME-DEPENDENT BEHAVIOUR AND DURABILITY OF RC SLABS STRENGTHENED WITH NSM CFRP STRIPS

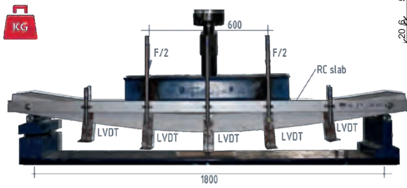
_OBJECTIVES AND MOTIVATION

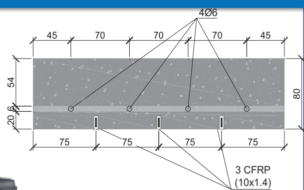
The present research intends to contribute for the knowledge on the long-term deformational performance and durability of concrete structures strengthened with **carbon fiber reinforced polymer (CFRP)** according to the near-surface mounted (NSM) technique. For that purpose a wide experimental program will be executed using slab specimens submitted to **accelerated ageing tests.** The slabs were expose under various conditions of environment, load and chemical degradation. The results obtained from the experimental programs will be used for **predicting the service life** of structures strengthened with the NSM technique supported in **numerical models**.

_EXPERIMENTAL PROGRAM



Set up of monotonic test

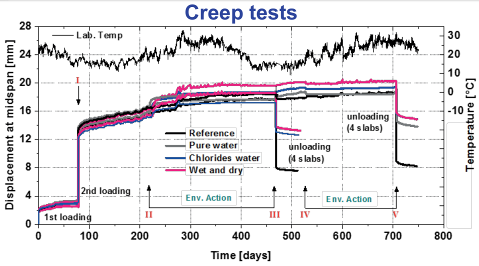




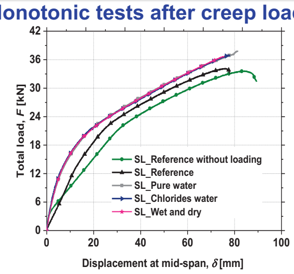
Cross-section geometry

_RESULTS

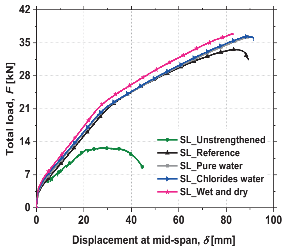
Creep tests



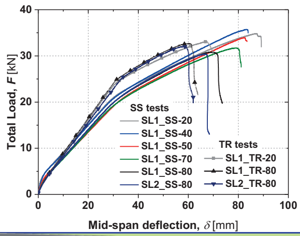
Monotonic tests after creep loading

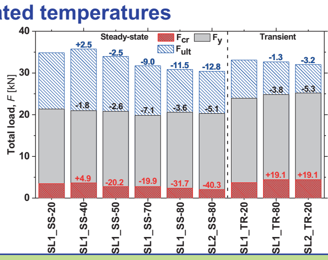


Monotonic tests



Monotonic tests at elevated temperatures





Failure mode at 80°C

U C · University of Minho School of Engineering · FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR · COMPETE · QREN QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL

Institute for Sustainability and Innovation in Structural Engineering

SEISMIC SRENGTHENING OF RESIDENTIAL BUILDINGS. RISK ANALYSIS AND MITIGATION

Paula Raquel Lamego

Supervisors: Paulo B. Lourenço / M. Luísa Sousa

❑ OBJECTIVES

- **Analysis of the efficiency of strengthening techniques in existing buildings**
- **Cost analysis of the interventions**
- **Cost / Benefit viability**

❑ TYPOLOGIES UNDER STUDY

- **Stone masonry buildings with wooden floors – Figure 1**
- **Stone masonry buildings with concrete slabs (“placa” building) – Figures 2 and 3**
- **Traditional concrete buildings, constructed before 1983 (new seismic legislation) – Figure 4**


Fig. 1


Fig. 2


Fig. 3


Fig. 4

❑ SEISMIC VULNERABILITY AND COST/BENEFIT ANALYSIS OF STRENGTHENING SOLUTIONS

- **The analysis of the seismic vulnerability of existing buildings is carried out in detail based in the pushover analysis methodology with posterior construction of capacity curves and vulnerability curves. As an example, it is shown in Figure 5 an image of the model of the building presented on Figure 1**
- **The effectiveness of each strengthening solution can be verified comparing the cases with and without reinforcement**

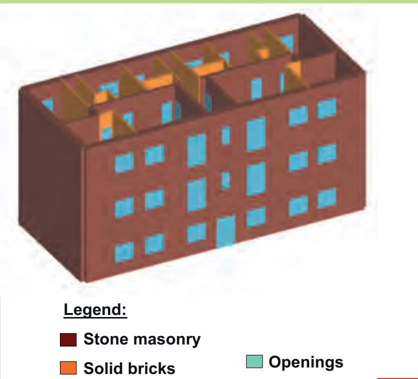


Fig. 5

Strengthening solution	Cost of reinforcement	Performance increase over the unreinforced building	Cost/ Benefit ratio
Strengthening of the exterior walls in stone masonry with reinforced plaster with transverse connectors	33.195,00€	+99%	**1,31**
Introduction of a “crown” rc beam in the connection between surrounding walls and roof structure	3.989,00€	+33%	**0,20**
Introduction of a bracing interior wall	3.277,00€	+33%	**0,15**

❑ CONCLUSIONS

- **It was shown that the approach adopted in this work can be applied for cost/benefit analysis of strengthening solutions**
- **The feasibility of the solutions in terms of building performance and cost can be quantified namely to support the involved technicians at the decision-making process. It is also useful to justify the choice of a particular solution**

· U C ·

University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

Pedro Miguel Gomes Fernandes

Supervisors: José Sena-Cruz / José Xavier

BOND BEHAVIOUR OF NSM CFRP-CONCRETE SYSTEMS: DURABILITY AND QUALITY CONTROL

❑ OBJECTIVES AND MOTIVATION

- The present thesis intended to contribute for the knowledge on the durability and long-term performance of bond of concrete structures strengthened with NSM CFRP systems, under different environmental and load conditions. Additionally, this work present the potential of an existing nondestructive methodology capable of giving in real-time continuous information about the curing process of epoxy resins since casting, which can be used for quality control and assistance to decision-making for in-situ FRP applications.

❑ EXPERIMENTAL PROGRAM

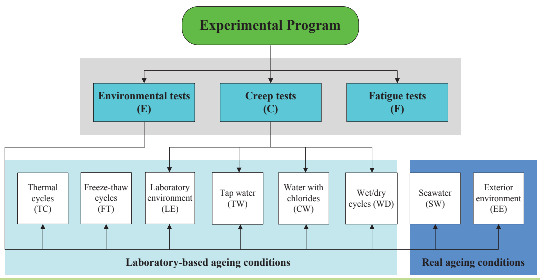


Fig.1 - Scheme of durability tests

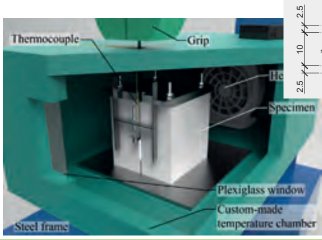


Fig.2 - Direct pullout test (DPT)

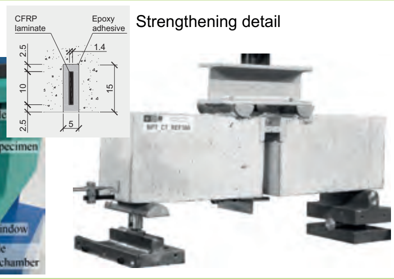
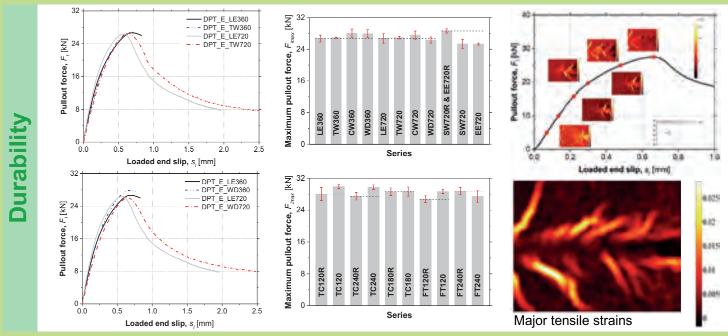
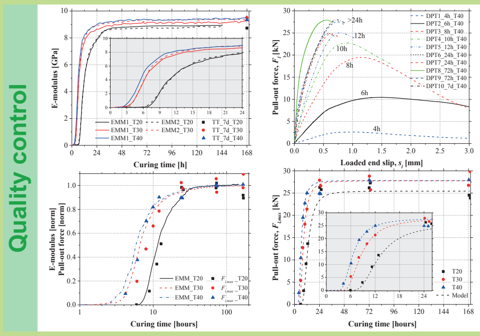


Fig.3 - Beam pullout test (BPT)

❑ RESULTS





❑ CONCLUSIONS

- In general, results of durability tests presented in this work showed that the effects of environmental and load conditions imposed, which can be considered quite severe, did not lead to a significant damage on NSM-CFRP strengthening system. The maximum decrease of about 12% on bond strength occurred for the specimens subjected to the real outdoor environments (real ageing conditions). A relationship between the evolution of epoxy E-modulus and the maximum pullout force was assessed, highlighting the potential of applying EMM-ARM for quality control and decision-making assistance of NSM systems.

University of Minho
School of Engineering

PhD grant No. SFRH/BD/80338/2011

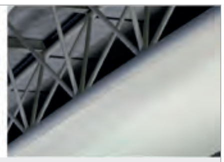
pfernandes@civil.uminho.pt

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

COMPETE

QREN QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL





Institute for Sustainability and Innovation in Structural Engineering

Pedro Gil Girão dos Santos

Supervisors: Luís Godinho/João Correia/Alfredo Dias

Hybrid performance-based wood panels for a smart construction

❑ DEFINITION OF MATERIALS AND ADHESION SYSTEMS BETWEEN MATERIALS

- The main objective of this Project is to develop a new kind of structural wood panel based on the CLT and SIP concepts.
- The basic design of the panels to be developed consist in a set of five elementary layers (a central one in insulating material and four in wood (two on each side of the insulation material and arranged orthogonally to each other)) (Fig. 1).

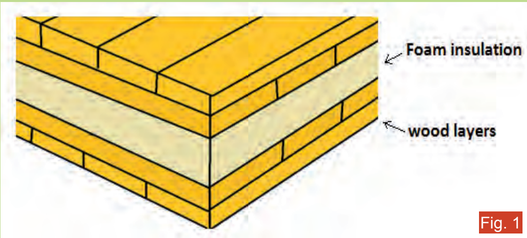


Fig. 1

❑ GLUING PROGRAM

- Different Wood Species
  - Maritime Pine (*Pinus pinaster*);
  - Acacia (*Acacia melanoxylo*).
- Different Glue Types
  - PUR - Polyurethane
  - EPI - Emulsion Polymer isocyanate
- Combining Different Wood Species with Different Glue Types in Different Conditions (Fig. 2)


Fig. 2

❑ EXPERIMENTAL PROGRAM

- Interface Wood/Wood (Fig. 3)
  - Delamination Tests (Annex C - EN 16351)
  - Shear Tests (Annex D - EN 16351)
- Interface Wood/Insulation (Fig. 4)
  - Shear Strength (ASTM C273 And/Or ASTM C393)
  - Flatwise Tensile Strength (ASTM C297) (Fig. 5)
- Optimization Of the Panels
- Life Cycle Assessment From Cradle-to-gate (A1-A3) And From Cradle-to-grave (A1-C4) (EN 15804) (Fig. 6)


Fig. 3


Fig. 4


Fig. 5

Production stage			Construction process stage		Usage stage							End-of-life stage				Benefits and loads beyond the system boundary
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport	Construction installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction/demolition	Transport	Waste processing	Disposal	Reuse, recovery or recycling potential

Fig. 6

University of Minho
School of Engineering

centro de inovação e competências da floresta

PEDROSA & IRMÃOS, LDA.

Institute for Sustainability and Innovation in Structural Engineering

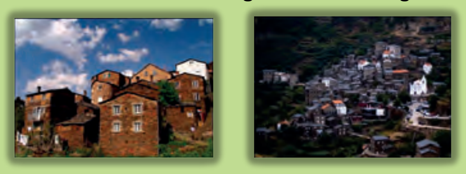
Ricardo S. Barros

Supervisors: Daniel V. Oliveira / Humberto Varum

MATERIAL AND STRUCTURAL BEHAVIOR ASSESSMENT OF SCHIST MASONRY CONSTRUCTIONS

❑ EXPERIMENTAL RESEARCH

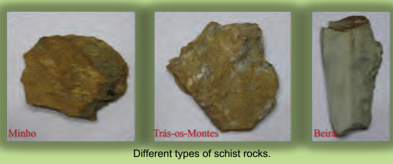
- The masonry schist constructions represent a very important cultural, architectural and historical heritage in Portugal and Europe.
- It is essential to understand the material and structural behavior of this kind of constructions to safeguard the heritage.



Schist masonry constructions.

❑ Geology of the Schist

- Mainland Portugal is part of the largest morphostructural unit of the Iberian Peninsula.
- Schist is a metamorphic rock that has a regular parallel or prismatic schistose structure. The mineral layers of the schistose structure are visible to the naked eye.

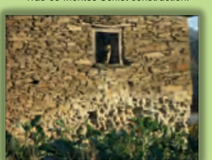


Different types of schist rocks.

❑ Constructive and damage survey

Sheet for survey for schist constructions.

Trás-os-Montes Schist construction.

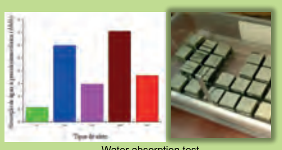


Erosion damage.

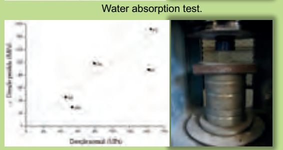
❑ SCHIST CHARACTERIZATION

Laboratory tests performed for the material characterization

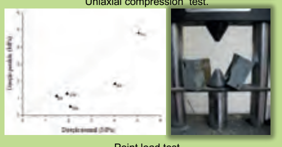
- Optical Microscopy
- Scanning Electron Microscopy
- Resistance to water absorption at atmospheric pressure (EN 13755: 2005)
- Resistance water absorption by capillarity (EN 1925: 2006)
- Ultrasonic test (ASTM E797-05)
- Resistance to the uniaxial compressive strength (EN 1926: 2006)
- Schmidt hammer test (EN 12504-4: 2003)
- Peak load resistance (IRSM 1985)
- Resistance to salt crystallization (EN 12370: 2001)



Water absorption test.



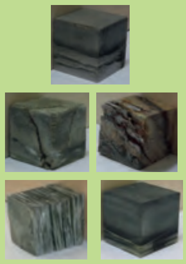
Uniaxial compression test.



Point load test.

Characterization of different schist's from Portugal.

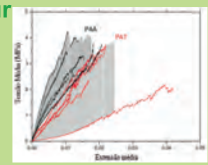
Region	Direction	Compressive strength	porosity	Resistance to salt crystallization
Vila Nova de Foz Côa	⊥	High	Very low	Resistant
	//	High		
Serra de Arga	⊥	Moderate	Low	Not resistant
	//	Moderate		
Carrazedo de Montenegro	⊥	High	Low	Not resistant
	//	High		
Sobral de São Miguel	⊥	Moderate	Low	Not resistant
	//	Moderate		
Barqueiros	⊥	High	Low	Not resistant
	//	High		



Salt crystallization test.

❑ Characterization of the structural behaviour

- Mortar characterization
- Analysis of the resistance to uniaxial compression
- Analysis of the resistance to diagonal compression
- Analysis of strengthening methodologies



Prisms stress-strain graph.

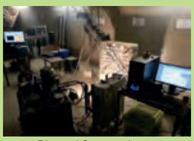
Prisms with different mortars.

Diagonal Compression tests results.

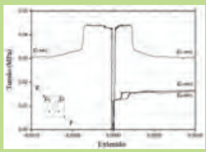
Walls	Shear strength (MPa)	Shear Modulus (MPa)
NR	0,03	32,50
DR	0,06	35,52
DRB	0,07	273,15

Uniaxial Compression tests results.

Prisms	Stress (MPa)	E (MPa)
PAT	3,76	101,07
PAA	3,88	119,97



Diagonal Compression test.



Walls stress-strain graph.

Reinforced wall.

University of Minho
School of Engineering

Fundação para a Ciência e a Tecnologia

isise

Institute for Sustainability and Innovation in Structural Engineering

3D acoustic diffusers with organic shape: numerical study and optimization

Ricardo J. Patraquim G. P.
Supervisors: Luís Godinho / Paulo Amado Mendes

MOTIVATION

- **Sound diffusers are a common technical solution used in the last four decades for conditioning performance rooms with greater acoustic requirements, such as theatres, concert halls or auditoria.**
- **A significant number of the acoustic diffusers commercially available are based on the phase grating diffusers or Schroeder-type diffusers, such as QRD (Fig. 1).**
- **However, in some particular cases, the visual appearance of the acoustic conditioning of the room with QRD's is considered by architects to be unaesthetic or visually unattractive in modern spaces…**
- **… and thus other geometrical forms of the diffusive surfaces or elements need to be customized, optimized and explored (Fig. 2).**

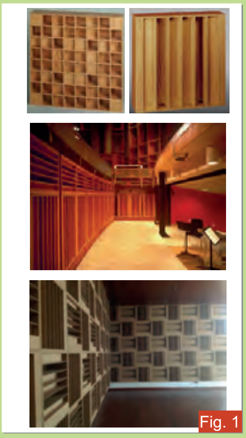


Fig. 1

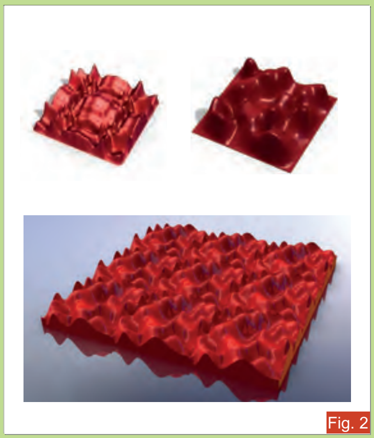


Fig. 2

STRATEGY

- **Algorithm for generating curved surfaces: RBF (Fig. 3)**
- **Numerical model for predicting the sound scattering from a surface: Kirchoff's approximation and BEM (Fig. 4)**
- **Metric to evaluate the merit of a shape: Diffusion Coef. (Fig. 5)**
- **Shape optimization: Genetic algorithm (Fig. 6)**
- **Experimental Validation: ISO 17497-2 (Fig. 7)**

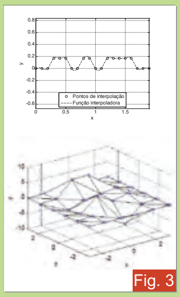


Fig. 3

$$c\,p(\underline{x}_0,\omega)+\int_{\Gamma}H(\underline{x},\vec{n},\underline{x}_0,\omega)\,p(\underline{x},\omega)\,d\Gamma+i\rho\omega\int_{\Gamma}G(\underline{x},\underline{x}_0,\omega)\frac{p(\underline{x},\omega)}{Z(\underline{x})}d\Gamma=p^{inc}(\underline{x},\underline{x}_F,\omega)$$

Γ – surface of the diffuser discretized

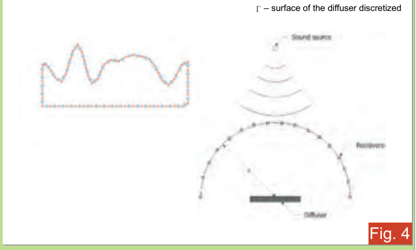


Fig. 4

$$d_\theta=\frac{\left(\sum_{i=1}^{n}10^{L_i/10}\right)^2-\sum_{i=1}^{n}\left(10^{L_i/10}\right)^2}{(n-1)\sum_{i=1}^{n}\left(10^{L_i/10}\right)^2}$$

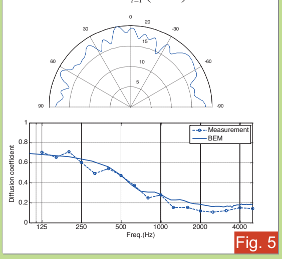


Fig. 5

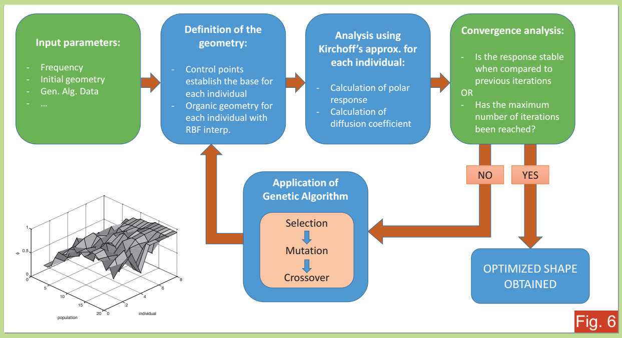


Fig. 6

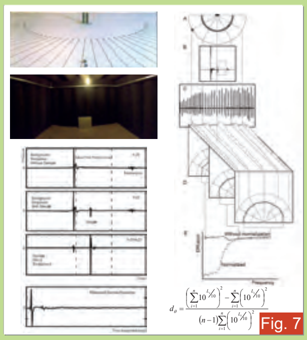


Fig. 7

PARAMETERS

U C
University of Minho
School of Engineering
FCT Fundação para a Ciência e a Tecnologia
CASTELHANO & FERREIRA
Soluções Globais para Espaços de Trabalho

Institute for Sustainability and Innovation in Structural Engineering

Rodrigo de Melo Lameiras

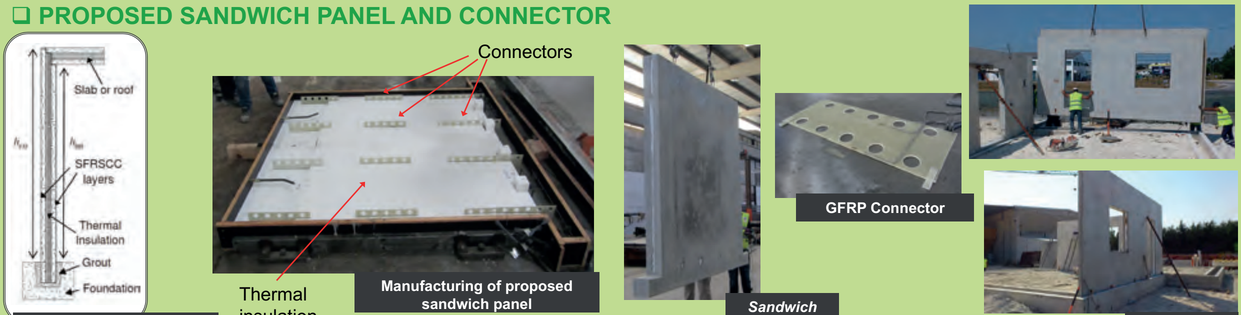
Supervisors: Joaquim Barros / Miguel Azenha

SANDWICH STRUCTURAL PANELS COMPRISING THIN-WALLED SFRSCC AND GFRP CONNECTORS: FROM MATERIAL FEATURES TO STRUCTURAL BEHAVIOUR

❑ ABSTRACT

An innovative sandwich structural panel composed of two outer Steel Fibre Reinforced Self-Compacting Concrete (SFRSCC) thin layers and a lightweight thermal insulating core material was developed for the walls of a pre-fabricated housing system. An in-depth investigation in the material scale was carried out in order to assess the post-cracking behaviour of SFRSCC. Eleven types of Glass Fibre Reinforced Polymer (GFRP) laminates consisted of polyester resin and differing on the kind of fibre reinforcement and on fibre content were produced and evaluated as material candidates for the production of connectors. Some GFRPs were characterized under pin-bearing tests. An innovative connector system that consists on a GFRP perforated plate that is embedded into SFRSCC layers was proposed. Experimental research devoted to the assessment of the pull-out and push-out shear behaviour of GFRP-SFRSCC connections were performed with specimens representative of the developed sandwich panel. Analytical frameworks to evaluate the load capacities of the connections when loaded transversally and longitudinally were developed based on experimental results. The feasibility of using the proposed connector was also determined trough an experimental work conducted with composite beam specimens using connectors made by two different types of GFRP laminates. In addition, the performed bending tests were simulated by using a computer program based on the FEM for assessing the stress field installed in the components that form the composite beam for having a better knowledge on the stress redistribution between GFRP connector and surrounding SFRSCC that occurs during the loading process. Finally, an experimental program was conducted on the shear behaviour of the wall panels subjected to in-plane loads, i.e., representative of the loading condition that the wall panels are subjected when seismic loads acts in the building. Full-scale panels (2.0 m by 2.0 m), with and without openings, were subjected to a constant vertical load representative of the slab reaction, while horizontal reversed cyclic loading was imposed to the panels. The seismic behaviour of panels were evaluated in terms of strength, stiffness, ductility and energy dissipation.

❑ PROPOSED SANDWICH PANEL AND CONNECTOR



System cross section

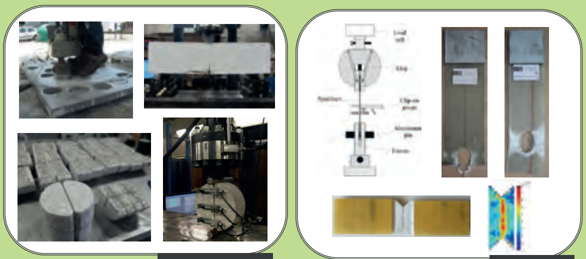
Manufacturing of proposed sandwich panel

GFRP Connector

Sandwich panel

Prototype

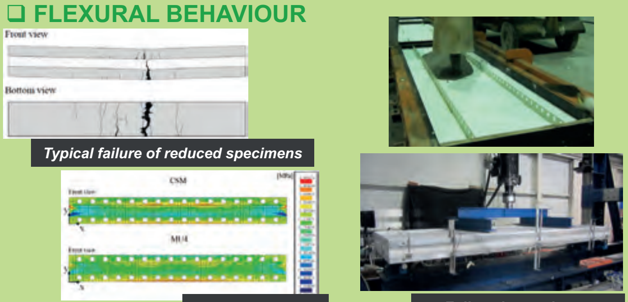
❑ STUDIES ON MATERIAL SCALE



SFRSCC

GFRP

❑ FLEXURAL BEHAVIOUR



Typical failure of reduced specimens

FE simulation

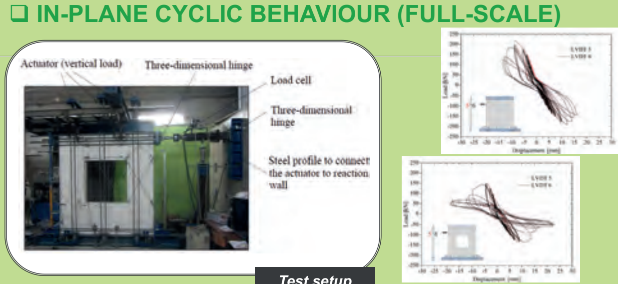
Full-scale specimens

❑ PULL-OUT AND PUSH-OUT TESTS

Pull-out tests

Push-out tests

❑ IN-PLANE CYCLIC BEHAVIOUR (FULL-SCALE)



Test setup

Typical responses

University of Minho
School of Engineering

FCT
Fundação para a Ciência e a Tecnologia

Institute for Sustainability and Innovation in Structural Engineering

Rosamaria Codispoti

Supervisors: Renato S. Olivito / Daniel V. Oliveira

MECHANICAL PERFORMANCE OF NATURAL FIBER-REINFORCED COMPOSITES FOR THE STRENGTHENING OF ANCIENT MASONRY

OVERVIEW

The present PhD Thesis was developed thanks to the collaboration between the Civil Engineering Departments of University of Calabria (Italy) and University of Minho (Portugal). The main topic of this work concerned the study of natural fiber-reinforced composites. The study is composed of a vast experimental part, carried out in the Civil Engineering Laboratory and Fibrous Materials Laboratory at University of Minho, and a numerical part, with the purpose of analyzing the performance of natural fiber-reinforced polymer (NFRP) and grout (NFRG) applied to ancient masonry structures.

EXPERIMENTAL TESTS ON COMPOSITES

In the first part of the experimental program, mechanical characterization tests of matrixes and fibers was done, carrying out compressive and three point bending tests on mortar and tensile tests on resin and fabrics. Three different types of matrixes were used to produce composite materials: two thermosetting matrixes, epoxy and polyester resin (NFRP), and a mortar matrix(NFRG). Consequently of this, three composite materials were manufactured ($NFRP_{eposy}$ – $NFRP_{polyester}$ – NFRG). Moreover, in order to analyze the performance of composites in terms of maximum load capacity, tensile strength, and Young's modulus, tensile tests were carried out in laboratory.

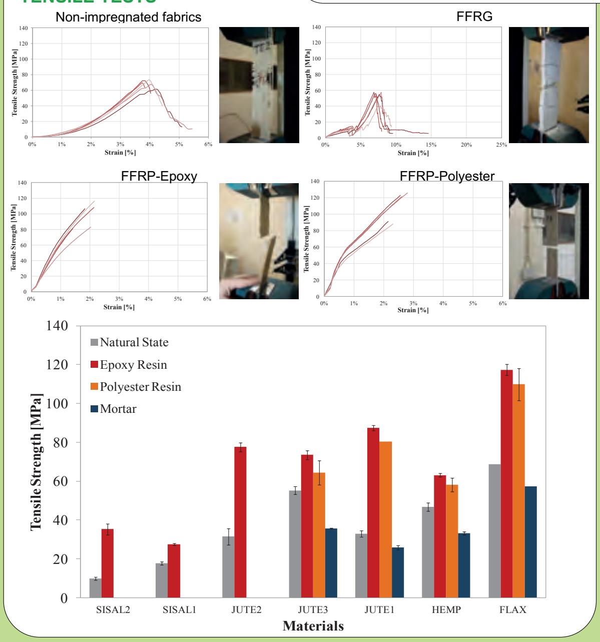
EXPERIMENTAL TESTS ON STRENGTHENED ELEMENTS

In the second part of the experimental plan, the bond behavior between composite materials (NFRP-NFRG) and masonry was investigated. For this purpose, pull-out tests, three point bending tests, and single-lap shear bond tests were carried out on masonry clay bricks reinforced externally with natural fiber-based composites. Finally, to get feedback with the current standards, a comparison with the theoretical approach provided by the Italian technical document (DT-200 R1/2012) was made. In addition to the characterization of mechanical properties of NFRP, also physical properties were calculated in terms of weight per unit area (GSM) and density..

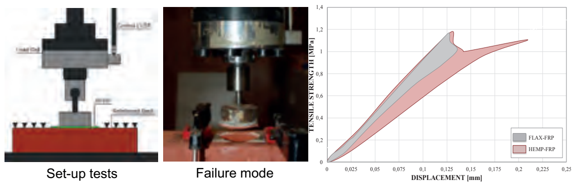
MATERIALS

In order to fulfill the aim of this thesis, five types of natural materials have been used: flax, hemp, sisal, jute and coir. A total of seven kinds of bidirectional fabrics have been put in examination (figure 3.4), different for both density but also in composition, in fact, mixed fabrics, with the presence of different materials in each direction, were tested.

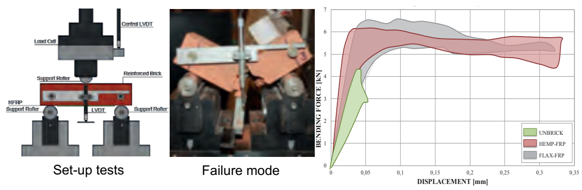
TENSILE TESTS



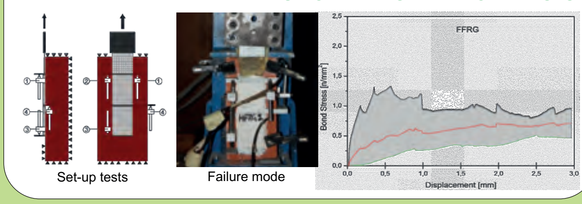
PULL-OUT TESTS



THREE-POINT BENDING TESTS



SINGLE-LAP SHEAR BOND TESTS



EXPERIMENTAL AND NUMERICAL RESULTS: COMPARISON

UNREINFORCED BRICK

REINFORCED BRICK

University of Minho
School of Engineering

University of Calabria
Dep. of Civil Engineering

Institute for Sustainability and Innovation in Structural Engineering

Rui Manuel Maia Pinto de Matos

Supervisors: Carlos Rebelo / Paulo Pinto

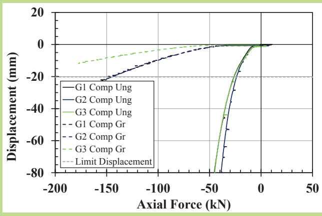
STEEL TOWERS FOR WIND TURBINES

❑ OVERVIEW

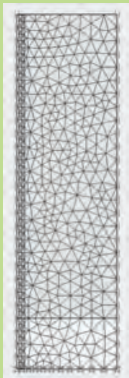
- This study is focused on the theme of the renewable energy, namely the wind energy, which had registered a big increase over the last few years. The main objective is to study the feasibility of the production, assembly and use of higher towers for wind turbines.
- The use of higher heights will bring new problems to the design and the price of the towers, so this study will focus on some of those topics.
- In this work an overview and the design of several different solutions will be presented to be used on higher towers (150 to 200 m high), a study for a new typology of foundations as alternative for the current direct foundation, estimation of the pre-stress losses on bolts and monitoring of a fully functional wind tower.

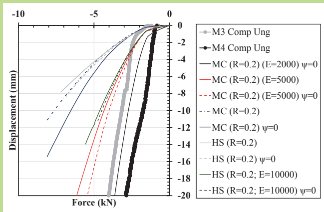
❑ FOUNDATION DESIGN (EXPERIMENTAL AND NUMERICAL STUDY)

- The actual foundation typology for current wind towers (80 to 100m) is based on direct foundation and represents a big percentage of the total cost of the structure (about 20%). The purpose of this work is to check the feasibility of reinforce the current direct foundation by using steel micropiles and so, reduce the required diameter for the direct foundation.



Experimental tests

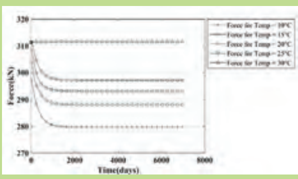




Numerical analysis

❑DESIGN RECOMMENDTIONS FOR HIGHER WIND TOWERS

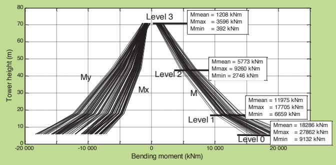
The design recommendations for higher wind towers will be included taking into consideration several structural solutions (steel, concrete and steel+concrete). The use of a new friction connection between the tower segments to improve the tower fatigue behavior it will be considered in the recommendations with the results of a long term measurement.



Friction connection

❑MONITORING

A fully function tower instrumented along the height will be monitored for a long time in order to estimate the stresses and the behavior of the tower for a high range of wind speed. As the final part of this work will be estimated a fatigue spectrum for the measured wind speeds in order to validate the design values or purpose new ones.



University of Minho
School of Engineering

SUSTAINABLE STEEL CONSTRUCTION

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

isise Institute for Sustainability and Innovation in Structural Engineering

Sanam Moghimi

Supervisors: Alexandra Carvalho/ Paulo B. Lourenço

SEISMIC RISK MITIGATION STRATEGY; COST EFFECTIVE ANALYSIS

❑ COST-EFFECTIVE ANALYSIS

- **In this research, it is intended to cooperate with LNECLOSS platform and also to take advantage of the procedures already established in National Laboratory of Civil Engineering studying the seismic behavior of RC structures and update the different algorithms in order to generate building structures considering different retrofitting solutions.**
- **Cost-Effective Analysis applied to seismic risk analysis is a systematic procedure for evaluating decisions related to strategic risk management, taking into account the different factors affecting seismic risk such as hazard, vulnerability, exposure and generalized costs of strengthening policies implementation.**

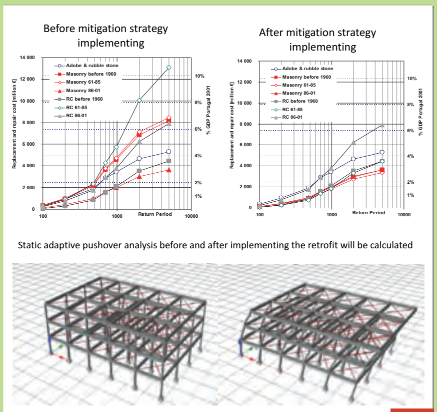


Fig. 1

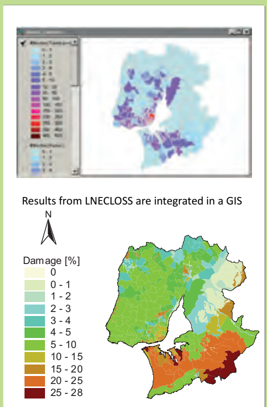


Fig. 2

❑ SEISMICAL BEHAVIOUR OF RC BUILDING- BEFORE AND AFTER RETROFITTING STRATEGIES

- **In order to understand the impact of different retrofitting solutions, it is intended to cooperate with an ongoing study focused on the evaluation of the seismic behavior of RC buildings design without adequate seismic provisions which considers a methodology based on a detailed numerical study of the seismic behavior of reinforced concrete buildings with representative characteristics of a significant part of the Portuguese building stock that adequately simulates the main aspects of the buildings' structural response.**

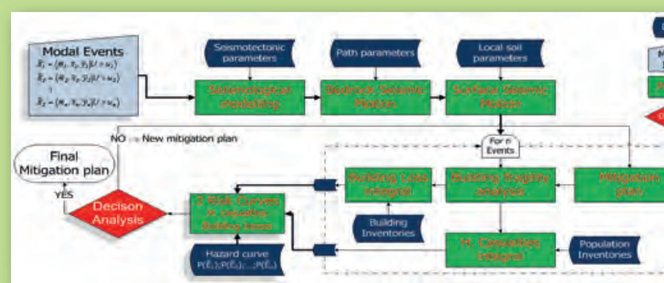


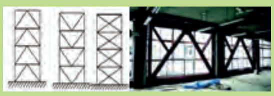
Fig. 3

a)

b)

c)

d)



❑ RETROFITTING TECHNIQUES AND COST BENEFIT ANALYSIS

- **The <u>techniques</u> which have been considered in this study are a) FRP sheets, b) Reinforced concrete jacketing, c) Cast-in-place infill walls and d) Steel bracings.**
- **The models related to these techniques is applied in Seismostruct to interpret the fragility curves after retrofit, then to evaluate its costs and assessment of damage and economic loss.**
- **With all results in hand, the cost benefit will be applied in order to identify the most effective mitigation strategies**
- **The main <u>objective</u> of these tests is to develop a Cost Benefit Model to evaluate the most effective mitigation strategies for the existing RC building stock of large urban areas.**

· U C ·

University of Minho
School of Engineering

LNEC LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

Institute for Sustainability and Innovation in Structural Engineering

Sandra Raquel de Sousa Monteiro

Supervisors: Alfredo Dias / Sérgio Lopes

LOAD DISTRIBUTION ON TIMBER-CONCRETE COMPOSITE FLOORS

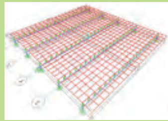
❑ MAIN OBJECTIVE

Understand the manner in which a concentrated (point or line) external load applied to a timber-concrete composite (TCC) slab is transversally transmitted to each supporting element across the main beams of the slab.

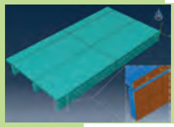
Aiming at:
- **finding the parameters that most affect the load distribution;**
- **creating a simple rule to predict the actual behavior.**

Theoretical methods
- **FE models**
  - **Grid model**

  - **Frame+Shell model**



  - **Solid model**



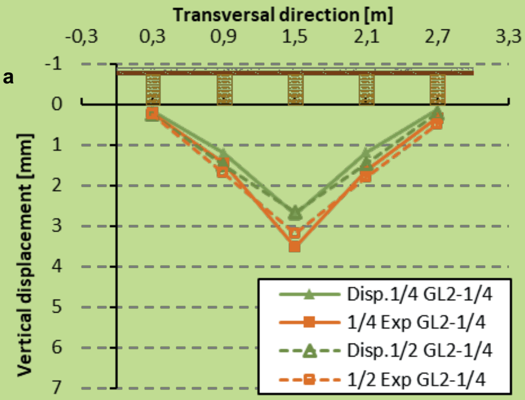
- **Analytical method**
  - **Guyon-Massonnet method** (Distribution Coefficients Method)

Experimental tests
- **2 real scale specimens** (model validation)
- **5 real scale specimens**

❑ EXPERIMENTAL TESTS

The TCC floor specimens, with different characteristics, were built and tested subjected to point (at ½ and ¼ span) and line loads applied aligned with the longitudinal direction of the beams, one at a time.

<table>
<tr><th></th><th colspan="7">Geometrical characteristics</th><th colspan="4">Material characteristics</th></tr>
<tr><th rowspan="2">Specimen</th><th rowspan="2">Span</th><th rowspan="2">Width</th><th rowspan="2">Concrete thickness</th><th rowspan="2">Timber interlayer</th><th rowspan="2">Beam section</th><th rowspan="2">Beam spacing</th><th colspan="2">Concrete layer</th><th rowspan="2">Timber beams</th><th rowspan="2">Connection type</th></tr>
<tr><th>Strength class</th><th>Aggregate</th></tr>
<tr><td>S1</td><td rowspan="3">4.00</td><td rowspan="5">3.00</td><td rowspan="2">0.05</td><td rowspan="2">No</td><td rowspan="4">0.12 × 0.24</td><td rowspan="5">0.60</td><td>C25/30</td><td>Limestone</td><td rowspan="5">Glulam GL 24h</td><td rowspan="2">Dowel type</td></tr>
<tr><td>S2</td><td>LC16/18</td><td>Cork</td></tr>
<tr><td>S3</td><td>0.03</td><td>Yes (0.02)</td><td rowspan="3">C25/30</td><td rowspan="3">Limestone</td><td>Screws</td></tr>
<tr><td>S4</td><td>2.00</td><td rowspan="2">0.05</td><td rowspan="2">No</td><td rowspan="2">Dowel type</td></tr>
<tr><td>S5</td><td>6.00</td><td>0.12 × 0.32</td></tr>
</table>



Experimental *vs.* Numerical displacements for S3-hc=0.03m when loaded at ¼ span

❑ SENSITIVITY ANALYSIS

After validating and finding the most adequate FE model (Frame+Shell) a 2-stage parametric study was developed:

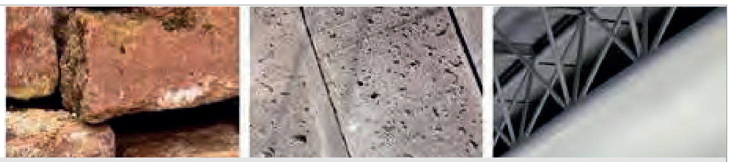
- **1st stage: in order to state the experimental program;**
- **2nd stage: in order to identify the parameters that most affect the transversal distribution of load.**

With all the data gathered a simple rule to predict the percentage of load associated with each beam was established.

❑ CONCLUSIONS

- **The loaded beam receives the biggest share of load;**
- **The remaining beams participation depends on the loaded beam location and on the span (the longer the span, the wider the spreading).**
- **The load distribution is more effective the further the distance of the loaded point to the supports.**
- **Design considerations, as the “degree of oversizing”, have great influence on the load distribution.**
- **The developed model is adequate to predict the load distribution of the TCC floors considered and the simplified rule led to results close to the real ones (differences <(±)10%).**

University of Minho
School of Engineering



Institute for Sustainability and Innovation in Structural Engineering

Sara Gomes

Supervisors: Daniel Dias-da-Costa / Luis Neves

RELIABILITY ANALYSIS OF FRP STRENGTHENED PRESTRESSED CONCRETE GIRDERS

❑ OBJECTIVES

- This thesis had as main objective the development of a framework to assess the reliability of FRP strengthened PC girders adopted for bridges (Fig. 1), including: i) the statistical characterisation of mechanical properties of CFRP, ii) the calibration of partial safety factors for CFRP considering reliability analysis; and iii) the time-dependent reliability analysis of PC girders strengthened with CFRP.

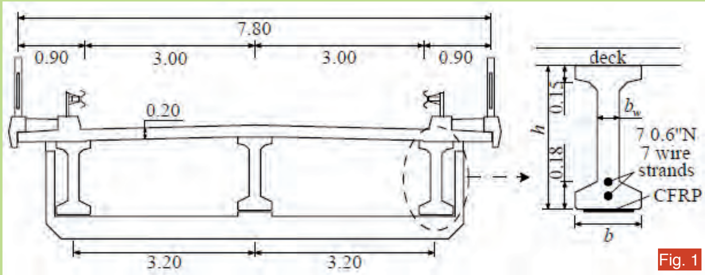


Fig. 1

❑ METHODOLOGY

- Statistical analysis were performed considering tensile tests from CFRP laminates.
- The calibration of partial safety factors adopted a hybrid approach combining numerical models using a strong discrete approach to model concrete in fracture (Fig. 2) and to better simulate the influence of concrete cracks in FRP, with analytical models. Additional, reliability analyses were computed with FORM.
- The time-dependent reliability analysis considered spatial corrosion of pre-stressed strands randomly generated over the girder length (Fig. 3) and was calculated using an analytical model and FORM.

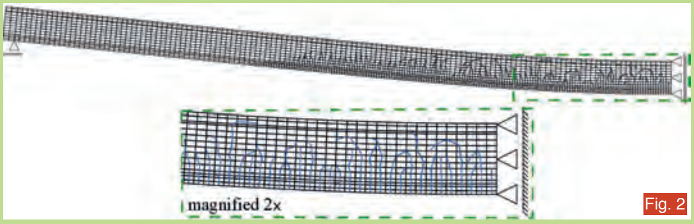


Fig. 2

Fig. 3

❑ RESULTS

- Statistical models for Young's modulus, tensile strength and ultimate strain were obtained (Fig. 4).
- A partial safety factor of 1.13 was obtained for CFRP laminates (Fig. 5) and traffic loads, resistance and loads uncertainties were found to be critical for these type of analyses.
- The CFRP laminates can increase reliability and keep it nearly unchanged through time after strengthening (Fig. 6).

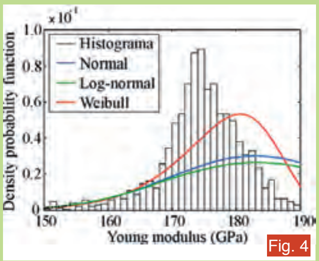


Fig. 4

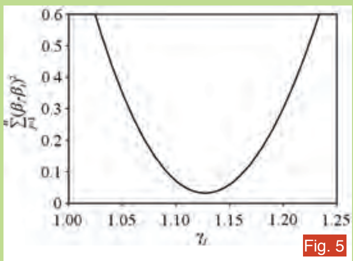


Fig. 5

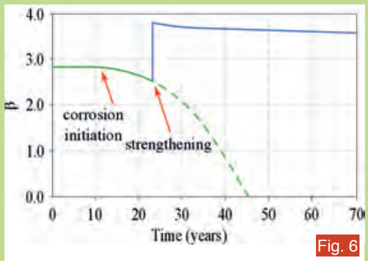


Fig. 6

University of Minho
School of Engineering

FCT Fundação para a Ciência e a Tecnologia

Institute for Sustainability and Innovation in Structural Engineering

Seyed Ebrahim Hashemi Rafsanjani

Supervisors: Paulo B. Lourenço / Nuno Peixinho

High strain rate constitutive modeling for historical structures subjected to blast loading

❑ STRAIN DEPENDENT COMPOSITE INTERFACE MODEL

- A newly developed dynamic interface model is introduced accounting for strain rate effects. The rate-dependent failure envelop is divided into three parts, namely tension mode, coulomb friction mode, and compressive cap mode. The developed model is attributed to interface elements to simulate the mortar behavior between the masonry units for Micro numerical simulation of masonry structures.

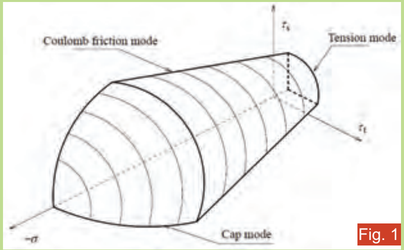


Fig. 1

❑ STRAIN DEPENDENT ANISOTROPIC CONTINUUM MODEL

- A novel strain rate dependent plasticity model for masonry is proposed, with validation using the high strain rate response of masonry walls. The present model adopted the usual approach of considering different yield criteria in tension and compression. These criteria are plasticity based, obey a non-associated flow rule, are numerically stable and inexpensive, and are characterized by a few material input parameters. Validation of the capability of the model is carried out together with a parametric study to evaluate the influence of the most likely dominant parameters.

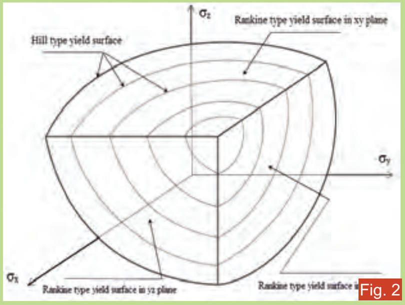


Fig. 2

❑ DESIGN RULES FOR MASONRY INFILL WALLS TO EXPLOSIVE LOADS

- The iso-damage curves are addressed for a given masonry infill wall along with three different types of typical masonry infill walls in Portugal, with three different thicknesses. The anisotropic continuum model is involved as material model in present study. Then, a large number of analyses are performed to develop the P-I diagrams for different masonry infills under blast and different loading conditions.

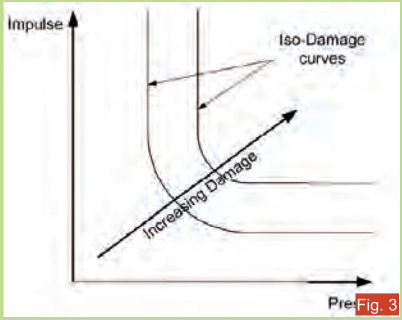


Fig. 3

❑ ENGINEERING APPLICATION: A CASE STUDY IN SAMARRA

- The new anisotropic continuum model is taken into engineering applications to solve real problems. The full-scale numerical simulation of the blast response of Al-Askari holy shrine is considered to practice and validate the model capability. Besides the real explosion, two different scenarios are also defined to estimate the most likely high strain rate response of the shrine under different explosions producing different pressure profiles.

Fig. 4

U C

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Seyed Hamid Maljaee

Supervisors: Paulo. B Lourenço / Bahman Ghiassi

LONG-TERM DURABILITY OF BOND IN FRP-MASONRY COMPONENTS

❑ Objectives

The study addresses the long-term behavior of bond between FRP and masonry through integrated experimental and analytical activity. The specimens are exposed to different environmental conditions, water immersion and hygrothermal condition, to investigate the degradation of constituent materials and FRP-masonry interfacial bond. The long-term performance of the bond behavior under sustained loads (creep behavior) are also investigated. Throughout the study, two types of specimens were prepared to assess the influence of surface treatment on the bond degradation behavior (ORG: specimens prepared with original bricks, GR: specimens prepared after grinding the brick's surfaces)

❑ Water immersion

The effect of one-year water immersion on the material properties and bond behavior between FRP and brick was investigated. Thermal properties of epoxy resin was also analyzed through DSC tests during water immersion period. Variation of debonding force due to water immersion is presented in Fig 1.

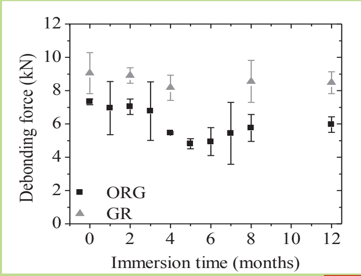


Fig. 1

❑ Hygrothermal exposure

The experimental program consisted of exposing FRP-strengthened bricks and material samples to hygrothermal exposure conditions in a climatic chamber. The exposure included 6-hour temperature cycles ranging from +10˚C to +50˚C with constant relative humidity of 90%, see Fig. 2.

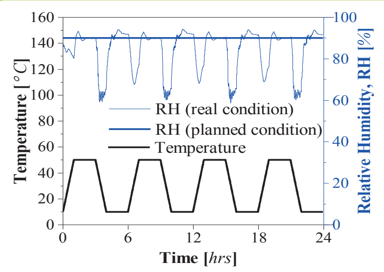


Fig. 2

Variation of thermal properties of epoxy resin due to hygrothermal exposure was measured using DSC tests.

Fig 3 and 4 illustrate variation of debonding force and debonding area in ORG and GR-specimens, respectively due to hygrothermal exposure.

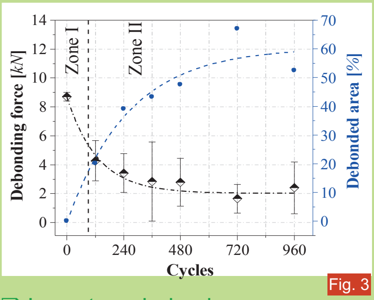


Fig. 3

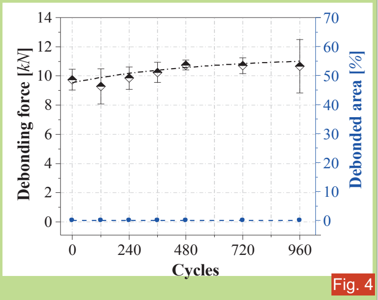


Fig. 4

❑ Long-term behaviour

The tensile creep tests were carried out in different stress levels ranging from 20%-40% of ultimate strength. According to the results, epoxy resin showed a nonlinear viscoelastic behavior under sustained loading, see Fig. 5. A rheological model was developed in this study to predict time-stress-dependent response of epoxy resin.

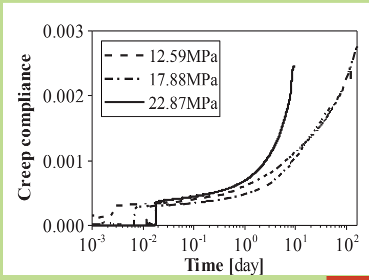


Fig. 5

The long-term behaviour of bond between FRP and brick was assessed through single-lap shear tests in two types of specimens, ORG- and GR- specimens.

The bond creep test setup is shown in Fig. 6.

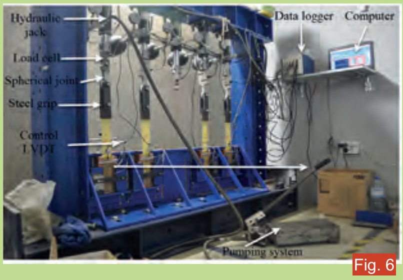


Fig. 6

In general, surface treatment showed better bond performance in different exposures and under sustained loading.

University of Minho
School of Engineering

Institute for Sustainability and
Innovation in Structural Engineering

Slobodanka Jovašević

Supervisors: Carlos Rebelo / Marko Pavlović / José António Correia

IN-SITU BOLTED CONNECTIONS IN LATTICE TOWERS FOR WIND ENERGY CONVERTERS

❑ TOWER GEOMETRY

- **This work program, in the scientific domain of the Steel Composite Structures, consists of development of a new concept for hybrid steel towers to support 5MW wind converters (Fig. 1) and assessment of connections behaviour between built-up polygonal cross-sections (Fig. 2) Both, normal strength steel (S355) and high strength steel (S690) are considered.**
- **Polygonal built-up cross-section are used instead of CHS in order to use advantages of polygonal over circular sections, as well as to improve fatigue life of the connections and members considering that the fatigue behaviour of preloaded high strength bolted joints under shear or friction loads can bear higher fatigue loads then welded joints.**

Fig. 1

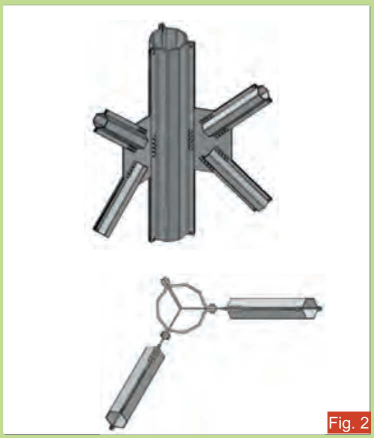


Fig. 2

❑ EXPERIMENTAL RESEARCH – BEHAVIOUR OF CONNECTIONS IN BENDING

- **The behaviour of the in-situ bolted connections between polygonal built-up profiles (Fig. 3) with failure modes shown in Fig. 4 is assessed by means of monotonic bending tests.**

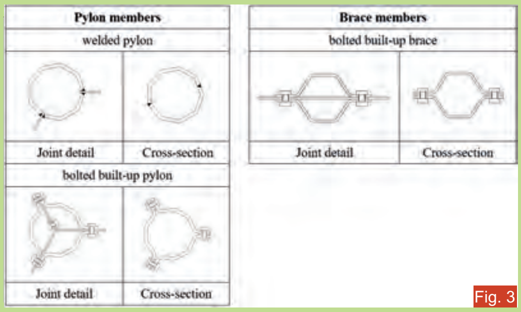


Fig. 3

Failure modes:
Gusset plate net section failure
Gusset plate buckling
Brace net section failure
Brace – block tearing

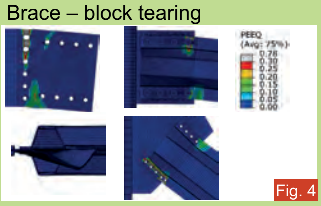
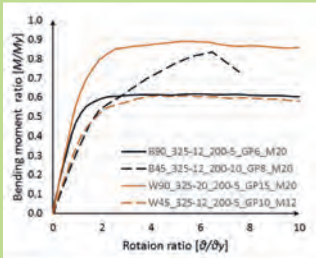


Fig. 4



❑ PARAMETERS

- **The <u>parameters</u> which are varied in the tests are <u>steel grade</u> (S355 and S690), the <u>dimensions of gusset plate, thickness of pylon and brace, pylon section (Bolted and Welded) and pylon to brace angle.</u>**
- **Pylon diameter is 325mm and brace diameter is 200mm for all cases.**

P	Steel	angle	t_p	t_b	t_{gp}
				[mm]	
1	S355	B90°	12	5	6
2	S355	B45°	12	10	8
3	S355	W90°	20	5	15
4	S355	W45°	12	5	10
5	S690	B90°	6	3	3
6	S690	B45°	6	5	4
7	S690	W90°	10	3	8
8	S690	W45°	6	3	5

- **The main <u>objective</u> of these tests is to assess the strength, stiffness and rotation capacity of in-situ bolted connections between polygonal built-up profiles.**

University of Minho
School of Engineering

LULEÅ TEKNISKA UNIVERSITET

MARTIFER METALLIC CONSTRUCTIONS

FRIEDBERG

SCI

Institute for Sustainability and Innovation in Structural Engineering

Subramani Pichandi

Supervisors: Raul Fangueiro / Daniel Oliveira

DEVELOPMENT OF COMPOSITE AUXETIC STRUCTURES FOR CIVIL ENGINEERING APPLICATIONS

❑ EXPERIMENTAL RESEARCH

- **This research work is in the area of Auxetic materials (possess negative Poisson's ratio) (Fig. 1). The main objective of this work is to develope novel auxetic structures and composites for strengthening of civil structural elements.**
- **Two different types of auxetic structures has been developed from braided composite rods (refer Fig. 2) using various technical fibers as core (glass, basalt, and carbob) and polyester multifilament as sheath.**
- **Mechanical properties (Poisson's ratio and Tensile strength) of developed auxetic structures were studied in detailed manner by varying their materials and structural parameters. This will help to develope structures for specific conditions.**
- **Auxetic composites from unidirectional carbon fiber sheet with epoxy resin through angle-ply technique was developed and studied their tensile and auxetic behavior. The no. Of layer used is 24 with the angle of ±30°. Weight of each layer is 100 gm/sqr. Meter.**

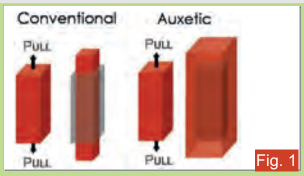
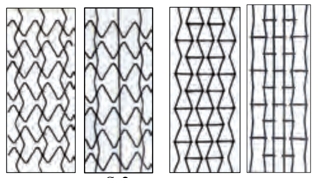


Fig. 1



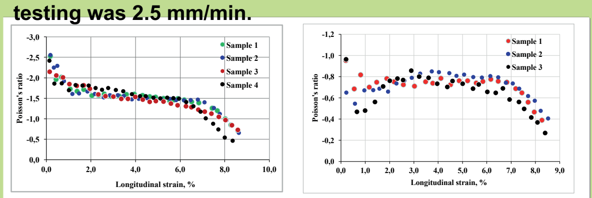
S-1 S-2 S-3 S-4

(S-1) Auxetic basic structure based on lozenge grid, (S-2) Auxetic structure modified based on lozenge grid, (S-3) Auxetic structure basic based on re-entrant hexagon and (S-4) Auxetic structure modified based on re-entrant hexagon.

Fig. 2

❑ TESTING OF AUXETIC AND TENSILE BEHAVIOR

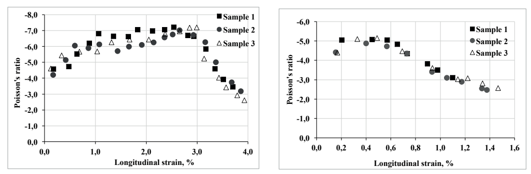
- **The auxetic and tensile behavior of auxetic structures were studied by using universal tensile testing machine with cross head speed of 25 mm/min. The test dimensions of S-1 and S-2 were 40 cm in length and 14 cm in width. Whereas the dimensions of S-3 and S-4 are 40 cm in length and 11 cm in width. During testing videos were captured and later videos converted in to images. From the images, the transverse and longitudinal deformation (strain) of structures were calculated. Then, the Poisson's ratio of the structures were calculated using the formulae, Poisson's ratio = -(Transverse strain/Longitudinal strain). The Poisson's ratio of the structures were shown in the Fig. 3 and Fig. 4. Tensile results of the structures given in the table 1. The Poisson's ratio of the composites (sample size – 25 * 1.5 cm with gauge length of 15 cm) studied using tensile testing machine with Digital Image correlation (DIC) technique. The cross head speed used for testing was 2.5 mm/min.**



S-1 S-2

Auxetic behavior of structures based on lozenge grid

Fig. 3



S-3 S-4

Auxetic behavior of structures based on re-entrant hexagon

Fig. 4

❑ PARAMETERS

- **The parameters studied for the structures are type of core fiber, angle of vertical undulation rods, rib length, and BCRs diameter.**
- **The effect of layers on auxetic behavior of composites was studied.**

Table 1. Tensile results of structures (glass, 4800 tex)

Sample	Avg. Max. Tensile Load, kN	Avg. Elongation at max. tensile load, %
S – 1	4.93 (15.2)	9.35 (6.32)
S – 2	3.45 (11.2)	8.89 (5.04)
S – 3	10.40 (8.33)	5.14 (5.45)
S – 4	15.23 (0.88)	4.04 (12.15)

❑ CONCLUSION

- **The Poisson's ratio of the structures were significantly modified by varying their angle of vertical undulation rods.**
- **The strengthening of the structures were improved by modifying structures with vertical straight rods.**
- **The Poisson's ratio of the auxetic composites observed as -0.240.**

University of Minho
School of Engineering

Institute for Sustainability and Innovation in Structural Engineering

Telma Ribeiro

Supervisor: Daniel V. Oliveira

CONSERVATION OF EARTH HERITAGE: AN APPROACH FOR A NEW METHODOLOGY

❑ Introduction

It is estimated that around 30% of world population lives, nowadays, in earthen buildings. In what concerns world heritage, in the UNESCO list, 10% is identified as earthen architecture (Fig.1 – Archeological complex of Chan Chan city, Trujillo – Peru), and in the list of world heritage in danger there are 57% of monuments made with earth identified.

In the last thirty years the interest in earth heritage and its preservation has increase due to all conferences, seminars and publications that occurred in this area. Also the creation of networks, associations, and organizations worldwide contributed for the dissemination of knowledge and awareness for this particular heritage. The preservation and protection of earthen architecture is essential, not only, for guarantee it for future generations, but most important, to learn from it (Fig 2 – Rammed earth house in advance state of degradation, in Alentejo – Portugal). Studies regarding conservation and/or restoration of earth heritage have been developed, however compatibility between earth and conservation products; and the creation of a preventive conservation methodology, are two areas that still need more analysis.

This project aims to study the interaction between products commonly used in earth conservation (consolidants and water repellents) and adobe (Fig.3 (1)) and rammed earth probes (Fig.3 (2)), in terms of efficiency; durability; compatibility; and reversibility. In the other hand, based on the results obtained, it will be discuss an approach for a conservation methodology applied on earth heritage.

Fig. 1

Fig. 2

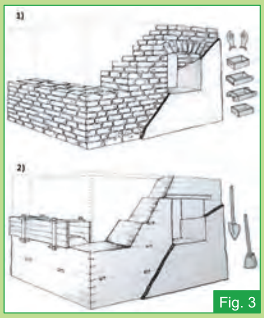


Fig. 3

❑ Workplan

EARTHEN TECHNIQUES

Adobe | Rammed earth

↓

EXPERIMENTAL PROGRAM

Consolidants | Water repellents

Efficiency and compatibility evaluation

(+ artificial aging)

Durability evaluation

↓

VALIDATION

In situ analysis

↓

OUTPUTS

New study about interaction between conservation products and earth material

Development of a new methodology for conservation of earth heritage

U C

University of Minho School of Engineering

FACULDADE DE CIÊNCIAS E TECNOLOGIA UNIVERSIDADE NOVA DE LISBOA

UNIVERSIDADE NOVA DE LISBOA

CORES PhD. Course Conservation and Restoration of Cultural Heritage

FCT Fundação para a Ciência e a Tecnologia

isise Institute for Sustainability and Innovation in Structural Engineering

Thiago Brazeiro Carlos

Supervisors: João Paulo C. Rodrigues / Rogério Antocheves / Dhionis Dhima

FIRE BEHAVIOR OF RC BEAMS STRENGTHENED WITH CFRP LAMINATE STRIPS

❑ OBJECTIVE

- **This research consists in assessing the flexural behavior of RC beams strengthened with CFRP laminates at high temperatures, based on the results of a large experimental and numerical testing program.**
- **Investigate the effectiveness/ influence of new fire protection systems to thermal insulate the beams with different thicknesses (20, 35 and 50mm): vermiculite-perlite (VP), ordinary Portland with expanded clay aggregates (EC) and ordinary Portland (OP) cement based mortars.**
- **Provide experimental and numerical results for the development of simplified calculation methods for fire design of CFRP-strengthened RC beams, so that they may be considered for a future revision of Eurocode 2, Part 1.2.**

❑ PARTNERS

- **S&P Clever Reinforcement Ibérica, Lda.**
- **TRIA, S.A.**
- **STAP, S.A.**
- **ARGEX, S.A.**

❑ RESEARCH PLAN

- **The experimental program (*Table 1*) includes ten fire resistance tests on RC beams, nine of which on CFRP-strengthened beams protected with three different fire protection materials of three possible thicknesses (*t*), and one on an un-strengthened and un-protected RC beam (reference test). The specimens and thermocouple distribution in their cross-section are shown in *Figs. 1* and *2*, respectively.**
- **The experimental tests are being performed at LEME*. The test set-up is shown in *Figs. 3* and *4*.**

Table 1. Experimental program

N	Test reference	Insulation material	*t* (mm)	*P* (kN)	Heating curve
1	RC	Un-protected	-	24.0	ISO 834
2	EC-20	EC mortar	20		
3	EC-35		35		
4	EC-50		50		
5	OP-20	OP mortar	20		
6	OP-35		35		
7	OP-50		50		
8	VP-20	VP mortar	20		
9	VP-35		35		
10	VP-50		50		

Note: the beams will be subjected to a constant applied load (*P*) corresponding to 70% of the design value of the load bearing capacity of a not CFRP strengthened RC beam at normal temperature. Moreover, the fire resistance tests will be heating according the fire standard curve ISO-834.

- **A numerical analysis are being carried out using ABAQUS software (*Fig. 5*).**

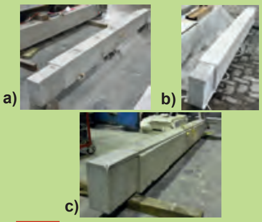


Fig. 1 Specimens protected with: a) EC, b) OP and b) VP mortars

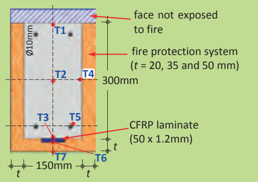


Fig. 2 Thermocouple distribution and cross-section of the specimens

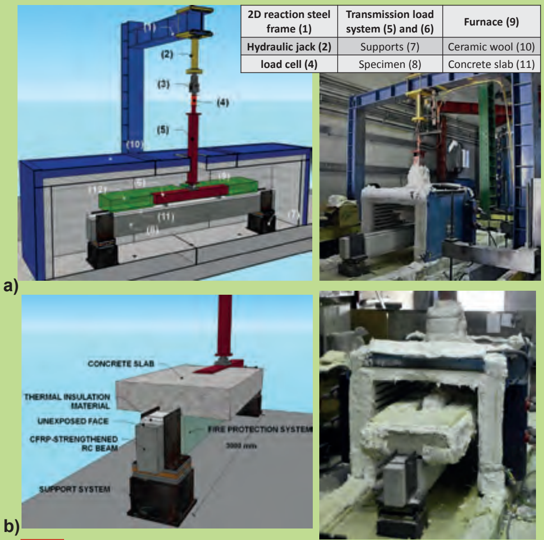


Fig. 3 Scheme of the experimental system: a) isometric view; b) details of the beam's fire protection and support systems (without furnace)

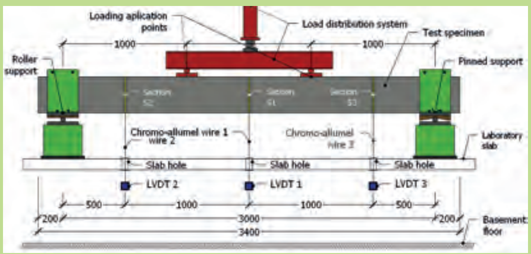


Fig. 4 Characteristics of the experimental set-up for flexural tests of beams

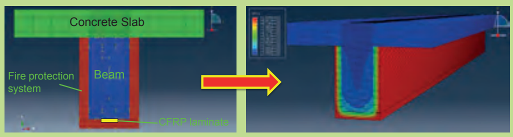


Fig. 5 Numerical modelling of CFRP-strengthened beams

University of Minho School of Engineering

CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico

**LEME – Laboratory of Testing Materials and Structures of University of Coimbra, Portugal*

Institute for Sustainability and Innovation in Structural Engineering

Thomas Sturm Moreira

Supervisors: Luis Ramos / Paulo Lourenço

EXPERIMENTAL CHARACTERIZATION OF DRY-STACK INTERLOCKING COMPRESSED EARTH BLOCK MASONRY

❑ EXPERIMENTAL RESEARCH

- ❑ **Characterization of the structural behaviour of dry-stack masonry made of interlocking compressed earth blocks (ICEB), see (Fig. 1). The ICEBs allow arrangement of single and double-leaf walls with a transverse locking course (Fig. 2).**
- ❑ **The experimental program was divided into 3 groups according to the subject of study and specimen type:**
  - **Material characterization (ecxample Fig. 3)**
  - **Masonry characterization (Fig. 4 to 6)**
  - **Shaking table test (Fig. 7)**

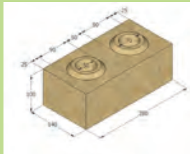


Fig. 1 - ICEB .

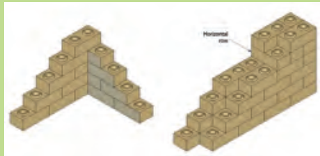


Fig. 2 - Single an double lead walls.

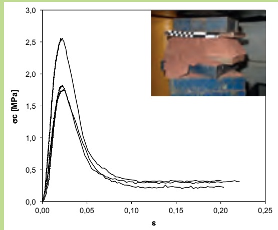


Fig. 3 - Compression of ICEB.

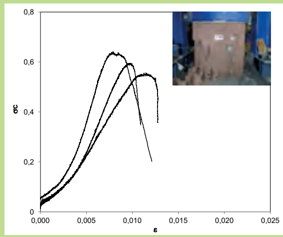


Fig. 4 - Compression of wallet.

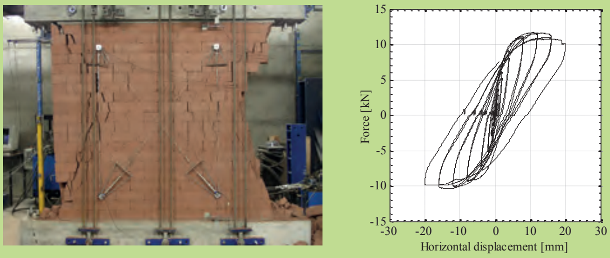


Fig. 6 - Cyclic in-plane shear test of wall: (a) specimen; (b) hysteretic curve.

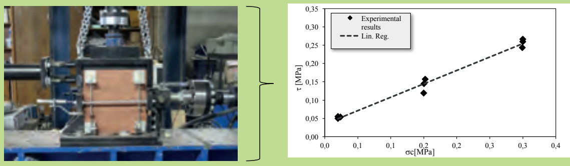


Fig. 5 - Triplet shear test: (a) test setup; (b) compression vs. shear strength.

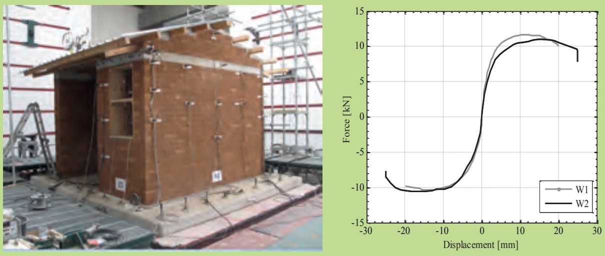


Fig. 7 - Shaking table test of small masonry house: (a) mock-up; (b) envelopes.

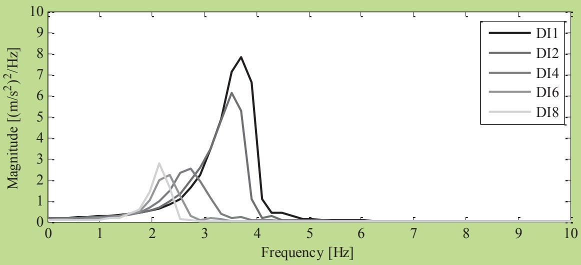


Fig. 9 - Degradation of mock-up after consecutive incremental tests (max. PGA=0.59g)

❑ RESULTS

- **The compressive strength of the masonry prisms, was close to 1.0 MPa.**
- **The average Young's modulus of the prisms were between 129 MPa and 141 MPa.**
- **The masonry had a compressive strength of around 0.5 MPa.**
- **The cyclic in-plane shear test of walls showed a crack limit at around 3 mm. The experimentally determined behavior factor had an average of around 3, but the Eurocode 8 (2003) limits it to 1.5 for unreinforced masonry structures .**
- **During the damage survey of the shaking table test, no significant cracks were seen before a PGA of 0.3g.**
- **The main damage at the final stage corresponded to horizontal cracks on tops of the walls, to the failure of one pier and to the imminent collapse of a corner.**

* The initial shear value depends on the compression state (f_p)

University of Minho
School of Engineering

C-TAC
Territory, Environment and Construction Research Centre

MOTA-ENGIL
ENGENHARIA

isise Institute for Sustainability and Innovation in Structural Engineering

BEHAVIOUR OF STEEL MEMBERS SUBJECTED TO HAZARDOUS LOADING IN SUPPORT OFFSHORE STRUCTURES

Tiago Jorge da Cruz Manco

Supervisors: Prof. Luís Simões da Silva / Prof. João Pedro Martins / Prof.ª Constança Rigueiro

❑ BACKGROUND

- The behaviour of steel members in support offshore structures subject to hazardous loading (mainly ship collisions and explosions) is a critical aspect in offshore structures and a hot topic in research nowadays.
- The main elements composing floating offshore structures are stiffened panels, namely curved panels. However, design provisions to predict their strength are practically non-existent.

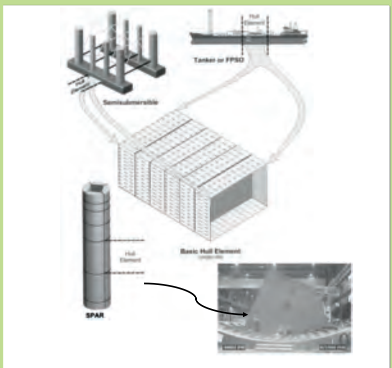


Fig. 1. Main structural elements in floating structures (stiffened steel shells).
Source: Chakrabarti, S. (2005). "Handbook of Offshore Engineering". vol. I & II. Elsevier, Illinois, USA.

❑ OBJECTIVES

- Development of predictive models for the behaviour of steel curved panels in support structures of offshore platforms subjected to normal and hazardous loading;
- Development of numerical models of unstiffened and stiffened curved panels under normal loading (in-plane and out-of-plane loading) and hazardous loading conditions (collisions and explosions);
- Development of analytical models capable of predicting the resistance of unstiffened and stiffened curved panels under in-plane and out-of-plane loading;
- Development of design guidelines based on the analytical models;

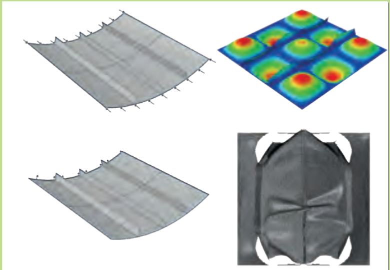


Fig. 2. Numerical models of stiffened panels under in-plane and out-of-plane loading.

❑ TASKS

- Task 1 – Characterization of the various types of offshore structures, respective elements and relevant normal and hazardous loading;
- Task 2 – Numerical study;
  - Nonlinear analysis of curved panels under uniaxial compression;
  - Nonlinear analysis of curved panels under out-of-plane loading (impact and explosions);
- Task 3 – Analytical study;
  - Formulation of curved panels with large deflection theory;
  - Buckling and postbuckling behaviour of curved panels under uniaxial compression;
  - Postbuckling behaviour of curved panels under out-of-plane loading;
- Task 4 – Design proposals for unstiffened and stiffened curved panels;

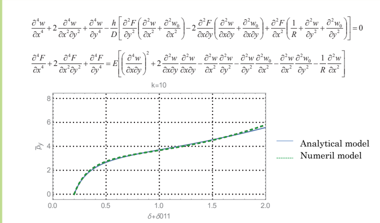


Fig. 3. Comparison of the equilibrium path obtained by analytical and numeric models for unstiffened curved panels

University of Minho
School of Engineering

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

isise Institute for Sustainability and Innovation in Structural Engineering

ADVANCED NUMERICAL MODELS FOR THE ANALYSIS OF THE BEHAVIOR OF STRUCTURES STRENGTHENED WITH AN INNOVATIVE TECHNIQUE

Tiago Valente

Supervisors: Joaquim Barros/ Lúcio Lourenço

❑ STRENGTHENING TECHNIQUE

- Reinforced concrete (RC) frame structures constructed following outdated seismic codes, or even before seismic codes were published (before 1958), may be vulnerable to loading conditions typical of a seismic event → represent a hazardous risk for its inhabitants.
- A strengthening technique based on the application of thin layers of an Ultra High Ductile Fiber Reinforced Mortar (UHDFRM) on infill masonry walls (Figure 1) of RC frame buildings is being developed in a ongoing research project between CiviTest and UM
- The main purpose of this research is to develop numerical models that will allow to conduct accurate simulations of the behavior of masonry infilled RC frames strengthened by the application of thin layers of an UHDFRM to the infill walls.

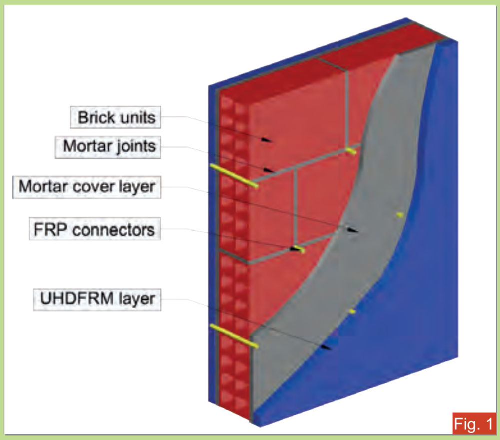


Fig. 1

❑ RESEARCH STRATEGY

- By taking data from experimental tests, advanced numerical tools will be developed and implemented into a FEM-based software, in order to upgrade its capabilities to perform reliable predictions of the behavior of RC frame type structures infilled with masonry walls and strengthened with the proposed technique.
- The experimental program includes the performance of direct shear tests to assess the sliding-opening relationship between UHDFRM and the substrate; push-out and triplet tests to assess the influence of the FRP connectors.
- Prototypes of this type of structures will be tested under representative loading configurations (Figure 2) for tailoring the performance of the computer program in terms of predicting the load carrying capacity, energy absorption and dissipation capacities, and failure modes, before and after have been strengthened.

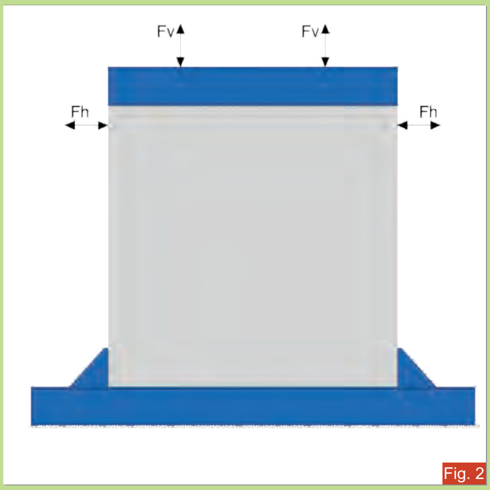


Fig. 2

❑ ACKNOWLEGMETS

- This research is co-funded by CiviTest – Pesquisa de Novos Materiais para a Engenharia Civil, Lda and FCT (SFRH/BDE/96381/2013).

· U C ·

University of Minho
School of Engineering

isise CIVITEST FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

isise Institute for Sustainability and Innovation in Structural Engineering

Trayana Tankova

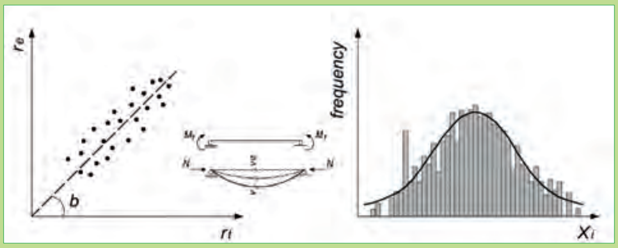
Supervisors: Luís Simões da Silva / Liliana Marques

CONSISTEN SAFETY ASSESSMENT AMONG EUROCODE 3 STABILITY DESIGN RULES FOR STEEL MEMBERS

❑ RESEARCH OBJECTIVES

- ❑ Development of a safety assessment procedure for semi-ductile failure modes of steel structures focused on stability, consistent with other failure modes for steel structures leading to a proposal for the partial factor γ_{M1}^{*} in EC3-1-1;
- ❑ Assessment of the EUROCODE3 stability design rules for columns, beams and beam-columns
- ❑ Extension of the existing analytical models and rules for flexural buckling of web-tapered columns and lateral-torsional buckling of web-tapered beams, to a wider range of loading and cross-section shape combinations;

❑ SAFETY ASSESSMENT OF STABILITY DESIGN RULES ACCORING TO EUROCODE 3

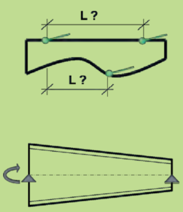


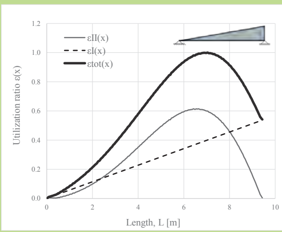
- ❑ Safety assessment procedure in line with the recommendations of EN1990 is developed, as special focus is given to the stability failure modes;
- ❑ Advanced methods for safety assessment are considered;
- ❑ Statistical characterization of basic variables is proposed for material and geometrical properties and imperfections is carried out

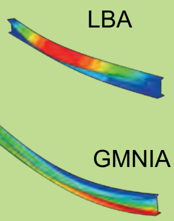
❑ EXPERIMENTAL PROGRAMME ON WEB-TAPERED MEMBERS

- ❑ Experimental tests were carried out on web-tapered columns, beams and beam-columns. The columns were tested for in-plane flexural buckling and the beams for lateral-torsional bucking. The beam-column was tested under major axis bending moment and axial force
- ❑ Material coupon tests. Coupons were extracted from each member (3 coupons from flanges and webs)
- ❑ Geometrical imperfections: advanced laser measurement
- ❑ Residual stresses: test are performed in all columns and beam-column. The residual stresses were measured using the sectioning method

❑EXTENSION OF THE STABILITY DESIGN VERIFICATION TO NON-UNIFORM MEMBERS IN GENERAL







- ❑ The results, conclusions and recommendations from the safety assessment, experiment program are used in order to develop analytically sound design rule for stability design of non-uniform members in general.
- ❑ The proposal is based on interaction equation which is verified in sufficient number of locations along the member length. It makes use of LBA calculations
- ❑ The proposed method is consistent with the EUROCODE3 design rules for columns and beams, applicable to prismatic members

University of Minho School of Engineering

Cofinanciado por: COMPETE 2020 PORTUGAL 2020 UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Institute for Sustainability and Innovation in Structural Engineering

A CUTTING-EDGE RESILIENCE-BASED RISK ASSESSMENT FRAMEWORK FOR EXISTING BRIDGE NETWORKS

Vicente Novo Moreira

Supervisors: José Campos e Matos / Daniel Vitorino Oliveira / Michael Havbro Faber

❑ ABSTRACT

Risk-based assessment has gained major importance during the last decades due to the fact that if critical structures and infrastructures fail, enormous losses (social and economic) are incurred. Hence, structures have to be able to sustain induced damage and to recover from it. Therefore, a resilience-based risk assessment methodology is proposed to quantify the resilience of single structures and infrastructures network in order to achieve such properties.

❑ METHODOLOGY

- **Resilience-based risk assessment framework for bridges' networks, evaluating posterior structural performance, consequences and recovery time for defined target functionality level (Fig. 1);**
- **Development of a Key Performance Indicator (KPI), based on several concepts related to structural resilience, being more emphasis given to the technical domain (structural engineering) (Fig. 2).**

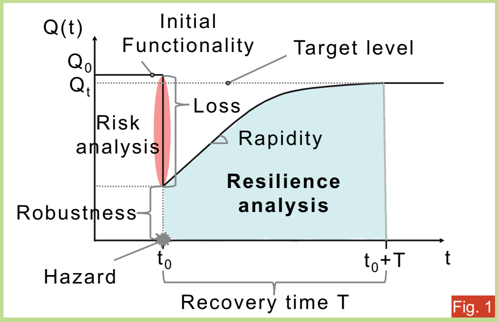


Fig. 1

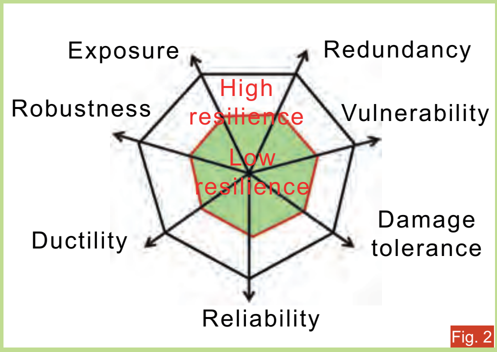


Fig. 2

❑ IMPROVEMENT OF PERFORMANCE-BASED ASSESSMENT

- **In order to achieve the defined functionality level, or performance, technical and spatial conditions are considered into the analysis, namely resourcefulness, rapidity, robustness and redundancy;**
- **Damage-based and risk-based analysis incorporated within the same KPI, at both local and network level, being possible to assess different impacts on communities.**

❑ CONCLUSIONS

- **Structural resilience description and contextualization was successfully carried out and better understanding of this concept was achieved. A radar-graph is proposed for functionality quantification, attending to the technical domain and recovery time;**
- **Risk analysis also incorporated in the framework for direct and indirect losses evaluation, establishing basis for decision-making analysis (stakeholders and other key decision makers).**

University of Minho
School of Engineering

isise Institute for Sustainability and Innovation in Structural Engineering

Worajak JANWAEN

Supervisors: Professor Joaquim António Oliveira de Barros / Dr. Inês Gonçalves Costa

BEHAVIOR OF CFRP-CONFINED RECTANGULAR RC COLUMNS USING A NEW STRENTHENING TECHNIQUE

❑ EXPERIMENTAL RESEARCH

- **In this work a new technique aiming an efficient confinement of reinforced concrete (RC) columns of rectangular cross-section is presented. This technique is based on the concept of applying strips of carbon fiber reinforced polymer (CFRP) wet layup sheets with a certain pre-stress level by using a mechanical system (Fig. 1)**

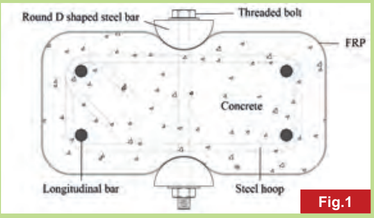
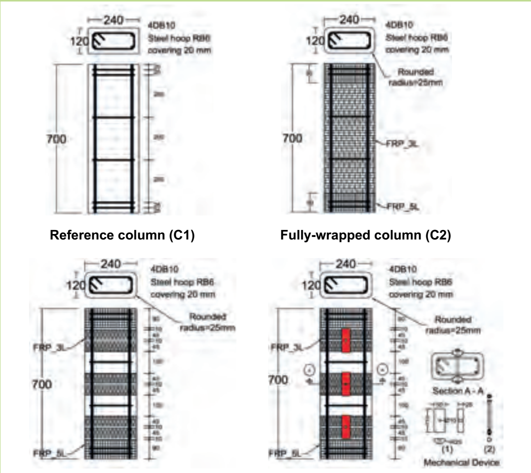


Fig.1

❑ EXPERIMENTAL PROGRAM

- **All specimens in this study have a cross section of 120×240 mm², height of 700 mm, and corner radius of 25 mm.**
- **The experimental program was composed by four types of columns (Fig. 2)**
- **All columns were subjected to axial compressive loading until their failures**



Reference column (C1)

Fully-wrapped column (C2)

Partially-wrapped column (C3)

Column strengthened according to the new technique (C4)

Fig.2

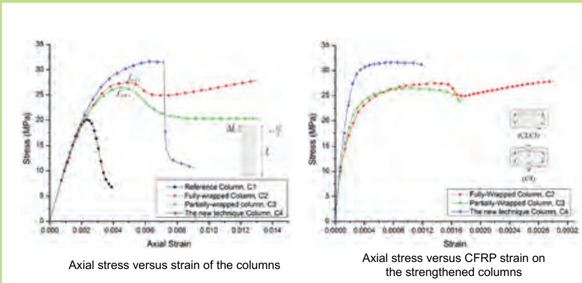
❑ EXPERIMENTAL RESULTS

Column Type	Maximum Load (KN)	Effective cross-section (mm²)	Maximum stress (MPa)	% of stress increase
Reference column (C1)	578	28800.0	20.07	-
Fully-wrapped column (C2)	789	28263.5	27.91	39.06
Partially-wrapped column (C3)	751	28263.5	26.58	32.44
New technique column (C4)	866	27192.3	31.84	58.64

❑ FAILURE MODES

Fig.3

❑ STRESS-STRAIN RESPOND



Axial stress versus strain of the columns

Axial stress versus CFRP strain on the strengthened columns

Fig.4

❑ CONCLUSIONS

- **The new strengthening technique provided a significant increase of the load carrying capacity at both serviceability and ultimate limit states compared to the conventional strengthening techniques**

❑ ONGOING WORK

- **The confinement effectiveness of higher cross section aspect ratios will be investigated**

U C
University of Minho School of Engineering
civiTEST
CASAIS

Institute for Sustainability and Innovation in Structural Engineering

Ziaaddin Zamanzadeh

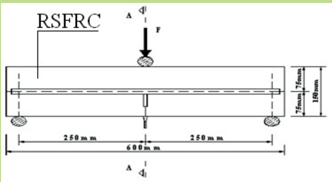
Supervisors: Joaquim Barros / Lúcio Lourenço

CEMENT BASED MATERIALS REINFORCED WITH RECYCLED STEEL FIBRES: MECHANICAL, DURABILITY AND STRUCTURAL PERFORMANCE

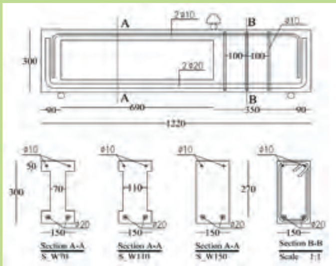
❑ AIM AND OBJECTIVES

- **Characterisation of the post cracking properties of Recycled Steel Fibre Reinforced Concrete (RSFRC).**
- **Assessment of the potentialities of RSF as a shear reinforcement of relatively shallow RC beams.**
- **Design and advanced modelling of RSFRC elements failing in shear and bending.**
- **Development of RSFRM panels (thin cement based mortar panels reinforced with relatively high content of RSF) for structural strengthening.**
- **Design and advanced modelling of RC beams strengthened with RSFRM panels, failing in shear.**

❑ EXPERIMENTAL RESEARCH



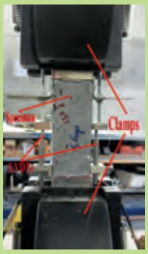
Three point notched beam bending test



Assessment of the potentialities of RSFRC for RC beams failing in shear

The technique used for the production of RSFRM

Compression test



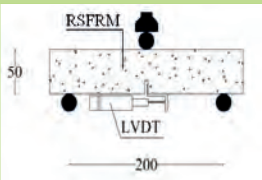
Tensile test

Drying shrinkage

Water absorption by capillarity

Iosipescu test

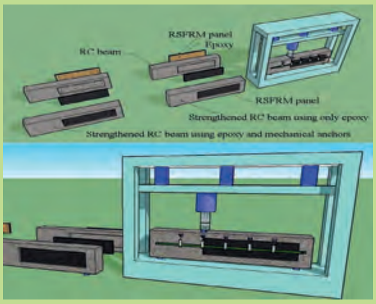
Diffusion of chlorides by migration



Three point bending test

Water absorption by immersion

Permeability to air



Assessment of the potentiality of RSFRM for the shear strengthening of RC beams

❑ CONCLUSIONS

✓**Fibre pull-out was the governing failure model in three point notched beam bending tests.**
✓**Safe predictions of shear capacity were obtained for all the studied cases by using the formulations proposed by RILEM and fib guidelines.**
✓**RSFRM panels were capable of increasing the load carrying and deflection capacity of the tested RC beams.**

University of Minho
School of Engineering

BOOKS

X Congresso Construção Metálica e Mista

Livro de actas do X CMM, Coimbra, Portugal, 26 e 27 de novembro de 2015

Editors: Luís Simões da Silva, Paulo Vila Real, João Rocha de Almeida e Rodrigo Gonçalves

Publisher: CMM – Associação Portuguesa de Construção Metálica e Mista

ISBN: 978-989-99226-1-7

Year: 2015

Editions and print run number per edition: 1st edition | 300 prints

Summary

The X Congress of Steel and Composite Construction took place in a period in which the Portuguese Steel Construction sector has affirmed itself as an engine of innovation and internationalization of the national industry. With a turnover of more than € 2,500 million (2013) and a volume of exports with growth of 30% and 80% of production, we can assure that at present this sector has great vitality, is technologically advanced and has a strong capacity International competitiveness.

CMM thus maintains its commitment to the technological innovation and competitiveness of the sector, aiming to promote a platform of conciliation between all the players in the sector, around a strategy and action program defined for the consolidation of the sector, with the focus in the global market and enhancing the recognition of excellence they hold, contributing decisively to the affirmation of Portuguese Steel Construction worldwide as a sustainable, high quality and innovative construction solution.

The X Steel and Composite Construction Congress is the largest and most relevant national conference of steel and composite construction, it is held biennially and promoted by CMM, and brings together designers, companies of the sector and researchers, with the participation of recognized national and international speakers. Following the previous editions, the X Steel and Composite Construction Congress is again focused on promoting the use of steel and composite construction and taking an active position promoting innovation in the steel construction sector at national and international level. As well as, disseminating the latest innovations in the field of this type of construction and giving the guidelines of research in this field, promoting the exchange of experiences.

As already established in the previous nine editions, the X Congress of Steel and Composite Construction will be composed of Lectures and Scientific Sessions and Technical Sessions, Seminars, Workshops and technical-commercial presentations of the companies present, as well as a Technical Exhibition, which has several companies and relevant entities of the sector, being this a privileged space for the exchange of experiences between the companies and the technicians of the sector.

Following this internationalization strategy and the search for more and new markets, CMM recognizes the importance that the urban rehabilitation of the building can have in the next years for the steel construction sector. We know that one-third of Portuguese buildings are degraded and require urban rehabilitation interventions.
The tenth edition of the Steel and Composite Construction Congress was dedicated to the specific theme of Rehabilitation of the built environment, highlighting the importance of this sector. Urban rehabilitation means that it is recovering and reusing resources and equipment already built, managing in many cases to restore to the city's historic areas that have long been desertified. For national companies in steel construction sector, this action area allows to increase their business in the domestic market of traditional construction, in a period in which the construction and new public works still remain below the expectro.

Luís Simões da Silva
President of CMM e da Organizing Committee of
X Congress of Steel and Composite Construction

Table of Contents

Preface
Commissions
Sponsorships
Conferences
1. Modular design of high-rise buildings
2. New strategies in the seismic of bolted beam-to-column connections
3. Seismic hazard in Portugal and choice of accelerometric registers for analysis of structures
4. Rehabilitation of the Hercílio Cruz Bridge
Communications
1. Steel construction in the oil and mining industry and in the production of renewable energy
2. Architecture and steel
3. Energy efficiency and sustainability in buildings
4. Execution and quality management of steel construction
5. Major Projects
6. Stell and composite bridges
7. Structural safety and performance of new materials and products
8. Industrialized solutions for the construction of buildings

1st International Meeting of the Young Transportations Geotechnics Engineers of the ISSMGE

Proceedings of the 1st YTGE meeting, Guimarães, 4 September, 2016

Editors: Joaquim Tinoco, André Paixão, Cristina Alves Ribeiro

Publisher: University of Minho

ISBN: 978-972-8692-96-4

Year: 2016

Editions and print run number per edition: 1st edition

How to buy: Open access

Online: http://dx.doi.org/10.5281/zenodo.143498

About this book: ebook of Abstracts and Presentations

Summary

The Young Transportations Geotechnics Engineers (YTGE) network was proposed by Prof. A. Gomes Correia in the framework of the 3rd International Conference on Transportation Geotechnics 2016 (3rd ICTG 2016), to be held in Guimarães, Portugal.

The main goal of this network is to increase the attractiveness of transportation geotechnics for younger generations of engineers (less than 35 years old), whilst contributing to strengthen the role of young engineers in society. The network will be responsible for organizing several initiatives for the young community in the field of transportation geotechnics.

The 1st International Meeting of the Young Transportations Geotechnics Engineers of the ISSMGE (1st YTGE meeting), associated with the 3rd ICTG 2016, aims to provide an international forum for doctoral and post-doctoral students as well as research engineers and engineers involved in innovation in transportation geotechnics, to present and discuss their main research results and to identify future research and engineering practice needs.

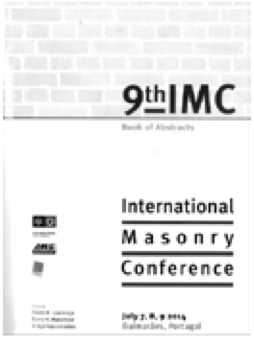
The 1st YTGE meeting, held in Guimarães, Portugal, on September 4, 2016, intended to create a knowledge exchange network and compile what the best and most advanced practices worldwide in the transportation geotechnics field are, either in academic or in industrial domains. It was covered all the disciplines in transportation geotechnics (roads, highways, bridges, airports, railways, waterways, canals and terminals- harbors) under the umbrella of ISSMGE - TC 202. A total of twenty contributions were submitted from all over the world (covering ten different countries). Moreover, the 1st YTGE meeting was attended by thirty eight participants from seventeen different countries.

Table of contents

Sponsors
Preface
1. The Future of Geotechnical Engineering (only some aspects or ideas for thought …)
2. Journal Publishing and the Basket of Metrics
3. A Model Incorporating Large Strain and Nonlinear Soil Properties for PVD-assisted Consolidation
4. Dynamic Nonlinear Finite Element Simulation of Light Falling Weight Deflectometer (LWD) Tests on Unsaturated Road Foundation Layers
5. Evaluation of Granular Material Degradation in Repeated Load Triaxial Test
6. Intelligent Earthworks Optimization System
7. Optimum Design of Unpaved Roads Reinforced With Geotextiles: Comparison of Internationally Published Methodologies
8. Soil-Transition Slab Interaction in Jointless Bridges
9. Some Effects of Fiber Addition on the Behavior of Clean Sands under Cyclic Loadings
10. Testing Soil Compaction – High-speed Measurements of scaled Falling Weights
11. The use of Seismic Wave Velocities in the Evaluation of Stiffness, Damping and Anisotropy of Geomaterials in Routine Laboratory and Field Tests
12. Assessment of the Short and Long Term Behaviour of the Track at a Railway Transition zone
13. Biaxial Fatigue Test for the Utilization of Stabilized Soils in the Subgrades of High Speed Rail Infrastructures
14. Effect of the Soil's Suction History on the Small Strain Behavior
15. Modeling of Lateral Sleeper-ballast Interaction on Rail Track
16. Monitoring Track Defects on a Ballasted High Speed Railway
17. Trend of Research for Transportation Geotechnics in Japan (TC202 Japanese Domestic Committee Activity)
18. Understanding Critical Velocity Effects on High Speed Railways
19. Use of Data Mining Tools for Cut Soil Slope Condition State Identification

9th International Masonry Conference

Proceedings of the 9th International Masonry Conference (9IMC), Guimarães, 07-09 July, 2014



Editors: Paulo B. Lourenço, Barry A. Haseltine, Graça Vasconcelos

Publisher: University of Minho

ISBN: 978-972-8692-85-8

Year: 2014

Editions and print run number per edition: 1st edition | 500 prints

Foreword

The 9th International Masonry Conference took place at University of Minho, Guimarães, Portugal, between 7 and 9 July 2014, co-organized by University of Minho and the International Masonry Society. This Conference series has become one of the most important international events in the masonry world and takes place every four years.

Over 450 participants from more than 40 countries, registered in the conference, which provided a platform for discussion and exchange ideas and to gain new insights on the possibilities and challenges of new and ancient masonry construction. The future of modern masonry and of building conservation is limited only by the designer, contractor or industry inability to adopt a masonry perspective on a building challenge.

The present book includes contributions from authors all over the world in topics such as Innovation for Masonry, Masonry Materials and Testing, Earthquake Resistance, Repair and Strengthening, Conservation and Historic Buildings, Masonry and Building Physics, Architecture with masonry and Case Studies. Special sessions have been organized in Energy Efficiency, Sustainability and eco-materials, Earthen Architecture, and Masonry infills and earthquakes.

We thank all professional engineers and architects, building officials, educators, researchers, students, masonry industry and construction professionals, among other interested in the art and science of masonry, that accepted to exchange their experiences and to contribute to the success of masonry practice, research and innovation. We are sure that the valuable contributions of this book will be a precious guidance for others.

Table of contents

Preface
Committees
Sponsors
Keynote Lectures
1. Architecture with Masonry
2. Analysis of Masonry Structures
3. Case Studies
4. Codes and Standards/Training and Education in Masonry
5. Conservation and Historic Buildings
6. Earthen Construction
7. Earthquake Resistance and Retrofitting
8. Innovation and Sustainability of Masonry
10. Masonry and Building Physics
11. Masonry Materials and Testing
12. New Construction Techniques/Technologies
13. New Developments in Design/Verification
14. Reliability and Performance/Fire Resistance
15. Repair and Strengthening

Advances in Transportation Geotechnics III

Proceedings of the 3rd International Conference on Transportation Geotechnics, Guimarães, 4-7 September, 2016

Editor: António Gomes Correia

Publisher: University of Minho

ISSN: 1877-7058

Year: 2016

Editions and print run number per edition: Vol. 143 (1526pp)

How to buy: Elsevier

Online: http://www.sciencedirect.com/science/journal/18777058/143

About this book/Journal: EI Compendex, SCOPUS, WoS

Summary

The Transportation Geotechnics International Conference series began under the auspices of ISSMGE-TC3 and was initiated in 2008 at the University of Nottingham, UK, as an International event designed to address the growing requirements of infrastructure for societies. The 2nd International Conference on Transportation Geotechnics took place in 2012, at Sapporo, Japan, under the ISSMGE-TC202 that follows the TC3 activities for the period 2009-2013. To continue the success of these conferences and the output of ISSMGE-TC202, the 3rd took place from 4 to 7 September 2016, at the City of Guimarães. Following the previous one, the challenges addressed by this conference included a better understanding of the interactions of geotechnics on roads, rails, airports, harbours and other ground transportation infrastructure with the goal of providing safe, economic, environmental, reliable and sustainable infrastructures.

This Journal, vol. 143 of Procedia Engineering, contains 182 peer-reviewed papers resulting from 292 accepted abstracts from 50 countries and more than 900 authors. All the papers are indexed in SCOPUS and WoS in open access and free for downloading on Procedia Engineering's website: (http://www.sciencedirect.com/science/journal/18777058/143). Addition publications related with this Conference, such as: Keynote Lectures are also available: at (http://www.sciencedirect.com/science/article/pii/S221439121630040X); (http://www.sciencedirect.com/science/article/pii/S2214391216300460), as well as the 1st Proctor Lecture, is on the website of the Transportation Geotechnics journal (http://www.sciencedirect.com/science/article/pii/S2214391216300113). A special Issue of the Transportation Geotechnics Journal (vol. 8, 2016), entitled "Use of Geosynthetics in Transportation Geotechnics", was also part of the material of the Conference and available at: http://www.sciencedirect.com/science/journal/22143912/8.

Table of contents

Preface
Chapter 1: Optimized Geomaterial (including hydraulically bound materials
and asphalt mixtures): Use, Reuse and Recycling
Chapter 2: Unsaturated Soil Mechanics in Transportation Geotechnics
Chapter 3: Foundations and Earth Structures
Chapter 4: Slope Stability, Stabilisation, and Asset Management
Chapter 5: Mechanistic-empirical Design
Chapter 6: Rail Track Substructures, including Transition Zones
Chapter 7: Subsurface Sensing for Transportation Infrastructure
Chapter 8: Macro and Nanotechnology Applied to Transportation Geotechnics
Chapter 9: Sustainability in Transportation Geotechnics
Chapter 10: Case histories

BIM no Departamento de Engenharia Civil: Rumo às necessidades do tecido empresarial

Universidade do Minho, Campus de Azurém, Guimarães, 6 de maio de 2015

Editors: M. Azenha, L. Bidarra

Publisher: University of Minho

Year: 2015

Summary

Information systems have been taking a role of particular importance in the regeneration of the construction sector. In this context, Building Information Modelling (BIM) as a collaborative design methodology has been proving itself as a fundamental tool to provide adequate response to the growing need for process/procedure optimization and improved decision making techniques. The objective of this event, integrated in the III Week of the Civil Engineering Department of the University of Minho, is to demonstrate the potential of utilizing BIM towards the needs of the construction industry.

The event was based on 5 presentations held by students conducting MSc Dissertations at UMinho on subjects related to BIM. An interesting feature of these Dissertation was the intricate connection of all of them with real-case situations and industry partners. The event was held in Portuguese language. In this context, acknowledgements are made to the following companies: Newton, EDP, Modular System, EFACEC, Casais.

The event was organized in coordination with the Students Association of Civil Engineering (University of Minho), in particular by: Tiago Gouveia, José Tiago Oliveira and João Rodrigues.

URL: http://hdl.handle.net/1822/38848

Table of contents

- Programação gráfica aplicada à criação de classes de objetos com geometria complexa – Luís Bidarra
- Implementação de metodologias BIM no contexto do projeto de estruturas de obras hidroelétrica – Alexandre Marques
- A integração de técnicas BIM no projeto e na construção de estruturas de madeira – Vito Lopes
- Classificação e organização de objetos BIM e sua aplicação em modelos 4D e 5D – Ana Quintela
- Aplicação de metodologias BIM no contexto da remodelação/reabilitação: caso de estudo de um edifício industrial – André Lima

IFireSS 2015

Book of abstracts of the International Fire Safety Symposium 2015, University of Coimbra, Coimbra, 20-22 April, 2015

Editors: João Paulo C. Rodrigues, George V. Hadjisophocleous, Luís Laím, Hélder D. Craveiro

Publisher: University of Coimbra

ISBN: 978-989-98435-3-0

Year: 2015

Editions and print run number per edition: 1st edition

Summary

The IFireSS Symposium is a result of the cooperation between CIB's Comission W014 Fire Safety, ALBRASCI and the University of Coimbra (UC) and aims to contribute to the exchange of ideas and knowledge of the best of what is being done in the issue of Fire Safety and plan the future.

The "Conseil International du Bâtiment – CIB" was established in 1953 with the objective to stimulate and facilitate international cooperation and information exchange between governmental research institutes in the building and construction sector. In 1998 the full name CIB changed to "International Council for Research and Innovation in Building Construction". Nowadays, about 500 organizations are members of CIB, from whom about 5000 individual experts participate in over 50 CIB Commissions.

A CIB Commission is a worldwide network of experts in a defined scientific area who meet regularly and who collaborate in international projects and exchange information on a voluntary basis. CIB W014 is a working commission and one of its objectives is to provide the research and exchange of information between members in the topic of Fire Safety. The Organization of the symposium is a way of achieving this objective.

The Luso-Brazilian Association for Fire Safety (ALBRASCI) was established recently by Portuguese and Brazilian experts in the area of Fire Safety to create a platform for the development of Fire Safety in both countries.

The University of Coimbra (UC) is a reference in higher education and research in Portugal, due to the quality of the courses taught and to the advances achieved in pure and applied research in various areas of knowledge.

Table of contents

Sponsors
Preface
Fire Safety of Structures.
Mechanical and Thermal Properties of Materials.
Fire Chemistry, Physics and Combustion.
Fire Reaction.
Smoke Control.
Fire Risk Assessment.
Evacuation and Firefighting.
Fire Regulations, Standardization and Construction Trends.

Construir em Madeira

Proceedings of the Building with Timber Seminar, UMinho, Guimarães, 15 June, 2016

Editors: Jorge M. Branco, Paulo B. Lourenço

Publisher: University of Minho

ISBN: 978-972-8692-92-6

Year: 2016

Editions and print run number per edition: 1st edition

Online: http://www.hms.civil.uminho.pt/events/

Summary

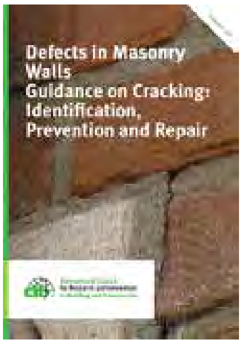
Today, wood and its derivatives are materials with a great renewable potential, reinforced by the current environmental concerns. Nevertheless, these environmental concerns are not the sole leaver when it comes to building by using wood. When put to good use/ when properly applied, wood can be the best solution for building a bridge, a building, for placing a coating (?) or a pavement. Nowadays, there is no valid reason that justifies not studying the possibility of using wood during the planning stage of a construction/when planning a construction. Only a lack of knowledge and information can explain why a wood constructive solution is not foreseen. It is with this mission that this seminar arises as well as this publication. With it, it is our intention to contribute to the enlightenment of the technical and civilian community about the wood building potential. To approach the most current subjects such as the ones connected to energy expenditure, to the use of BIM, high wood buildings or rehabilitation, without forgetting the most controversial aspects when wood is used as a building material such as fire hazard and durability.

Using wood to build is possible, efficient and most desirable for a sustainable world. Now, it only remains to find out if we, as the scientific and technical community, are prepared to face the challenges ahead of us/ to face the challenges of the future.

Table of contents

Sponsors
Preface
1. Safety assessment and strengthening of Ica Cathedral in Peru: the hidden timber skeleton
2. ¿Por qué construir con CLT? Mis experiencias en España desde 2003
3. Definição de nZEB em Portugal – Contributo com base em análises de custo de ciclo de vida
4. As ligações nas estruturas de madeira. Tradicionais e aparafusadas
5. Criptoméria Açoriana – Do inferno ao paraíso
6. Pavimentos de madeira - Conceção, Reabilitação e Reforço
7. BIM aplicado à Construção em Madeira - Parametrização e sistematização de processos num caso prático
8. ttt torre turística transportável – estrutura de madeira polivalente
9. Multistorey building made of CLT: How to design it right?
10. Comportamento a temperaturas elevadas de ligações de madeira pregadas
11. Madeira@Arquitectura

Defects in Masonry Walls. Guidance on Cracking: Identification, Prevention and Repair



Editors: Hipólito Sousa, Ercio Thomaz, Humberto Roman, John Morton, José M. Silva, Márcio Corrêa, Oscar Pfeffermann, Paulo B. Lourenço, Romeu S. Vicente, Rui Sousa, Portugal

Publisher: CIB

ISBN: N/A

Year: 2014

Editions and print run number per edition: 1st edition

Online: http://site.cibworld.nl/dl/publications/pub_403.pdf

Summary
CIB Commission W023 - Structural Walls is fundamentally concerned with masonry, mainly with Codes, Historic Buildings and Seismic Design.
Important concerns have been raised, particularly about the serviceability behaviour of masonry walls, structural or infilling, since it has been realised that there is a need to pay more attention to these aspects, recognising their relation with defects on masonry walls.
A working group: WG1- Serviceability of Masonry Walls was created in 2011 within the Commission with the mission to prepare a guide focused on avoiding cracking defects in masonry walls.
Considering the diversity of masonry uses, this guide was intended to be a concise document, to have general interest and to complement the guidance in structural codes.
The objective is not to deal with the diagnosis of masonry defects, or with the defects associated with seismic or ancient buildings, but to help technicians with its identification, prevention and repair.
The document was prepared by a Panel of Authors, members of CIB Commission W023 and other experts, under the Coordination of Hipólito Sousa, also Convenor of WG1.
The authors are: Ercio Thomaz (Brazil), Hipólito Sousa (Portugal), Humberto Roman (Brazil), John Morton (UK), José M. Silva (Portugal), Márcio Corrêa (Brazil), Oscar Pfeffermann (Belgium), Paulo B. Lourenço (Portugal), Romeu S. Vicente (Portugal) and Rui Sousa (Portugal).
Information about the masonry practices in their countries was also provided by the following experts: Barry Haseltine (UK), Dirk Martens (Netherlands), Erhard Gunkler (Germany), Jan Kubica (Poland), Oliver Dupont (France), Roberto Capozucca (Italy) and Tor-Ulf Weck (Finland). A revision of the English language of the document was made by John Morton (UK) and Barry Haseltine (UK).
The document was approved in general at the Commission meeting in Antwerp (Belgium) in October 2014. It was subsequently subjected to minor adjustments and brought to the attention of all members of the Commission and then published by the CIB Secretariat.

Table of contents
Preface
1 Introduction
1.1 Motivation
1.2 Main Objectives
1.3 Organization
2 Specifics of Walls and Identification of Defects
2.1 Building Masonry Solutions
2.2 Defects in Masonry Walls
2.2.1 General Aspects
2.2.2 Identification of Masonry Cracking
3 Prevention of Cracking in Masonry Walls
3.1 General Cause of Cracking
3.2 Improvement in Serviceability Behaviour
3.2.1 Codes and Design Criteria
3.2.2 Detailing Aspects of Movements and Joints
3.2.3 Permissible Deviations and Tolerances
3.3 Cracking Prevention in Masonry Partition Walls
3.3.1 General
3.3.2 Origin of Defects in Interior Walls (Partitions)
3.3.3 Prevention of Cracks
3.3.4 Calculation of the Deflection
3.3.5 Limitation of the Deflection
3.3.6 Practical Means to Protect Partitions from Cracking
3.4 Cladding Cracking in UK and Ireland
3.5 Brazilian Standards for Prevention of Cracking In Masonry
3.5.1 Introduction
3.5.2 Masonry Deformability
3.5.3 Limits for Dimensions and Cuts in Masonry
3.5.4 Control and Movement Joints
3.5.5 Deflection Limits
3.5.6 Observations Regarding Reinforced Concrete Structures
3.5.7 IPT Recommendations
4 Repair Strategies for Cracking in Masonry Walls
4.1 Problem Assessment and Strategies
4.2 Brazilian Cracking Repair Techniques
4.2.1 Introduction
4.2.2 Prevention and Repair
4.2.3 Repair Methods
4.2.4 Case Study
4.2.5 Remarks
5 Conclusions and Guidance to Prevent and Repair Cracking in Masonry Walls
5.1 General Remarks
5.2 Guidance to Prevent Cracking
5.3 Repair Strategies
5.4 Research Needs

Design of Steel Structures

Eurocode 3: Design of steel structures Part 1-1 – General rules and rules for buildings

Authors: Luís Simões da Silva, Rui Simões and Helena Gervásio

Publisher: ECCS, Wiley and Ernst & Sohn

ISBN: (ECCS) 978-92-9147-134-8
(Ernst & Sohn) 978-3-433-0316-36

Year: 2016

Editions and print run number per edition: 1rd edition, 2010, 2000 ex.; 2nd edition, 2016, 1500 ex.

How to buy: ECCS – European Convention of Constructional Steelwork
CMM – Associação Portuguesa de Construção metálica e Mista

Summary

This book details the fundamental concepts of Eurocode 3, Part 1-1: General rules and rules for buildings and their practical application. Following a discussion of the Eurocode 3 basis of design, including the principles of reliability management and the limit state approach, the steel material standards and their use under Eurocode 3 are detailed.

Structural analysis and modelling are presented in a chapter that will assist the design engineer in the first stages of design. This is followed by a major chapter that provides the design criteria and approaches for the various types of structural members. The theoretical basis and checking procedures are closely tied to the Eurocode requirements, making for a unique presentation of theory into practice. The following chapters expand on the principles and applications of elastic and plastic design of steel structures.

Throughout the book, many design examples presented represent a significant part of the manual. These examples will facilitate the acceptance of the code and provide for a smooth transition from earlier national codes to the Eurocode. This 2nd edition incorporates new material and additional design examples. The new material comprises: i) a revised section dealing with the design for torsion of steel members, including a new worked example illustrating an open cross section beam subject to bending and torsional moments; ii) a revised section on the elastic critical moment of beams; iii) an improved explanation on the classification of cross sections subject to bending and axial force; iv) an additional worked example of a beam-column with transversal loads and end moments; v) a new Annex containing formulas for common torsional cases; vi) a revised and expanded Annex with formulas for elastic critical moment calculation.

Table of contents

Foreword
Preface
1. INTRODUCTION
1.1. General Observations
1.2. Codes of Practice and Normalization
1.3. Basis of Design
1.4. Materials
1.5. Geometric Characteristics and Tolerance
2. STRUCTURAL ANALYSIS
2.1. Introduction
2.2. Structural Modelling
2.3. Global Analysis of Steel Structures
2.4. Classification of Cross Sections
3. DESIGN OF MEMBERS
3.1. Introduction
3.2. Tension
3.3. Laterally Restrained Beams
3.4. Torsion
3.5. Compression
3.6. Laterally Unrestrained Beams
3.7. Beam-Columns
4. ELASTIC DESIGN OF STEEL STRUCTURES
4.1. Introduction
4.2. Simplified Methods of Analysis
4.3. Member Stability of Non-prismatic Members and Components
4.4. Design Example 1: Elastic Design of Braced Steel-Framed Building
5. PLASTIC DESIGN OF STEEL STRUCTURES
5.1. General Principles for Plastic Design
5.2. Methods of Analysis
5.3. Member Stability and Buckling Resistance
5.4. Design Example 2: Plastic Design of Industrial Building
REFERENCES
Annex A. Formulas for common torsional cases
Annex B. Elastic critical moment

Design of Steel Structures - UK EDition

Eurocode 3: Design of steel structures Part 1-1 – General rules and rules for buildings

Authors: Luís Simões da Silva, Rui Simões, Helena Gervásio and Graham Couchman

Publisher: ECCS, Wiley and Ernst & Sohn and SCI

ISBN: (ECCS) 978-92-9147-123-2
(Ernst & Sohn) 978-3-433-0313-53

Year: 2014

Editions and print run number per edition: 1rd edition, 2014, 800 ex.

How to buy: ECCS – European Convention of Constructional Steelwork
CMM – Associação Portuguesa de Construção metálica e Mista

Summary

This book is the first in a series of joint SCI-ECCS publications, a series we believe will be extremely helpful in guiding UK designers through the changes that the Eurocodes represent.

It is a derivative of the general ECCS book "Design of Steel Structures", and includes complementary UK-specific information relating to the National Annexes and common practice. The level of detail provided means this UK edition will help designers, whatever their previous experience, apply Eurocode 3 easily and correctly in the United Kingdom.

The book details the fundamental concepts of Eurocode 3, Part 1-1: General rules and rules for buildings and considers their practical application. Following a discussion of the Eurocode basis of design, including the principles of reliability management and the limit state approach, the steel material standards and their use alongside Eurocode 3 are covered. Structural analysis and modelling are presented in a chapter that will assist the designer in the early stages of that process. This is followed by a major chapter that presents the various design criteria and approaches that should be used for different types of structural member. The format of presentation is uniquely designed to ensure that rules for practical application are a true reflection of the Eurocode theory. The following chapters expand on the principles and application of elastic and plastic design of steel structures. Throughout the book, many design examples are used to facilitate the understanding of the reader and thereby enable a smooth transition from earlier national standards to the Eurocodes.

Table of contents

Foreword
Preface
U.K. Foreword
1. INTRODUCTION
1.1. General Observations
1.2. Codes of Practice and Normalization
1.3. Basis of Design
1.4. Materials
1.5. Geometric Characteristics and Tolerance
2. STRUCTURAL ANALYSIS
2.1. Introduction
2.2. Structural Modelling
2.3. Global Analysis of Steel Structures
2.4. Classification of Cross Sections
3. DESIGN OF MEMBERS
3.1. Introduction
3.2. Tension
3.3. Laterally Restrained Beams
3.4. Torsion
3.5. Compression
3.6. Laterally Unrestrained Beams
3.7. Beam-Columns
4. ELASTIC DESIGN OF STEEL STRUCTURES
4.1. Introduction
4.2. Simplified Methods of Analysis
4.3. Member Stability of Non-prismatic Members and Components
4.4. Design Example 1: Elastic Design of Braced Steel-Framed Building
5. PLASTIC DESIGN OF STEEL STRUCTURES
5.1. General Principles for Plastic Design
5.2. Methods of Analysis
5.3. Member Stability and Buckling Resistance
5.4. Design Example 2: Plastic Design of Industrial Building
REFERENCES
Annex A. Abacus to calculate the coefficients C_1, C_2 and C_3

Design procedures for the use of composites in strengthening of reinforced concrete structures

State-of-the-Art Report of the RILEM Technical Committee 234-DUC

Editors: Carlo Pellegrino, José Sena-Cruz

Publisher: Springer

ISBN: 978-94-017-7335-5

Year: 2016

Editions and print run number per edition: 1st edition

How to buy: Springer, Amazon

RILEM Technical Committee 234-DUC

Composite materials, as FRP (Fiber-Reinforced Polymer), are currently used to repair and strengthen existing reinforced concrete (RC) and prestressed reinforced concrete (PRC) structures both with Externally Bonded (EBR) and, with less diffusion, Near Surface Mounted (NSM) techniques. The structural behaviour of FRP-strengthened RC elements and structures has been widely studied over the last decades and some studies have resulted in the first design guidelines for strengthened concrete. American ACI 440.2R-08 (2008), European fib T.G. 9.3 (2001), Italian Recommendations CNR DT 200 (2004), German, British, Japanese and Canadian documents, are examples of such guidelines (currently under revision due to the continuously increasing knowledge on the topic) but their predictions are sometimes contrasting and disagreeing with experimental results related to particular applications. In this context, the research on FRP strengthened RC elements (both EBR and NSM) is more advanced with respect to masonry, for which the TC MSC is already active, but there are a number of critical issues, typical of RC structures, which are not sufficiently clear. These aspects, synthetically described below, will be treated in the proposed TC.

Despite the number of experimental, analytical and numerical works available in literature aimed at investigating the mechanical performances of RC strengthened elements and structures, design rules for the intervention and procedures aimed at checking the efficiency of the strengthening technique are not well defined yet. In particular the efficiency of the intervention in relation to the existing mechanical and geometric characteristics of the RC structural element, particularly the existing steel reinforcement, does not seem deeply studied.

Summary of the book

This book analyses the current knowledge on structural behaviour of RC elements and structures strengthened with composite materials (experimental, analytical and numerical approaches for EBR and NSM), and the comparison of the predictions of the current available codes/recommendations/guidelines with selected experimental results. The book shows possible critical issues (discrepancies, lacunae, relevant parameters, test procedures, etc.) related to current code predictions or to evaluate their reliability, in order to develop more uniform methods and basic rules for design and control of FRP-strengthened RC structures. General problems/critical issues are clarified on the basis of the actual experiences, detect discrepancies in existing codes, lacunae in knowledge and, concerning these identified subjects, provide proposals for improvements. The book will help to contribute in promoting and consolidating a more qualified and conscious approach towards rehabilitation and strengthening existing RC structures with composites and their possible monitoring.

Table of contents

1. Introduction
2. Design by Testing and Statistical Determination of Capacity Models
3 Bond Between EBR FRP and Concrete
4 Shear Strengthening of RC Elements by Means of EBR FRP
5 Confinement of RC Elements by Means of EBR FRP Systems
6 Special Problems
7 Prestressed FRP Systems
8 NSM Systems
9 Fiber Reinforced Composites with Cementitious (Inorganic) Matrix

Dimensionamento de Estruturas de Aço

Comparação entre o Eurocódigo 3 e a Norma Brasileira NBR8800


Authors: Luís Simões da Silva, Rui Simões, Helena Gervásio, Pedro Vellasco e Luciano Lima

Publisher: ECCS e ed. uerj

ISBN: 978-85-7511-399-8

Year: 2016

Editions and print run number per edition: 1rd edition, 2016, 500 ex.

How to buy: ECCS – European Convention of Constructional Steelwork
CMM – Associação Portuguesa de Construção metálica e Mista

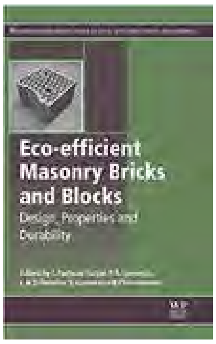
Summary

This book is the first in a series of joint Brazil – Portugal publications, a series we believe will be extremely helpful in guiding the Brazilian structural engineers through the changes that the Eurocodes represent. It is a derivate of the general ECCS book "Design of Steel Structures" and includes specific information relating to the Brazilian Standard NBR8800.
According to the objectives of the ECCS Eurocode Design Manuals, this book aim to provide a "simple" theoretical basis and a description of the design proceedings and detailed design examples.
Consequently, this book is more than a manual: it details the fundamental concepts of Eurocode 3, and considers their practical application that intends to represent real design situations instead of the simplified examples usually found in most books of structural design.
General topics are covered, such as the general principles of design, material properties, geometrical characteristics and tolerances, methods of analysis, the design criteria for steel structural members subjected to internal forces (tensile, shear and bending, compression and torsion).
The Portuguese Edition of this book also includes a presentation of the design proceedings presented in the Brazilian Standard NBR 8800 for the design of steel structures and composite structures for buildings. As additional contribution, all design examples previously solved according to Eurocode 3, are now presented according to the standard NBR8800, to facilitate a critical analysis of these two important standards for the structural design in steel.

Table of contents

Foreword
Preface
1. INTRODUCTION
1.1. General Observations
1.2. Codes of Practice and Normalization
1.3. Basis of Design
1.4. Materials
1.5. Geometric Characteristics and Tolerance
2. STRUCTURAL ANALYSIS
2.1. Introduction
2.2. Structural Modelling
2.3. Global Analysis of Steel Structures
2.4. Classification of Cross Sections
3. DESIGN OF MEMBERS
3.1. Introduction
3.2. Tension
3.3. Laterally Restrained Beams
3.4. Torsion
3.5. Compression
3.6. Laterally Unrestrained Beams
3.7. Beam-Columns
4. ELASTIC DESIGN OF STEEL STRUCTURES
4.1. Introduction
4.2. Simplified Methods of Analysis
4.3. Member Stability of Non-prismatic Members and Components
4.4. Design Example 1: Elastic Design of Braced Steel-Framed Building
5. PLASTIC DESIGN OF STEEL STRUCTURES
5.1. General Principles for Plastic Design
5.2. Methods of Analysis
5.3. Member Stability and Buckling Resistance
5.4. Design Example 2: Plastic Design of Industrial Building
REFERENCES

Eco-efficient Masonry Bricks and Blocks: Design, Properties and Durability



Editors: Fernando Pacheco-Torgal, Paulo B. Lourenco, Joao Labrincha, P Chindaprasirt, S Kumar

Publisher: Woodhead Publishing

ISBN: 978-1782423188
Year: 2014

Editions and print run number per edition: 1st edition
How to buy: www.elsevier.com

Online: https://www.elsevier.com/books/eco-efficient-masonry-bricks-and-blocks/pacheco-torgal/978-1-78242-305-8

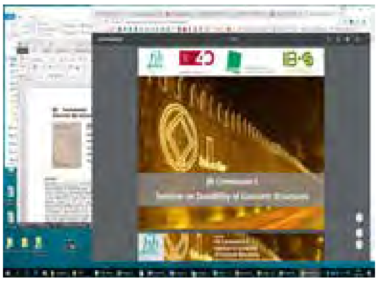
Summary
Masonry walls constitute the interface between the building's interior and the outdoor environment. Masonry walls are traditionally composed of fired-clay bricks (solid or perforated) or blocks (concrete or earth-based), but in the past (and even in the present) they were often associated as needing an extra special thermal and acoustical insulation layer. However, over more recent years investigations on thermal and acoustical features has led to the development of new improved bricks and blocks that no longer need these insulation layers. Traditional masonry units (fired-clay bricks, concrete or earth-based blocks) that don't offer improved performance in terms of thermal and acoustical insulation are a symbol of a low-technology past, that are far removed from the demands of sustainable construction.
This book provides an up-to-date state-of-the-art review on the eco-efficiency of masonry units, particular emphasis is placed on the design, properties, performance, durability and LCA of these materials. Since masonry units are also an excellent way to reuse bulk industrial waste the book will be important in the context of the Revised Waste Framework Directive 2008/98/EC which states that the minimum reuse and recycling targets for construction and demolition waste (CDW) should be at least 70% by 2020. On the 9th of March 2011 the European Union approved the Regulation (EU) 305/2011, known as the Construction Products Regulation (CPR) and it will be enforced after the 1st of July 2013. The future commercialization of construction materials in Europe makes their environmental assessment mandatory meaning that more information related to the environmental performance of building materials is much needed. Key Features:

- Provides an authoritative guide to the eco-efficiency of masonry units
- Examines the reuse of waste materials
- Covers a range of materials including, clay, cement, earth and pumice
- Readership
- Civil engineers, contractors working in construction and materials scientists working both in industry and universities

Table of contents

1. Introduction to eco-efficient masonry bricks and blocks
2. The design and mechanical performance of high-performance perforated fired masonry bricks
3. Influence of large and highly perforated fired-clay bricks in the improvement of the equivalent thermal transmittance of single-leaf masonry walls
4. Traditional fired-clay bricks versus large and highly perforated fired-clay bricks masonry: influence on buildings thermal performance
5. The properties and durability of clay fly ash-based fired masonry bricks
6. Types of waste, properties, and durability of pore-forming waste-based fired masonry bricks
7. Types of waste, properties and durability of toxic waste-based fired masonry bricks
8. The properties and durability of high-pozzolanic industrial by-products concrete masonry blocks
9. The properties and durability of autoclaved aerated concrete masonry blocks
10. The design, properties, and performance of concrete masonry blocks with phase change materials
11. The design, properties and performance of shape optimized masonry blocks
12. The properties and durability of fly ash-based geopolymeric masonry bricks
13. The properties and durability of mine tailings-based geopolymeric masonry blocks
14. The properties and performance of red mud-based geopolymeric masonry blocks
15. Design and properties of fly ash, ground granulated blast furnace slag, silica fume and metakaolin geopolymeric based masonry blocks
16. The properties and durability of adobe earth-based masonry blocks
17. The properties of compressed earth-based (CEB) masonry blocks
18. The durability of compressed earth-based masonry blocks
19. Topology optimization for the development of eco-efficient masonry units
20. Environmental performance and energy assessment of fired-clay brick masonry
21. Assessment of the energy and carbon embodied in straw and clay masonry blocks
22. Earth-block versus sandcrete-block houses: embodied energy and CO2 assessment

fib Commission 5: Seminar on Durability of Concrete Structures



Editors: José Campos e Matos, Miguel Azenha, José Granja, Hugo Guimarães, Brett Pielstick

Publisher: University of Minho

ISBN: 978-972-8692-82-7

Year: 2014

Editions and print run number per edition: 1st edition

Online: https://repositorium.sdum.uminho.pt/handle/1822/30869

Summary

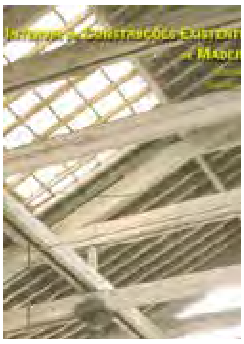
Commission 5 and the fib in conjunction with the Minho University are pleased to provide this seminar on the Durability of Concrete Structures. Commission 5 is one of about ten Commissions organized by the fib that gather experts in the field from across the world to collaborate and develop state of the art and technical reports as well as codes for the advancement of durability practices for the industry worldwide. This first of its kind seminar will provide unique access to these experts and the current and past work done within Commission 5 along with topics from these experts individual research and work applying durability principles to practice. Durability is a key component to the sustainability of concrete structures and serves a vital role in the design, construction and rehabilitation of these structures. We have also invited several distinguished local speakers to participate and provide there insight to the local industry. We invite you to participate in this unique experience and training that we hope will spark a desire for further research in durability of concrete structures and the application of these principle in everyday practice.

Table of contents

1. Durability Survey of Concrete and Segmental Bridges in America
2. An owner's perspective on probabilistic approaches for durability design
3. Corrosion prevention in marine concrete structures. Relevance of monitoring systems
4. fib Influence on CIA Durability Recommended Practice Notes
5. Benchmark for Deemed-To-Satisfy Rules
6. Durability Design of Reinforced Concrete Members being Repaired
7. Use of management systems for an optimized schedule of repair actions
8. Status of TG 5.13 - Corrosion Influence on Durability
9. ISO 16204 "Durability – Service Life Design of Concrete Structures" Norwegian field Studies on Carbonatinon and Chloride ingress
10. Birth Certificate Document

Intervir em Construções Existentes de Madeira

Proceedings of the Intervening in Existing Timber Constructions Seminar, UMinho, Guimarães, 05 June, 2014



Editors: Paulo B. Lourenço, Jorge M. Branco, Hélder S. Sousa

Publisher: University of Minho

ISBN: 978-972-8692-86-5

Year: 2014

Editions and print run number per edition: 1st edition

Online: http://www.hms.civil.uminho.pt/events/intervir_madeira

Summary

Throughout Europe, the presence of timber structures is an inescapable aspect of the built heritage and they are endowed for many reasons with a great historical, architectural and social value. However, despite their unquestionable value, sometimes existing timber structures require different intervention measures in order to ensure their safety and preservation. The reasons to intervene are numerous, from the inadequate maintenance of these structures to the need for safety analysis or reinforcement to mitigate the effects of damages and pathologies, or even a new use for the structure.

The analysis and diagnosis of existing buildings is a complex challenge requiring specialized knowledge from different sources and technical areas, especially in timber structures where a perfect understanding of the structural systems, material properties and performance is required.

In Portugal, intervention and rehabilitation works are still in a small numbers when compared with their recognized market potential, and this is also due to the scarce knowledge and training of specialized personnel. This fact is even more pronounced for the analysis, design and planning of interventions, whose teaching process has been neglected to the detriment of other construction materials. However, there is currently the intention to reverse this process and there is an increased interest in the maintenance, rehabilitation and intervention of existing timber structures, as well as to the construction of new buildings, taking into account the performance of these structures when they are subject to different types of demands.

This publication brings together contributions from various national and international experts. The contributions cover different aspects in the field of intervention in existing timber constructions, covering the components of structural and architectural inspection and analysis, and highlighting the measures and actions of restoration, recovery, rehabilitation and reinforcement, in order to present the best practices and new solutions available for the conservation and maintenance of timber constructions, guaranteeing high levels of performance, energy efficiency and sustainability in the built heritage. Several interventions in existing timber structures, carried out at national and international level, are presented, as well as new technologies and methods to be applied on recent structures.

Table of contents

Sponsors
Preface
1. Edifícios Pombalinos: Comportamento e reforço
2. Intervenções em coberturas medievais em madeira: Tradição e contemporaneidade
3. Conhecer a madeira como base de suporte a ações de reabilitação
4. Utilização e comercialização de madeira modificada
5. Nuevos barnices al agua para maderas de exterior: Alta durabilidad y fácil mantenimiento
6. Da inspeção à avaliação de segurança na reabilitação de estruturas de madeira
7. Reforço de elementos existentes de madeira
8. As estruturas tradicionais de madeira antes e agora - Análise de alguns exemplos de recuperação
9. Intervenções no património edificado - Castelo dos Mouros, Sintra
10. Construções em madeira - Vantagens plásticas na reabilitação
11. Restoration of historical timber structures - Criteria, innovative solutions and case studies

1º Congresso Português de Building Information Modelling

Livro de atas do 1º Congresso Português de Building Information Modelling, Universidade do Minho, Guimarães, 24-25 de novembro de 2016

Editors: M. Azenha, J.P. Martins, J.L. Granja

Publisher: Universidade do Minho

ISBN: 978-989-8793-04-1

Year: 2016

Summary

The growing importance of digital representation of construction elements brought about by 'Building Information Modelling' (BIM) is introducing very important changes in design, construction and facilities management. These digital processes are introducing new paradigms of relationship between the involved stakeholders with significant impact on workflow development.

The objective of the PTBIM conference series is to promote a discussion forum in Portuguese language, involving active participation by both professional and academic communities in Architecture and Engineering.
This first Edition of PTBIM took place in the Campus of Azurém of the Univeristy of Minho (24 and 25 November 2016), with 52 papers and more than 200 enrolled participants.

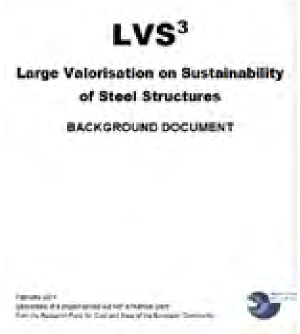
Even though the event took place at the University of Minho, in synergy between the Schools of Engineering and Architecture, it is important to mark the integrative character of this conference at the organizational level, with participation and support of several Higher Education Institutions: Faculty of Engineering of the University of Porto, Faculty of Architecture of the University of Porto and Technical University of Lisbon. It is also very important to address the engagement of the National Engineers and Architects Associations ('Ordem dos Engenheiros' and 'Ordem dos Arquitectos')

Table of contents

The proceedings have a total of 52 papers and can be downloaded for free in www.ptbim.org .

LVS³ Background Document

Large Valorisation on Sustainability of Steel Structures



Authors: H. Gervásio, P. Santos, L. Simões Da Silva, O. VASSART, A.L. Hettinger & V. Huet

Publisher: ECCS Press

ISBN: 978-92-9147-124-9

Year: 2014

Editions and print run number per edition: 1st edition

Online: pdf free online, http://sustainable-steel.eu/

Summary

The aim of this document is to provide in-depth information on the development and validation of life cycle methodologies focussing on the life cycle assessment of steel structures. This document was created in the framework of the dissemination project LVS3: Large Valorisation on Sustainability of Steel Structures (RFS2-CT-2013-00016).

This document focuses on two complementary methodologies:

(i) the macro-components approach, addressing the life cycle assessment of buildings and/or building components but excluding the quantification of energy in the use stage of a building;
(ii) an approach focussing on the use stage of a building and enabling the quantification of the operational energy of buildings.

Both approaches were developed and validated within the scope of the European RFCS project SB_Steel: Sustainability of Steel Buildings (SB_Steel, 2014).

The adopted approaches were implemented into available software tools in the scope of the current project LVS3. The former was implemented into LCA calculator, a tool developed by the University of Coimbra (Portugal) together with ECCS for iPad and iPhone applications; and AMECO, a tool developed by ArcelorMittal and CTICM. The latter was implemented by CTICM into AMECO.

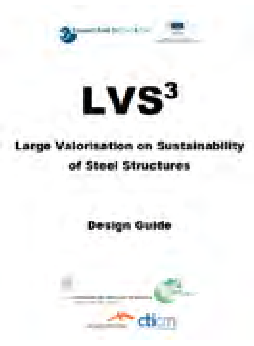
The document is divided into three main parts. In the first part (Chapter 2), a brief introduction to life cycle thinking is provided, followed by the presentation of different approaches for the sustainability assessment of buildings and by a description of the general framework of life cycle analysis, according to international standards. Then, the second part of this document (Chapter 3) provides a detail description of the adopted approaches for the assessment of life cycle environmental impacts and for the evaluation of the energy needs of a building during its operational life. Finally, in the last part of this document (Chapter 4), a case study is introduced, which was used for the validation of the adopted approaches.

Table of contents

1. Introduction
2. Life Cycle Assessment of Buildings
3. Simplified Methodologies for Building Assessment
4. Validation of Adopted Methodologies
REFERENCES
APPENDIX 1 – Database Of Macro-Components

LVS^3 Design Guide

Large Valorisation on Sustainability of Steel Structures



Authors: V. Huet, P. Santos, O. Vassart, A.L. Hettinger & H. Gervásio

Publisher: ECCS Press

ISBN: 978-92-9147-124-6

Year: 2014

Editions and print run number per edition: 1st edition

Online: pdf free online, http://sustainable-steel.eu/

Summary

The aim of this document is to provide information on the different steps used for the environmental assessment of steel and composite buildings in Ameco software.

The document was created in the scope of the dissemination project LVS3: Large Valorisation on Sustainability of Steel Structures (RFS2-CT-2013-00016). The Design Guide focuses on:

- A description of the calculation process: the technical specifications detail the successive steps used for the environmental assessment of buildings used in AMECO software;
- A guidance on the use of AMECO tool;
- Application of AMECO on case studies.

The approaches used in the software were developed and validated within the scope of the European RFCS project SB-Steel: Sustainability of Steel Buildings (SB_Steel, 2014).

These complementary methodologies are:

- the macro-components approach, addressing the life cycle assessment of buildings and/or building components but excluding the quantification of energy in the use stage of a building;
- an approach focussing on the use stage of a building and enabling the quantification of the operational energy of buildings.

The document "Background document", also deliverable of the RFCS LVS3 project, provides the detailed description of the adopted approaches: for the assessment of life cycle environmental impacts and for the evaluation of the energy needs of a building during its operational life.

Table of contents

1. Introduction and aim
2. Computer code and environment
3. General features of the program AMECO3
4. Technical description
5. Software output
6. Guidance on the Use of AMECO3 software
7. Case studies
8. References

Manual de Dimensionamento de Estruturas Metálicas

Eurocódigo 3: Projeto de Estruturas Metálicas, Parte 1-1: Regras gerais e regras para edifícios

Author: Rui António Duarte Simões

Publisher: CMM – Associação Portuguesa de Construção metálica e Mista

ISBN: 978-989-95605-9-8

Year: 2014

Editions and print run number per edition: 1rd edition, 2005, 1500 ex.; 2nd edition, 2007, 2500 ex; 3rd edition, 2014, 1024 ex.

How to buy: CMM – Associação Portuguesa de Construção metálica e Mista

Summary

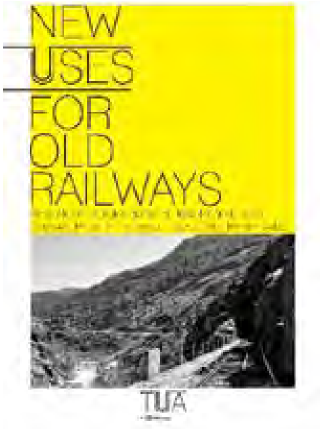
The present book, entitled by Manual of Design of Steel Structures, contains the basic theoretical concepts, as well as the main provisions and code rules applicable to the analysis and design of steel members (columns, beams, truss bars, among others) isolated or when inserted in structures. In addition to providing the theoretical concepts needed for a complete understanding of the involved phenomena, the book is an useful tool to support the application of the new European regulations for the analysis and design of steel structures - Eurocode 3: Design of Steel Structures, Part 1 -1: General rules and rules for buildings. In order to fulfill this objective, at the end of each chapter several solved examples are presented. These examples cover the analysis of steel structures and the design of members with several shapes, produced by different processes and submitted to different types of internal forces (axial force, bending moment, shear force and torsion), acting alone or combined.

This book is unique in portuguese language, being nowadays used by civil engineers and students of civil engineering in the main portuguese engineering universities and engineering offices. It is the first book of a serie of technical books published by CMM – The Portuguese Steelwork Association. Since the first edition, published in 2007, the book has been improved adding more contents and some new examples and performing several updates, taking into account the evolution of the eurocodes and the implementation of the national annexes.

Table of contents

Foreword
Acknowledgments
Symbology
1. General Concepts
1.1 Contents and objective
1.2 Regulation
1.3 Basis of design
1.4 Mechanical characterization of materials
1.5 Geometrical characterization
2. Analysis of Steel Structures
2.1 Global analysis of steel structures
2.2 First order analysis and second order analysis
2.3 Imperfections
2.4 Structural stability
2.5 Joint behavior
2.6 Cross section classification
2.7 Type of analysis
2.8 Examples
3. Design of Steel Members
3.1 General design criteria
3.2 Tension
3.3 General plasticity concepts
3.4 Design of restrained beams
3.5 Torsion
3.6 Compression
3.7 Design of unrestrained beams
3.8 Design of beam-columns
References

New uses for old railways



Editors: Anne McCants, Eduardo Beira, José Manuel Lopes Cordeiro, Paulo B. Lourenço, Hugo Silveira Pereira

Publisher: Inovatec, Lda

ISBN: 978-153-36963-0-4

Year: 2016

Editions and print run number per edition: 1st edition

How to buy: www.amazon.com

Online: https://www.amazon.com/New-uses-railways-Anne-McCants/dp/1533696306

Summary

Throughout the first half of the twentieth century the railway line of Tua / Bragança - begun in 1883, completed the first step (Mirandela) in 1887 and the second leg (Bragança) in1906 - was the "great highway" for the transport of people and goods in and out of the region of the upper Douro River, home to the viticulture made world famous in Port wine. This feat of mountain engineering, and the first railroad built by Portuguese engineers and contractors, allowed a previously remote region easy access to the city of Porto and hence to the mainland of Portugal (beyond Marão, the mountains that lay between the region and the litoral area), and on to the wider world. One hundred years later this heritage and memory deserves to be retrieved, recorded, analyzed and disseminated. Those involved in both economic growth and regional development can learn from the lessons of the past and must build upon it.

This project intends to challenge the academic community to study one century-long history of railways and development in a peripheral region (Trás os Montes) of a peripheral country. To publicize the memory and the "stories" of the line and to discuss its role in the region and enhance its common heritage, an integrated, interdisciplinary, "apolitical" project about the history and memory of the line may join the communities related to Tua valley. Tua line and its regional role have not been studied, but they deserve further attention.

The region has known a remarkable development during the second half of twentieth century. It is also an opportunity to dwell its recent history.

To this end, scholars of various aspects of railroad history were brought together to share their research on the experiences of other railroad projects, in terms of their decision-making processes, the management of labor, technical difficulties to overcome, or the economic and social impact of completed lines.

Table of contents

Introduction: rusty tracks and what to do with them, Ellan Fei Spero, Hugo Silveira Pereira

PART 1: RUSTY TRACKS AS HERITAGE

1.1 Railways Heritage: an overview, Günter Dinhobl

1.2 From railways to heritage: the closure of railway lines in Spain and their valorisation as a cultural good, Domingo Cuéllar

1.3 Railways: industrial and maritime archaeology, geographic information systems, history and culture, Dominic Fontana

1.4 A new age of steam? The Tua valley line, Portugal: experience and examples from the technological heritage operations and preserved railways of Britain, Dominic Fontana

1.5 Two case-studies in heritage and valorisation of old mountain railways in France, Michel Cotte

1.6 Railways and tourism in Italy, Stefano Maggi

PART 2: NEW APPROACHES TO OLD RAILWAYS

2.1 Opening of mountainous and peripheral regions by main and branch railway lines, Günter Dinhobl

2.2 Exploring cultural landscape with old railway tracks, Stefan Brauckmann

2.3 Vanishing tracks: short history of a cancelled line, Ivona Grgurinović

2.4 Remembering railway's past, conjuring up its future: what rail hikers have in mind while walking on rusty tracks, Peter F. N. Hörz

2.5 Dismantling an old rail track: opportunities in the Tua Valley, Paulo B. Lourenço, Graça Vasconcelos, Lurdes Martins

PART 3: PRACTICAL APPLICATIONS

3.1 Redesigning the classical Railrider: a transportable prototype for modern ages, Carlos Barbosa, João Figueiredo, Jorge Marques, Lídia Teixeira, Miguel Oliveira, Eduardo Beira, António Araújo

3.2 The Old Road: reusing, interpreting and commemorating an abandoned railway in southern England, 1964–2015, Colin Divall

3.3 Life, death and resurrection: further examples from the British experience of preserving railway and industrial heritage, Dominic Fontana

3.4 Draisine tourism in Germany: ideas for the Tua line?, Stefan Brauckmann

3.5 An example of renovation: adaptation of an old railway mountain line – the Chemin De Fer de l'Ardèche (South-Eastern France), Michel Cotte

Paredes de Alvenaria

Proceedings of the 4th Seminar on Masonry Walls (Paredes 2015), Lisboa, 18 June, 2015

Editors: Paulo B. Lourenço, Fernando Pinho, Graça Vasconcelos, Válter Lúcio

Publisher: University of Minho

ISBN: 978-972-8692-91-9

Year: 2015

Editions and print run number per edition: 1st edition | 300 prints

Foreword

The Seminar Masonry Walls: Rehabilitation and Innovation, took place at New University of Lisbon, Portugal, at June 18, and it was co-organized by University of Minho and the New University of Lisbon. This Seminar series has become regular each four years. Over 300 participants from distinct areas, namely architecture and engineering, provided a platform for discussion and exchange ideas and to gain new insights on the possibilities and challenges of new and ancient masonry walls.

The present book includes contributions from Portuguese specialists which have evidenced in engineering and architecture areas, namely in the building of emblematic masonry structures, structural rehabilitation of historical constructions, research and technology of masonry construction.

We thank all professional engineers and architects, building officials, educators, researchers, students, masonry industry and construction professionals, among other interested in the art and science of masonry, that accepted to exchange their experiences and to contribute to the success of masonry practice, research and innovation. We are sure that the valuable contributions of this book will be a precious guidance for others.

Table of contents

Preface
Committees
Sponsors
Lectures

1. Integrated vision of rehabilitation
2. Natural hydraulic Lime mortar in new materials
3. The rehabilitation and strengthening of connection in ancient buildings- The emergent solutions.
4. Behavior of stone masonry walls
5.Optimzed solutions for rehabilitation of residential building to achieve NZEB
6. Matter in architecture: Project with industry
7. Masonry infill walls and the seismic action: Rehabilitation and innovation
8. Thermal insulation of masonry Wall. Innovation, rehabilitation and fire performance
10. Seismic behavior of masonry: Recent experimental investigation
11. Solutions for masonry walls and new standards: thermal and acoustic insulation
12. Building with compacted earth blocks in seismic regions

RILEM TC-CMS Workshop: Cracking of massive concrete structures

Workshop proceedings e-book, Paris, France, 17 March, 2015

Editors: E. Fairbairn, M. Azenha, F. Benboudjema, A. Darquennes, A. Knoppik-Wróbel

Publisher: ENS Cachan - RILEM

ISBN: 978-2-35158-155-1

Year: 2015

Summary

The workshop on ”Cracking of massive concrete structures”, held on 17 March 2015 in Cachan, France, was organised by École normale supérieure de Cachan (ENS-Cachan), supported by Ecole Française du Béton. It was dedicated to the problems of early-age cracking in massive concrete structures.

The aim of the workshop was to establish an international forum of experts and promote discussion as well as exchange of knowledge in the domain of early-age behaviour of concrete structures.

Hereby we present the proceedings of the CMS Workshop. TC 254-CMS ‘Thermal Cracking of Massive Concrete Structures’ is framed within Cluster C of RILEM TC’s and it was proposed by Eduardo Fairbairn in 2013 (chair of the TC). The secretary of the TC is Miguel Azenha.

The subject matter of this TC is initially centred in establishing a state-of-the-art-report (STAR) on principles, criteria, methods and technologies applied worldwide to control thermal cracking in mass concrete, such as concrete dams, nuclear power plants, massive foundations, and massive members of concrete structures (including those in which cracking risk does not arise from large volumes of concrete). The TC also targets the establishment of guidelines on how to analyse and to control the risk of thermal cracks in mass concrete.

Even though this TC was initially targeted towards specific interests within the Latin-American Regional Group of RILEM (Lat-RILEM), it quickly attracted the attention of several members worldwide, thus exerting activity in the global scenario. The predicted life-span of the TC is 5 years.

Table of contents

Fairbairn E.: Case studies of massive concrete constructions: hydroelectric and nuclear power plants. p. 5

Knoppik-Wróbel A.: Degree of restraint concept in analysis of early-age stresses in concrete walls. p. 139

Koenders E. A. B.: Internal visco-elastic modulus for stress analysis of early-age concrete. p. 172

Grondin F., Loukili A.: Progress in the consideration of the microstructure effects on the aging behaviour of concrete. p. 201

Azenha M., Granja J.: Characterization of concrete properties at early ages: Case studies of the University of Minho. p. 239

Staquet S. et al.: Shrinkage induced cracking risk of concrete. p. 275

Briffaut M. et al.: Ring test for early cracking sensitivity of FRC: application on tunnel lining. p. 337

Kuperman S.: Avoiding thermal cracks in mass concrete: problems, solutions and doubts. p. 364

Benboudjema F. et al.: Issues on modelling cracking of massive concrete structures at early-age. p. 413

Buffo-Lacarrière L., Sellier A.: Early age modelling of low-pH concrete: Application to the behaviour of nuclear waste storage structures. p. 443

Honorio de Faria T. et al.: Modelling the mechanical behavior at early-age: influence of the boundary conditions at the structure scale and multiscale estimation of ageing properties. p. 480

Izoret L.: Is there more risk of cracking with today’s cements than with yesterday’s cements?

IFireSS 2015

Proceedings of the International Fire Safety Symposium 2015, University of Coimbra, Coimbra, 20-22 April, 2015

Editors: João Paulo C. Rodrigues, George V. Hadjisophocleous, Luís Laím, Hélder D. Craveiro

Publisher: University of Coimbra

ISBN: 978-989-98435-3-4

Year: 2015

Editions and print run number per edition: 1st edition

Summary

The IFireSS Symposium is a result of the cooperation between CIB's Comission W014 Fire Safety, ALBRASCI and the University of Coimbra (UC) and aims to contribute to the exchange of ideas and knowledge of the best of what is being done in the issue of Fire Safety and plan the future.

The "Conseil International du Bâtiment – CIB" was established in 1953 with the objective to stimulate and facilitate international cooperation and information exchange between governmental research institutes in the building and construction sector. In 1998 the full name CIB changed to "International Council for Research and Innovation in Building Construction". Nowadays, about 500 organizations are members of CIB, from whom about 5000 individual experts participate in over 50 CIB Commissions.

A CIB Commission is a worldwide network of experts in a defined scientific area who meet regularly and who collaborate in international projects and exchange information on a voluntary basis. CIB W014 is a working commission and one of its objectives is to provide the research and exchange of information between members in the topic of Fire Safety. The Organization of the symposium is a way of achieving this objective.

The Luso-Brazilian Association for Fire Safety (ALBRASCI) was established recently by Portuguese and Brazilian experts in the area of Fire Safety to create a platform for the development of Fire Safety in both countries.

The University of Coimbra (UC) is a reference in higher education and research in Portugal, due to the quality of the courses taught and to the advances achieved in pure and applied research in various areas of knowledge.

Table of contents

Sponsors
Preface
Fire Safety of Structures.
Mechanical and Thermal Properties of Materials.
Fire Chemistry, Physics and Combustion.
Fire Reaction.
Smoke Control.
Fire Risk Assessment.
Evacuation and Firefighting.
Fire Regulations, Standardization and Construction Trends.

Reabilitação de Fachadas

Proceedings of the Seminar on Rehabilitation of Façades, Guimarães, 22 September

Editors: Graça Vasconcelos, Paulo B. Lourenço,

Publisher: University of Minho

ISBN: 978-972-8692-94-0

Year: 2016

Editions and print run number per edition: 1st edition | 150 prints

Foreword

The Seminar Rehabilitation of Façades, took place at University of Minho, Portugal, at September 22, and it was co-organized by University of Minho.

The façades of buildings are among the most important constructive elements in a building as they compose the envelop and thus influences directly the energy efficiency and comfort of the users in buildings. One the other hand, it is considered that building façades are exposed and are vulnerable to the environment (temperature and humidity). These effects result often in materials decay and consequent reduction of the functional performance of the buildings, both at the level of aesthetics and hygro-thermal behavior. From the mechanical point of view, the main problem can be related to cracking due to seismic action.

Over 120 participants from distinct areas, namely architecture and engineering, provided a platform for discussion and exchange ideas and to gain new insights on the possibilities and challenges of rehabilitation of façades, either to improve seismic behavior or energy efficiency of buildings.

The present book includes contributions from Portuguese specialists which have evidenced in engineering and architecture areas, namely in the building of emblematic masonry structures, structural rehabilitation of historical constructions, research and technology of masonry construction.

We thank all professional engineers and architects, building officials, educators, researchers, students, masonry industry and construction professionals, among other interested in the art and science of masonry, that accepted to exchange their experiences and to contribute to the success of masonry practice, research and innovation. We are sure that the valuable contributions of this book will be a precious guidance for others.

Table of contents

Preface
Committees
Sponsors
Lectures
1. Rehabilitation of façades: the contribute of CTCV for the improvement of the performance of rehabilitation works
2. Rehabilitation solutions of façades as a contribute for achievement nZEBs - a case study in Portugal
3. Masonry veneer walls: design, conception and rehabilitation
4. Façade masonry walls: solutions and recommendation s for improving performance
5. Interventions in façades: new solutions for old problems
6. Contemporary trends in façades rehabilitation
7. Rendering façades: pathologies and strategies of conservation
8. Rehabilitation of façades in the perspective of a mortar producer: challenges and solutions
9. Anchorages in masonry walls: testing, design and applications
10. Rehabilitation of façades in ancient buildings: the case of Crist Convent
11. National Palace of Ajuda – restoration of the main façades and towers

Seismic Retrofitting: Learning from Vernacular Architecture

Editors: Mariana R. Correia, Paulo B. Lourenco, Humberto Varum

Publisher: CRC Press

ISBN: 978-1-138-02892-0

Year: 2015

Editions and print run number per edition: 1st edition

How to buy: www.crcpress.com

Online: https://www.crcpress.com/Seismic-Retrofitting-Learning-from-Vernacular-Architecture/Correia-Lourenco-Varum/p/book/9781138028920

Summary

Local communities have adapted for centuries to challenging surroundings, resulting from unforeseen natural hazards. Vernacular architecture often reveals very intelligent responses attuned to the environment. Therefore, the question that emerged was: how did local populations prepare their dwellings to face frequent earthquakes?

It was to respond to this gap in knowledge, that the SEISMIC-V research project was instigated, and this interdisciplinary international publication was prepared. The research revealed the existence of a local seismic culture (LSC), in terms of reactive or preventive seismic resistant measures, able to survive, if properly maintained, in areas with frequent earthquakes.

The fundamental contribution and aims of the publication were to enhance:

- The disciplinary interest in vernacular architecture;
- Its contribution to risk mitigation in responding to natural hazards;
- To encourage academic and scientific research collaboration among different disciplines;
- To contribute to the improvement of vernacular dwellings, which half of the world's population still inhabits nowadays.

Fifty international researchers and experts presented case studies from Latin America, the Mediterranean, Eastern and Central Asia and the Himalayas region, with reference to 20 countries, i.e. Algeria, Bolivia, Bhutan, Chile, China, Egypt, El Salvador, Greece, Haiti, Italy, Japan, Mexico, Morocco, Nepal, Nicaragua, Peru, Romania, Taiwan, Turkey and a closer detailed analysis of Portugal. This publication brings together 43 contributions, with new perspectives on seismic retrofitting techniques and relevant data, addressing vernacular architecture; an amazing source of knowledge, and to this day, home to 4 billion people.

The publication received the aegis of the Chair UNESCO - Earthen Architecture | ICOMOS – CIAV | ICOMOS-ISCEAH | PROTERRA. The project was possible thanks to the Institutional support provided by UNIVEUR-Ravello, Italy, and the DRCN - Northern Portugal Regional Directorate for Culture.

Table of contents

Part 1: Framework
Vernacular architecture: A paradigm of the LSC
Vernacular architecture?
Seismic-resistant building practices resulting from LSC
Practices resulting from seismic performance improvement on heritage intervention
Criteria and methodology for intervention in vernacular architecture and earthen heritage
Structural conservation and vernacular construction
Seismic retrofitting of historic earthen buildings
Local building cultures valued to better contribute to housing reconstruction programs
Part 2: LSC around the world
Latin America; Mediterranean region
Central and eastern Asian; Himalayas
The 2015 Nepal earthquake; Algeria; Bhutan; Chile
Sichuan Province, China; Egypt; El Salvador; Japan
Morocco; Romania; Taiwan
Part 3: LSC in Portugal
Recognising LSC, the SEISMIC-V research
Seismic hazard analysis: An overview
A brief paleoseismology literature review: Contribution for the LSC study
Portuguese historical seismicity
Seismic behaviour of vernacular architecture
The design of 1758's master plan and the construction of Lisbon 'downtown'
Timber frames as an earthquake resisting system
Part 4: Portuguese LSC: Assessment by regions
Lisbon: Downtown after the 1755 earthquake
The 1909 earthquake impact in the Tagus region
Costal Alentejo region
Historical Centre of Évora
Lower Alentejo
Algarve coastal region
Azores
Part 5: Typology performance study
Vernacular isolated buildings
A row building
Urban centres
Part 6: Conclusions of the research
Seismic mitigation planning at urban scale
Seismic retrofitting in vernacular architecture
Common damages and recommendations

Supplement to the Proceedings of 3rd International Conference on Transportation Geotechnics

Proceedings of the 3rd ICTG, Guimarães, Portugal, 4-7 September, 2016

Editors: António Gomes Correia, Manuel Parente

Publisher: Zenodo

ISBN: 978-989-20-6943-2

Year: 2016

Editions and print run number per edition: 1st Edition
Online: http://doi.org/10.5281/zenodo.167550

Summary

The Transportation Geotechnics International Conference series began under the auspices of ISSMGE-TC3 and was initiated in 2008 at the University of Nottingham, UK, as an International event designed to address the growing requirements of infrastructure for societies. The 2nd International Conference on Transportation Geotechnics took place in 2012, at Sapporo, Japan, under the ISSMGE-TC202 that follows the TC3 activities for the period 2009-2013. To continue the success of these conferences and the output of ISSMGE-TC202, the 3rd was scheduled for 2016, at the City of Guimarães, UNESCO World Heritage, Portugal. Following the previous one, the challenges addressed by this conference included a better understanding of the interactions of geotechnics on roads, rails, airports, harbours and other ground transportation infrastructure with the goal of providing safe, economic, environmental, reliable and sustainable infrastructures. This 3rd International Conference on Transportation Geotechnics took place from 4 to 7 September 2016. The first day was devoted to the first meeting of Young Transportations Geotechnics Engineers and 4 workshops. The other three days included 2 honours lectures (Proctor lecture, the first honour lecture of the TC202, and Mercer lecture), 2 keynote lectures, 10 theme lectures, 13 special lectures and 88 oral presentations distributed by 12 technical sessions. Furthermore 2 poster sessions allowed 56 more presentations. A technical exhibition (11 exhibitors-sponsors) was also available during these three days, promoting interaction with industry. The conference proceedings contain 182 peer-reviewed papers resulting from 292 accepted abstracts from 50 countries and more than 900 authors. The indexed SCOPUS papers are in open access and free for downloading on Procedia Engineering's website: (http://www.sciencedirect.com/science/journal/18777058/143). Both Keynote Lectures are also available: "Advances in Ground Modification with Chemical Additives: From theory to practice" at (http://www.sciencedirect.com/science/article/pii/S221439121630040X), and "Rutting Prediction in Airport Pavement Granular Base/Subbase: A stress history based approach" at (http://www.sciencedirect.com/science/article/pii/S2214391216300460). The 1st Proctor Lecture, distributed to the participants, is on the website of the Transportation Geotechnics journal (http://www.sciencedirect.com/science/article/pii/S2214391216300113). A special Issue of the Transportation Geotechnics Journal (vol. 8, 2016), entitled "Use of Geosynthetics in Transportation Geotechnics", was also part of the material available to the participants, which was free for download until 20th November 2016 at http://www.sciencedirect.com/science/journal/22143912/8.

This e-book is a supplement to the Proceedings of the 3rd ICTG and other documentation distributed to the participants, including a report of the Conference (photos, organization, sponsors, Conference programme, opening ceremony, social programme, the first meeting of the International Intelligent Construction Technologies Group, announcements, closing ceremony, and Conference statistics), as well as the links to the e-books of its associated Workshops and to the 1st Young Transportation Geotechnics Engineers meeting. Furthermore, the presentations made available by the authors are featured in the Keynote, Theme and Special Lectures, as well as in the Session Theme Lectures. It also includes the posters provided by the authors, and references to the Formal Meetings featured during the Conference.

Table of contents

Home
Preface
Conference Report
Photos
Organization
Sponsors & Exhibitors
Conference Programme
Opening Ceremony
Social Programme
IICTG
Announcement of the ECSMGE
Closing Ceremony
Statistics
Workshops and 1st YTGE
Contributions
Keynote Lectures
Theme Lectures
Special Lectures
Session Themes
Poster Sessions
Formal Meetings

COST Action TU1406: eBook of the 1st Workshop Meeting

Proceedings of the 1st Workshop Meeting of COST Action TU1406, ETH Zürich, 21-22 September, 2015

Editors: José C. Matos, Joan R. Casas, Eleni N. Chatzi, Niels P. Høj, Alfred Strauss, Irina Stipanovic, Rade Hajdin

Publisher: ETH-Zürich

ISBN: 978-3-906327-09-9

Year: 2015

Editions and print run number per edition: 1st edition

Online: http://e-collection.library.ethz.ch/eserv/eth:48466/eth-48466-01.pdf

Summary

COST Action TU1406 aims to address the European economic and societal needs by standardizing the condition assessment and maintenance level of roadway bridges. Currently, bridge quality control plans vary from country to country and, in some cases, within the same country. This therefore urges the establishment of a European guideline to surpass the lack of a standard methodology to assess bridge condition and to define quality control plans for roadway bridges.

The first meeting and workshop of COST Action TU1406 in Geneva, Switzerland, essentially framed the overarching goals, processes and eventual deliverables of the action and defined the foundations of the joint effort to follow. Due to the relevance for the success of the first part of the Action, the main work was devoted to the state-of-the-art and the different approaches along Europe on performance indicators used by different owners and operators to meet quality expectations of users.

Apart from oral presentations, 25 posters were delivered with a very high quality which served as the initial seed for the main task that Working Groups 1 to 3 are facing. This is the construction of a large European-wide data base containing performance indicators and performance goals used in the countries participating in the Action. This data base will be the milestone from where the standardization and homogenization of the condition assessment and maintenance level of roadway bridges in Europe can be finally build up. The bases for the elaboration of this data base have been settled in this first meeting in Geneva.

The large number of participants in the Action as well as the excellent attendance in this meeting show the interest around Europe in the objectives of the Action. As pointed out several times during the presentations and discussions in this first WG meeting, it is of paramount importance the involvement of academics as well as professionals working in the field of highway bridge assessment and management. The meeting in Geneva has been a key point to start the collaborative work between both parts.

In summary, looking to the success of this kick-off WGs meeting, the action members may be confident on the achievement of the required standardization of quality specifications for highway bridges in Europe.

Table of contents

1. Working Group 1
   1.1 Preface
   1.2 First Results of TU1406 - Technical Survey on Performance Indicators
   1.3 Performance Indicators for Bridges: Results Based on the ASCE SEI Technical Council on Life Cycle Performance, Safety, Reliability and Risk of Structural Systems
   1.4 Output-only data normalization for bridge damage indicators
   1.5 On the Modeling of Vulnerability, Robustness and Resilience of Infrastructure

2. Working Group 2
   2.1 Preface
   2.2 Performance goals
   2.3 Reliability level for evaluation of existing bridges
   2.4 Swiss Standards: a basis for developing performance criteria based on durability indicators for concrete bridges
   2.5 Using risk-management for setting performance goals

3. Working Group 3
   3.1 Preface
   3.2 Establishment of a QC Plan for Road Bridges
   3.3 Bridge quality control supported by knowledge-based expert tools
   3.4 Case study: Bridge Management System at Rijkswaterstaat
   3.5 Quality control plan for bridges with shallow foundations exposed to local scour in the Serbian road network

4. Appendix: Poster Contributions

COST Action TU1406: eBook of the 2nd Workshop Meeting

Proceedings of the 2nd Workshop Meeting of COST Action TU1406, University of Belgrade, 30 March – 1 April, 2016

Editors: Jose Matos, Joan Casas, Rade Hajdin, Snežana Mašović, Nikola Tanasić, Alfred Strauss, Irina Stipanović

Publisher: Faculty of Civil Engineering, University of Belgrade, Serbia
ISBN: 978-86-7518-187-3
Year: 2016
Editions and print run number per edition: 1st edition
Online: http://repositorium.sdum.uminho.pt/handle/1822/42247?locale=en

Summary
COST Action TU1406 aims to address the European economic and societal needs by standardizing the condition assessment and maintenance level of roadway bridges. Currently, bridge quality control plans vary from country to country and, in some cases, within the same country. This therefore urges the establishment of a European guideline to surpass the lack of a standard methodology to assess bridge condition and to define quality control plans for roadway bridges. The working group meetings and 2nd Workshop of COST Action TU1406 in Belgrade has seen the continuation of the work developed within WG1 and the first working sessions for WG2 and WG3. Lively discussions after the presentations and in the WG´s meetings has made possible to deliver a clear route map concerning on how and what the Action should focus in the coming years, looking at their specific goals and close interactions and avoiding overlapping of activities.

Table of contents
1. Opening Session
1.1 Welcome word from Prof. Rade Hajdin
1.2 Welcome word from Prof. José Matos
2. Session 1
2.1 Keynote speech: Indicators for Sustainability Assessment
2.2 Keynote speech: State of Art of Bridges Maintenance Programs in South America. Experience on seismic hazards and scour
2.3 Performance Indicators as Basis for Life-Cycle-Considerations
2.4 Structural robustness of bridges based on redistribution of internal forces
2.5 Robustness as performance indicator for masonry arch bridges
2.6 Performance indicators for road bridges – categorization overview
3. Session2
3.1 Structural behaviour of stone arch bridges
3.2 Forecasting of performance indicators
3.3 Interface for collection of performance indicators for roadway bridges– STSM experiences
3.4 A new perspective for robustness assessment of framed structures
3.5 Lifecycle-based discretization of bridge performance indicators
4. Session 3
4.1 The impact of the severe damage on the dynamic behavior of the composite road bridge
4.2 Effect of vehicle travelling velocity on bridge lateral dynamic response
4.3 Damage detection for bridge structures based on dynamic and static measurements
4.4 Qualitative performance indicators for bridge management in Italy
4.5 Using an air permeability test to assess curing influence on concrete durability
5. Session 4
5.1 Keynote speech: Data-driven Decision Making on Maintenance Activities in Serbia
5.2 Keynote speech: COST354 – The way forward for pavement performance indicators across Europe
5.3 Sustainable Construction of Bridges in Kanton Zürich
5.4Consequence modelling for bridge failures
5.5 Data collection on Bridge Management Systems
5.6 Scheduling bridge rehabilitations based on probabilistic life cycle condition information
6. Session 5
6.1 Environmental effects on bridge durability based on existing inspection data
6.2 Development of the bridge management system under the project BridgeSMS
6.3 The assessment method of Hungarian documents on bridge inspection
6.4 Development of a Quality Management Plan for Timber Bridges
6.5 Guide for the Assessment of Masonry Bridges – Technical Parameters
7. Session 6
7.1 Guest lecture: Introduction of COST Action TU1402 on Quantifying the Value of Structural Health Monitoring
7.2 Reports from Working Groups
7.2.1 Report from WG1
7.2.2 Report from WG2
7.2.3 Report from WG3
8. Closing Session
8.1 State of the Action TU1406
8.2 Closing remarks

COST Action TU1406: eBook for the 3rd Workshop Meeting

Proceedings of the 3rd Workshop Meeting of COST Action TU1406, TNO Delft, 20 – 21 October, 2016

Editors: Irina Stipanovic Oslakovic, Giel Klanker, Jose Matos, Joan Casas, Rade Hajdin

Publisher: University of Twente, Faculty of Engineering Technology, the Netherlands
ISBN: 978-90-365-4325-5
Year: 2016
Editions and print run number per edition: 1st edition
Online: http://repositorium.sdum.uminho.pt/handle/1822/45472?locale=en

Summary

The working group meetings and 3rd Workshop of COST Action TU1406 in Delft is the continuance of the work developed within WG1 and the second working sessions for WG2 and WG3. The state-of-the-art and the different approaches along Europe on performance indicators used by different owners and operators is close to its completion. A considerable amount of information has been collected and the posterior processing will become a relevant input for the rest of the WG´s. The collected research performance indicators were presented. This information will be the basis for the proposal of new indicators that will allow a more optimized definition of future quality control plans for highway bridges.

An important number of papers related to all WG´s were also presented. The keynote presentations explaining the experience from previous COST actions, on sustainability indicators and pavement performance indicators, will be very helpful for the Action in order to seek the best methodologies and approaches to gather the most relevant and representative data from the large existing database.

Looking to the work developed so far and to future planned activities, we may be confident on the achievement of the required standardization of the quality specifications for highway bridges in Europe.

Table of contents

1. Opening Session
- 1.1 WG2 and WG3 Workshop
- 1.2 TNO Innovation for built environment

2 Session 1
- 2.1 Keynote speaker: Advancement of fib Model Code for structural concrete to incorporate assessment of existing structures.
- 2.2 Performance goal assessment for existing bridges subject to pier local scour
- 2.3 Detailed Evaluation of Deteriorated Highway Bridges in Greece
- 2.4 Principal component analysis as a comparative technique for bridge management systems

3. Session 2
- 3.2 Resistivity as indicator of durability: survey in existing bridge
- 3.2 Reliability of existing bridges determined with physical models – chloride induced corrosion
- 3.3 Quality control of masonry bridges based on empirical influence lines of displacements

4. Session 3
- 4.1 Keynote speaker: Overview and preliminary results of Long Term Bridge Performance Program (LTBPP)
- 4.2 Reflections on Quality Control Plans for Girder and Frame Bridges
- 4.3 Project performance appraisal frameworks as blueprints for bridge quality control
- 4.4 Quality Control Plan for Earth Retaining Walls – Conceptual Framework

5. Session 4
- 5.1 Value-based method for condition assessment and management of bridges
- 5.2 Non-destructive investigation techniques in bridge inspection
- 5.3 Structural health monitoring based on static measurements with temperature compensation to detect stiffness reductions

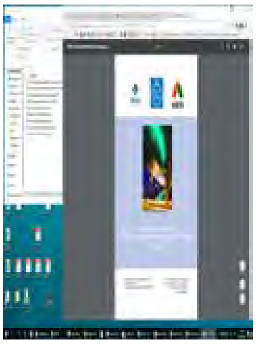
6. Session 5
- 6.1 Keynote speaker: Long term performance of concrete bridges under multiple hazards
- 6.2 Sustainability score for roadway bridges
- 6.3 Environmental performance framework for bridge infrastructure maintenance
- 6.4 Life-cycle cost optimisation on a set of bridges

7. Session 6
- 7.1 Bridge management practice & methodologies related to flooding hazards
- 7.2 Assessment of bridge performance by load testing after reconstruction
- 7.3 Interceptable Decaying Processes in Arch Bridges

8. Closing Session
- 8.1 Announcement of the next joint COST TU1402 - COST TU1406 – IABSE WC1 Workshop, Zagreb 2-3 March 2017

Training School COST Action TU1406

Performance-based assessment of existing road bridges



Editors: José Campos e Matos, Raid Karoumi

Publisher: KTH Royal Institute of Technology

ISSN: 1404-8450

Year: 2016

Editions and print run number per edition: 1st edition

Online: http://www.tu1406.eu/wp-content/uploads/2016/10/COST-TU1406-TRAINING-SCHOOL-Stockholm.pdf

Summary

The first Training School of COST Action TU1406 took place between 12 and 16 September 2016, in KTH Royal Institute of Technology, Stockholm, together with IABSE. It covered several topics related to performance assessment of bridges, namely, deterministic and probabilistic-based indicators, static and dynamic-based indicators, life cycle costing and bridge management. It involved 11 trainers and 17 trainees from 17 European Countries and from different stakeholders (from academia to industry). A good gender and inclusiveness countries balance was also achieved.

The group was very interesting, and networking was automatically done not only through the development of the different assignments which were given by the trainers but also by all the social activities (networking dinner and technical visit). The provided assignments were related to the topics above indicated, and which cover the COST Action WG1 and WG2 topics. Main results will be then used for the technical report of this Action, and the best assignments invited for future Workshops.
The following eBook, covers all the addressed topics by the different lecturers in the same order of the training school. It will be important not only for future training schools, but also for those interested in the quality control of roadway bridges. As Chair of the Action and as local organiser, we would like to acknowledge all who contributed to this important material from the trainers and the trainees. This was in fact a very important step towards the following training schools of COST Action TU1406.

Table of contents

State of the art in the assessment and asset management of road bridge structures Survey processes for gathering performance indicators and key performance indicators (Prof. Alfred Strauss)

Indicators (Dr. Niels Peter Høj)

Decision Support, Risk Analyses of Structures, Hazard identification, Costs / Benefit assessment (Dr. Niels Peter Høj)
Quality specifications for roadway bridges, standardization at a European level (Prof. Irina Stipanovic)

Probabilistic Modelling – Introduction (1) (Prof. Drahomír Novák)

Probabilistic Modelling – Recapitulation of Statistics (2) (Prof. Drahomír Novák)

Probabilistic Modelling – Simulation Methods (3) (Prof. Drahomír Novák)

Probabilistic Modelling – Freet Basic Features (4) (Prof. Drahomír Novák)

Probabilistic Modelling – Example (1) (Prof. Alfred Strauss)

Probabilistic Modelling – Approximation Techniques (5) (Prof. Drahomír Novák)

Probabilistic Modelling – Statistical Correlation in MC Methods (6) (Prof. Drahomír Novák)

Performance Assessment of Concrete Bridges (Prof. Radomír Pukl)

ATENA (Prof. Radomír Pukl)

Stochastic Nonlinear Analysis (Prof. Radomír Pukl)
SARA (Prof. Radomír Pukl)

The use of monitoring for management and upgrading of bridges (Prof. Raid Karoumi)

Fatigue assessment of existing steel bridges (Dr. John Leander)

Models for assessment of Dynamic Performance (Prof. Costin Pacoste)

Full-Scale Tests to Failure - Steel, Concrete and Prestressed Concrete (Prof. Lennart Elfgren)

LCC, LCA and BMS (Dr. Mohammed Safi)

The use of KPIs for a Sustainable Bridge Management (Prof. José C. Matos)

WG1 Technical Report – Performance Indicators for Roadway Bridges of COST Action TU1406

Editors: Alfred Strauss, Ana Mandić Ivanković

Publisher: University of Minho

ISBN: 978-3-900932-41-1

Year: 2016

Editions and print run number per edition: 1st edition

Online: http://www.tu1406.eu/wp-content/uploads/2016/10/COST_TU1406_WG1_TECH_REPORT.pdf

Summary

During the implementation of asset management strategies, maintenance actions are required in order to keep assets at a desired performance level. In case of roadway bridges, specific performance indicators are established for their components. These indicators can be qualitative or quantitative based, and they can be obtained during principal inspections, through a visual examination, a non-destructive test or a temporary or permanent monitoring system. The goal of WG1 is to explore those bridge performance indicators, in the course of international research cooperation, which capture their main technical, social and environmental performance along their service-life and can be used in a quality control of the overall bridge performance. Considerations also include: natural aging, quality of the material; service life design methods; sustainable indicators; environmental, economic and social based indicators, performance profiles. The final objective is the implementation of a performance indicator database for Europe with flexibility to accommodate country-specific requirements. The future implementation by different European countries will be hardly accomplished if the actual proposal derived from the work of WG1 had not taken into account what is actually carried out in the subject of bridge performance in the different countries involved in the Action. However, the proposal of global performance indicators should also take into account the advanced results on bridge performance gathered in the recent years because of the important research effort by several research groups in Europe and all around the world. For this reason, the main objective of WG1 from the beginning was to gather as much as possible the actual state-of-the-art (operational indicators already in use by the bridge owners) but also the research indicators under investigation that may have a feasible application in quality control plans of bridge operators in the near future. Each construction, during its life cycle, will face with deterioration depending on several factors such as the environmental condition, the natural aging, the quality of the material, the execution of works and the planned maintenance. Therefore, several design procedures based on the prediction of deterioration that will likely act on the structure will be developed in the framework of the international research. Work Group 1 (WG1) targets the characterisation and definition of performance indicators for the present and future structural conditions on deterministic and probabilistic level. It is known that management systems are supported in Quality Controls (QC) plans which in turn are supported by performance indicators. Therefore, it is extremely important to analyse such indicators in terms of used assessment frameworks (e.g. what kind of equipment and software is being used), and in terms of the quantification procedure itself. In this particular report, the objectives are to show the collected and analysed practical and research based performance indicators.

Table of contents

1. COST Action TU1406
 1.1 Scope
 1.2 Objectives
2. Framework
 2.1 Survey
  2.1.1 First survey phase
  2.1.2 Second survey phase
 2.2 Structure and development of the database
 2.3 Database - Processing
 2.4 Database – Findings
 2. 5Database – Homogenization
 2.6 From Performance to key performance indicators
  2.6.1 General
  2.6.2 Next steps
3. Glossary
 3.1 General
 3.2 Editing procedure
4. Operators Database
 4.1 Clustering and Homogenisation of Performance indicators
 4.2 Categorisation of Performance indicators
  4.2.1 Performance indicators at the component level
   4.2.1.1 Technical Aspects
   4.2.1.2 Socio-economic aspects
  4.2.2 Performance indicators at the system level
   4.2.2.1 Technical criteria
   4.2.2.2 Sustainability criteria
   4.2.2.3 Socio-economic criteria
  4.2.3 Performance indicators at the network level
 4.3 Performance indicators vs. goals (tasks) within bridge management
5. Research Database
 5.1 Collection of research based Performance indicators
 5.2 Sustainability issues
6. Conclusions and Future Developments | 7.References

TECHNOLOGY TRANSFER

CONTRACTS WITH INDUSTRY AND GOVERNMENT

isise Institute for Sustainability and Innovation in Structural Engineering

Rui Simões, L. Simões da Silva, Aldina Santiago, Helder Craveiro, Miguel Pereira

DEVELOPMENT OF A NEW OMEGA CONFIGURATION IN COLD-FORMED STEEL

❑ DEVEOPMENT OF A NEW PRODUCT

- A new cold-formed configuration (omega shape) was developed by the Steel-Mixed Construction Technologies, ISISE – University of Coimbra, in a partnership with the steelwork company O Feliz Metalomecânica S. A. – Braga (see Figures 1 and 2). This new product, designated by “Superomega”, was developed in accordance with eurocodes, aiming the following objectives: maximization of the effective cross-section area adding longitudinal stiffeners strategically positioned; ease for storage and transportation; ease to overlap in order to ensure continuity along internal supports; good aesthetic performance, among others.
- It was conceived 5 distinct profiles with heights 80, 120, 160, 200 and 250 mm, thicknesses between 1 and 3 millimeters in galvanized steel grades S280GD or S350GD according to the standard EN 10346.

Fig. 1

Fig. 2

❑ EXPERIMENTAL AND NUMERICAL BEHAVIOUR

- The structural performance was proved through the carried out of an experimental and numerical validation (Figures 3 and 4).

Fig. 3

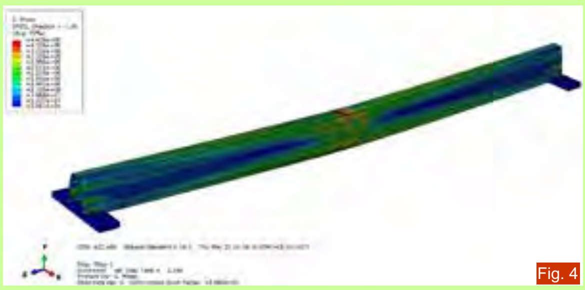


Fig. 4

O FELIZ METALOMECÂNICA

isise Institute for Sustainability and Innovation in Structural Engineering

SEISMIC RETROFIT PROJECT

GETTY CONSERVATION INSTITUTE, USA

❑ OVERVIEW

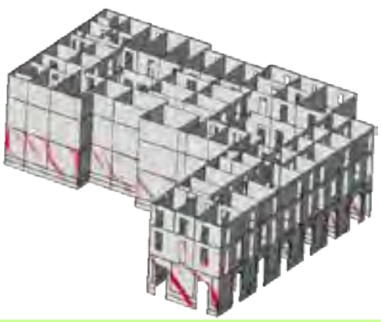
- The Seismic Retrofitting Project (SRP) seeks to combine traditional construction techniques and materials with high-tech methodologies to design and test easy-to-implement seismic retrofitting techniques and maintenance programs to improve the structural performance and safety of earthen buildings while minimizing loss of historic fabric.
- The SRP will provide guidance for those responsible for the implementation of seismic retrofitting projects (e.g., architects, engineers, and conservators), and work with authorities to facilitate the implementation of the designed techniques. The project's results are intended to be widely applicable across Latin America.
- Four case studies in Peru are considered in the project: (a) Casa Arones, Cusco; (b) Cathedral of Ica; (c) Church of Kuño Tambo, in the Cusco Region; (d) Hotel el Comercio, Lima.

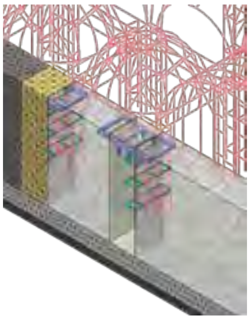
❑ IN SITU TESTING

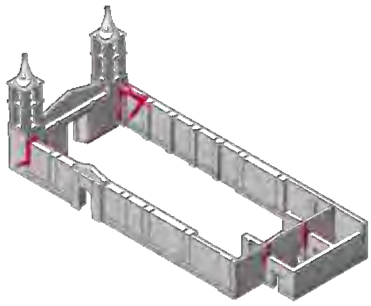
- The overall behavior of the buildings has been characterized by performing identification tests in order to try to provide their dynamic characteristics using the ambient vibration as a source of excitation. The mechanical properties of selected materials composing the structural part of the four structures were also characterized using sonic test equipment.

❑ MODELLING (BEFORE AND AFTER STRENGTHENING)

- Advanced finite element analyses were used for the safety assessment and to assist in strengthening design.







The Getty Conservation Institute

PATENTS

(12) PEDIDO INTERNACIONAL PUBLICADO SOB O TRATADO DE COOPERAÇÃO EM MATÉRIA DE PATENTES (PCT)

(19) Organização Mundial da Propriedade Intelectual
Secretaria Internacional

(43) Data de Publicação Internacional
5 de Janeiro de 2017 (05.01.2017)

WIPO | PCT

(10) Número de Publicação Internacional
WO 2017/002043 A1

(51) **Classificação Internacional de Patentes** : *E04C 5/07* (2006.01) *E04G 23/02* (2006.01)

(21) **Número do Pedido Internacional** : PCT/IB2016/053897

(22) **Data do Depósito Internacional** : 29 de Junho de 2016 (29.06.2016)

(25) **Língua de Depósito Internacional** : Português

(26) **Língua de Publicação** : Português

(30) **Dados Relativos à Prioridade** : 108611 30 de Junho de 2015 (30.06.2015) PT

(71) **Requerentes** : **CLEVER REINFORCEMENT IBERICA- MATERIAIS DE CONSTRUCÃO LDA** [PT/PT]; Rua de Portugal n. 20 Zona Industrial da Fontainhas Mota, s/n, 7350-297 Elvas (PT). **UNIVERSIDADE DO MINHO** [PT/PT]; Largo do Paço, 4704-553 Braga (PT).

(72) **Inventores** : **OLIVEIRA DE BARROS, Joaquim António**; Universidade do Minho, Departamento de Engenharia Civil, Campus de Azurém, 4800-058 Guimarães (PT). **FERRAZ MARQUES DOURADO, Filipe Nuno**; Sede na Rua de Portugal n 20 Zona Industrial da Fontainhas Mota, s/n, 7350-297 Elvas (PT).

(74) **Mandatário** : **VIEIRA PEREIRA FERREIRA, Maria Silvina**; Clarke, Modet & Co., Rua Castilho, 50-9º, 1269-163 Lisboa (PT).

(81) **Estados Designados** *(sem indicação contrária, para todos os tipos de proteção nacional existentes)* : AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Estados Designados** *(sem indicação contrária, para todos os tipos de proteção regional existentes)* : ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Euroasiático (AM, AZ, BY, KG, KZ, RU, TJ, TM), Europeu (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Publicado:

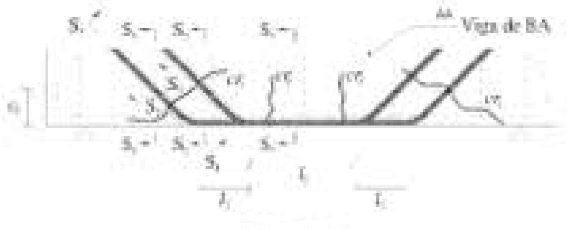
— *com relatório de pesquisa internacional (Art. 21(3))*

— *antes da expiração do prazo para modificar as reivindicações e a republicar na eventualidade de receção de tais modificações (Regra 48.2(h))*

WO 2017/002043 A1

(54) **Title** : CARBON FIBER REINFORCEMENT POLYMER AND ITS RESPECTIVE APPLICATION TECHNIQUE FOR THE STRENGTHENING OF CONCRETE STRUCTURES

(54) **Título** : LAMINADO DE MATRIZ POLIMÉRICA REFORÇADO COM FIBRA DE CARBONO E RESPETIVA TÉCNICA DE APLICAÇÃO PARA REFORÇAR ESTRUTURAS DE BETÃO



AA. REINFORCED CONCRETE BEAM

(57) **Abstract** : The present invention consists of a laminate having a polymer matrix reinforced with carbon fibres (CFRP) and the method of using the same to reinforce concrete structures. The laminate having a carbon fibre reinforced polymer matrix claimed has the shape of a clip or walking stick and comprises two or three straight segments interconnected by one or two transition zones. This product is designed for use in the field of civil engineering.

(57) **Resumo** : A presente invenção consiste num laminado de matriz polimérica reforçado com fibras de carbono (CFRP) e sua técnica de aplicação no reforço de estruturas de betão. O laminado de matriz polimérica reforçado com fibras de carbono agora apresentado compreende a forma de clip ou bengala e é compreendido por dois ou três segmentos retilíneos ligados por uma ou duas zonas de transição. Este produto destina-se a ser aplicado na área da construção civil.

Barros, J.A.O.; Dourado, F., *"Laminado de fibra de carbono e respetiva técnica de reforço de estruturas de betão/Carbon fiber laminate and its corresponding technique for the strengthening of concrete structures",* Pedido provisório de patente de invenção nacional nº 108611, Instituto Nacional da Propriedade Industrial, 2015.

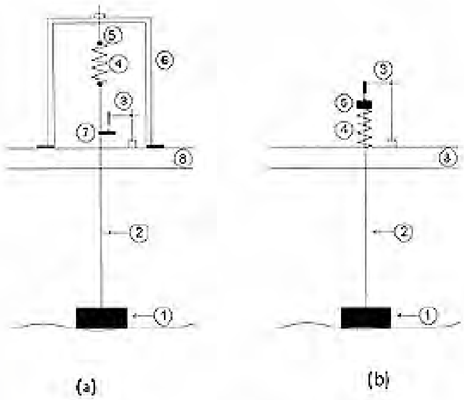
BOLETIM DA PROPRIEDADE INDUSTRIAL N.º 2016/11/08 32 de 105

PATENTES DE INVENÇÃO

Pedidos - BBCA/1A

A publicação dos pedidos de patentes de invenção a seguir indicados é efetuada nos termos do disposto no artigo 66.º do Código da Propriedade Industrial; da data de publicação do presente aviso começa a contar-se o prazo de dois meses para a apresentação de reclamações de quem se julgar prejudicado pela eventual concessão dos mesmos, nos termos do artigo 17.º do mesmo Código.

(11) **108449** (13) **A**
(22) 2015.05.08
(30)
(71) **PT UNIVERSIDADE DO MINHO**
(72) JOSÉ MANUEL SENA CRUZ
JULIO GARZÓN ROCA
GONÇALO GOMES ESCUSA
(51) **Int. Cl.**
G01N 3/00 (2006.01) G01B 3/00 (2006.01)
(54) **SISTEMA PARA MEDIÇÃO DE DESLOCAMENTOS EM ESTRUTURAS COM RECURSO A TRANSDUTORES DE DESLOCAMENTO**
(57) A PRESENTE INVENÇÃO CONSISTE NUM EQUIPAMENTO AUTÓNOMO PARA A MEDIÇÃO DE DESLOCAMENTOS EM ESTRUTURAS COMO POR EXEMPLO TABULEIROS DE PONTES, LAJES OU VIGAS CUJO MATERIAL CONSTITUINTE DESTAS ESTRUTURAS É BETÃO ARMADO E/OU PRÉESFORÇADO, AÇO, MADEIRA, ALVENARIA, PLÁSTICO, COMPÓSITO, ENTRE OUTROS, RECORRENDO A TRANSDUTORES DE DESLOCAMENTO, PARA APLICAÇÃO EM CASOS DE DIFÍCIL ACESSO A PONTOS FIXOS, NOS QUAIS A UTILIZAÇÃO DE OUTRAS TÉCNICAS EXISTENTES NÃO É VIÁVEL. ESTA INVENÇÃO É DE FÁCIL E RÁPIDA INSTALAÇÃO, SENDO CONSTITUÍDA PELOS SEGUINTES ELEMENTOS: (1) PESO PARA FIXAÇÃO DO CABO; (2) CABO; (3) TRANSDUTOR DE DESLOCAMENTO OU CONJUNTO DE TRANSDUTORES DE DESLOCAMENTO; (4) MOLA OU CONJUNTO DE MOLAS, INCORPORADAS OU NÃO COM TRANSDUTORES DE DESLOCAMENTO; (5) ESTICADOR OU ESTICADORES; (6) ESTRUTURA AUXILIAR PARA A FIXAÇÃO E TENSIONAMENTO DA MOLA; (7) BATENTE PARA TRANSDUTOR DE DESLOCAMENTO E (8) ESTRUTURA A MONITORIZAR.



Ver Fascículo Completo

(11) **108454** (13) **A**
(22) 2015.05.08
(30)
(71) **PT INSTITUTO SUPERIOR TÉCNICO**
(72) MIGUEL SÉRGIO DE ABREU NETO
LUÍS MIGUEL OURO COLAÇO
GONÇALO MENESES LEONEL
RODRIGO ORTINS FERREIRA
ANA LUÍSA VARÃO DIAS MOREIRA BRAGA
(51) **Int. Cl.**
A61G 7/00 (2006.01)
(54) **DISPOSITIVO MÉDICO PARA O AUXÍLIO NO POSICIONAMENTO DE INDIVÍDUOS EM DECÚBITO LATERAL**
(57) A PRESENTE INVENÇÃO REFERE-SE A UM DISPOSITIVO MÉDICO CUJO OBJETIVO É AUXILIAR NO PROCESSO DE ALTERAÇÃO DO POSICIONAMENTO DE INDIVÍDUOS EM DECÚBITO DORSAL PARA DECÚBITO LATERAL. O DISPOSITIVO UTILIZA UM PRINCÍPIO DE ALAVANCA PARA ORIGINAR O MOVIMENTO DE ROTAÇÃO DO INDIVÍDUO PARA A POSIÇÃO DE DECÚBITO LATERAL, COMPREENDENDO UM SUPORTE ESCAPULAR, COMPOSTO POR UM VEIO DE SECÇÃO CIRCULAR (8) E UMA PLACA ESCAPULAR (10), SENDO ESTA ÚLTIMA COLOCADA POR DEBAIXO DO INDIVÍDUO EM POSIÇÃO DE DECÚBITO DORSAL E O PRIMEIRO ENTRE O BRAÇO E O TRONCO. O DISPOSITIVO COMPREENDE AINDA UMA ESTRUTURA EM "T", ESTANDO O VEIO DE SECÇÃO

Sena-Cruz, J.M.; Garzón-Roca, J.; Escusa, G.; (2015) "Sistema para medição de deslocamentos em estruturas com recurso a transdutores de deslocamento", Registo Provisório de Patente n.º 20151000038321, Instituto Nacional da Propriedade Industrial.

BOLETIM DA PROPRIEDADE INDUSTRIAL N.º 2016/12/30 72 de 229

PATENTES DE INVENÇÃO

Pedidos - BBCA/1A

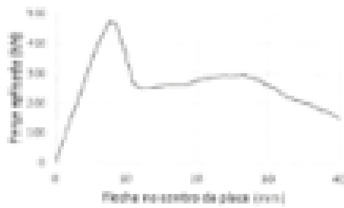
A publicação dos pedidos de patentes de invenção a seguir indicados é efetuada nos termos do disposto no artigo 66.º do Código da Propriedade Industrial; da data de publicação do presente aviso começa a contar-se o prazo de dois meses para a apresentação de reclamações de quem se julgar prejudicado pela eventual concessão dos mesmos, nos termos do artigo 17.º do mesmo Código.

(11) **108614** (13) **A**
(22) 2015.06.30
(30)
(71) **PT A. FERREIRA & FILHOS, S.A.**
(72) RAÚL MANUEL ESTEVES DE SOUSA FANGUEIRO
RAQUEL SOFIA OLIVEIRA CARVALHO
DIONÍSIO PEIXOTO DA SILVEIRA
CARLOS MANUEL DA SILVA FERREIRA
NOÉL ALBERTO DA SILVA FERREIRA
FILIPA MARIA BARBOSA FARIA MONTEIRO
(51) **Int. Cl.**
D04B 1/22 (2006.01)
(54) **ESTRUTURA FIBROSA AUXÉTICA COM FIOS DE ELEVADO DESEMPENHO PARA PROTEÇÃO MECÂNICA**
(57) A PRESENTE INVENÇÃO REFERE-SE A UMA ESTRUTURA FIBROSA COM FIOS DE ELEVADO DESEMPENHO MECÂNICO, COM COMPORTAMENTO AUXÉTICO, PARA SER UTILIZADA NA ÁREA DA PROTEÇÃO MECÂNICA CONTRA O CORTE E A PUNÇÃO. A PROTEÇÃO AO CORTE E À PUNÇÃO É PROPORCIONADA PELA UTILIZAÇÃO DE MATERIAIS E ESTRUTURAS FIBROSAS AUXÉTICAS COM ELEVADO DESEMPENHO MECÂNICO E GEOMETRIA TRIDIMENSIONAL DE PARALELOGRAMA, QUE, NO MOMENTO DE CONTACTO COM UM OBJETO CORTANTE OU PERFURANTE, PROTEGEM O UTILIZADOR EVITANDO O CONTACTO DIRETO DESTE COM O SEU CORPO DADO EXISTIR UMA EXPANSÃO LONGITUDINAL E TRANSVERSAL.

Ver Fascículo Completo

---

(11) **108615** (13) **A**
(22) 2015.06.30
(30)
(71) **PT FRANCISCO PEREIRA MARINHO & IRMÃOS, S.A.**
PT UNIVERSIDADE DO MINHO
(72) JOAQUIM ANTÓNIO OLIVEIRA BARROS
(51) **Int. Cl.**
E02D 29/14 (2006.01)
(54) **TAMPA EM BETÃO REFORÇADO COM FIBRAS E GRELHA EM MATERIAL COMPÓSITO PARA APLICAÇÃO EM INFRAESTRUTURAS**
(57) A PRESENTE INVENÇÃO CONSISTE NUMA TAMPA PARA APLICAÇÃO EM INFRAESTRUTURAS, CONSTITUÍDA POR BETÃO REFORÇADO COM FIBRAS DE ELEVADA RESISTÊNCIA E ELEVADA DUCTILIDADE (HPFRC) E UMA GRELHA DE MATRIZ POLIMÉRICA REFORÇADA COM FIBRAS DE VIDRO. A TAMPA PODE TER SECÇÃO CIRCULAR OU QUADRADA, PERMITINDO O ACESSO A INFRAESTRUTURAS COM UM DIÂMETRO OU LADO IGUAL OU INFERIOR A 600 MM, E DESENVOLVE CAPACIDADE DE CARGA PARA AS MAIORES EXIGÊNCIAS IMPOSTAS PELA NORMA EN-124 (CLASSE DE UTILIZAÇÃO D-400) - 40 TONELADAS.



Ver Fascículo Completo

---

(11) **108617** (13) **A**
(22) 2015.06.30
(30)
(71) **PT MISTOLIN, S.A.**
(72) MARCO JORGE PEDROSA SEBASTIÃO
FILIPE JOÃO COTOVIO EUFRÁSIO ANTUNES
SOLANGE SÁ MAGALHÃES
LUIS CARLOS HENRIQUES ALVES
(51) **Int. Cl.**
C11D 3/386 (2006.01) C11D 1/82 (2006.01)
(54) **COMPOSIÇÃO DE DETERGENTE NEUTRO PARA LIMPEZA DE SUPERFÍCIES DURAS COM GORDURA**
(57) A PRESENTE INVENÇÃO CONSISTE NUMA NOVA FORMULAÇÃO DE DESENGORDURANTE COM UM PH NEUTRO. A NOVA SOLUÇÃO CARACTERIZA-SE POR NÃO COMPREENDER QUALQUER ELEMENTO NOCIVO PARA A SAÚDE HUMANA E PARA O MEIO AMBIENTE. MAIS ESPECIFICAMENTE, CONSISTE NUMA COMPOSIÇÃO DE DETERGENTE QUE COMPREENDE ENZIMAS (LIPASE), TENSIOATIVOS ANIÓNICOS, TENSIOATIVOS ANFOTÉRICOS E TENSIOATIVOS NÃO-IÓNICOS COM BAIXAS CONCENTRAÇÕES MICELARES CRÍTICAS (CMC) E UM COMPORTAMENTO TOXICOLÓGICO, DERMATOLÓGICO E ECOLÓGICO CONSIDERADO COMO EXCELENTE, BEM COMO SOLVENTES COM DIFERENTES PESOS MOLECULARES. O TENSIOATIVO ANIÓNICO CONSISTE NO LAURIL ÉTER SULFATO DE SÓDIO, O NÃO-IÓNICO CONSISTE NO ALQUIL POLIGLICOSIDO ENQUANTO O TENSIOATIVO ANFOTÉRICO CONSISTE NUMA ALQUIL BETAÍNA. OS SOLVENTES UTILIZADOS NA

Barros, J.A.O., *"Tampa em betão reforçado com fibras e grelha em material compósito para aplicação em infraestruturas/Manhole cover in fibre reinforced concrete and Composite material grid for infrastructures"*, Pedido provisório de patente de invenção nacional nº 108615, Instituto Nacional da Propriedade Industrial, 2015.

ISISE is a Research, Development and Innovation (RD&I) Unit created in 2007 that involves researchers with different expertise mostly from the Departments of Civil Engineering from the universities of Coimbra and Minho. In the 2014 Research Assessment Exercise (2008-2014), ISISE was rated as Excellent.

ISISE currently comprises about 160 researchers, including over 100 PhD students. This report summarizes the research outputs of ISISE for the period 2014-2016.

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR
COMPETE 2020
PORTUGAL 2020
UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional