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Luís Simões da Silva

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José Sena-Cruz
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Paulo B. Lourenço

**Steel and mixed construction
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Luís Simões da Silva

Structural Concrete
Joaquim Barros

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ISISE HIGHLIGHTS

The fourth issue of the ISISE Newsletter covers the activities developed mainly in the last six months of the Institute. In this period, 3 R&D projects have been concluded, 10 new national and European R&D projects have been started with over 2.2 M€ of competi-

tive funding, 6 PhD theses have been concluded and 2 national events have been co-organized by ISISE members. In this period the Technical & Scientific Activities Report 2010-2012 of ISISE has been also published (available in www.isise.net).



Institute for Sustainability and
Innovation in Structural Engineering



Technical & scientific activities report 2010 2012

at: www.isise.net



FCTUC FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE DE COIMBRA



Universidade do Minho
Escola de Engenharia

Technical Report 2010 - 2012

R&D COMPLETED PROJECTS

> Capacities - STEELPROST: Innovative Fire Protective Coatings for Steel Structures

ISISE Principal Investigator: Luís Simões da Silva
Budget: Global: 2.357.464,00€/ISISE-UC: 616.909,00€
ID: FP7-SME-2008-2
Funding Entity: EU – fp7

Principal Contractor: European Convention of Construction Steelwork (ECCS)

Participating Institutions: European Convention of Construction Steelwork (ECCS); Asociación de la Industria Navarra; Construction Cluster of Slovenia; Alcea s.rl.; Bersch & Fratscher GmbH; Matherm SAS; Talleres Ruiz; Razpon D.O.O.; ITRI Ltd; Tecnologías Avanzadas Inspiralia; Acciona S.A.

Date: October 2012

Summary: The FP7-SME-2008-2-STEELPROST Research Programme provided a solution to current surface treatment limitations by developing a second generation of fire-protective coatings. The key enhancements on performance of intumescent coatings have been achieved by combining mechanical and fire resistant nano-additives with advanced spraying and drying technologies and advanced Fire Design principles application. The project has demonstrated the need for Fire Resistance (FR) performance to be combined with efficient design and coating procedures. SteelProst foreground is a patent pending technology. Aware of Steel Constructors needs, SteelProst Consortium has invested important efforts in order to integrate SteelProst foreground in current Fire Resistance legislations and the calculation principles set in the EuroCodes. Performance of

intumescent coatings has been doubled compared to current state of art. Mechanical and chemical resistance has been significantly improved while toxic gases emission has been reduced up to 25%. Industrial application achievements include drying times as quick as two hours for thick protective single layers and times shorter than 2 minutes for thin intumescent layers.

STEELPROST

“INNOVATIVE FIRE PROTECTIVE COATINGS FOR STEEL STRUCTURES”



> HSS-SERF - High Strength Steel in Seismic Resistant Building Frames

ISISE Principal Investigator: Carlos Rebelo
Budget: Global: 2.088.410,00 € / ISISE- UC: 160.000,00 €

ID: RFSR-CT-2009-00024

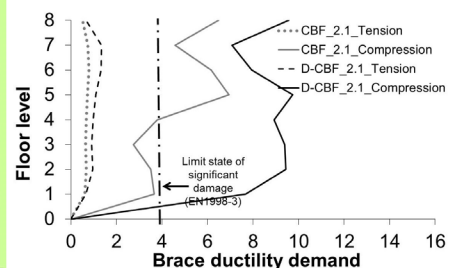
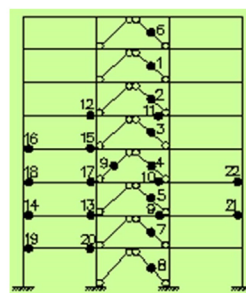
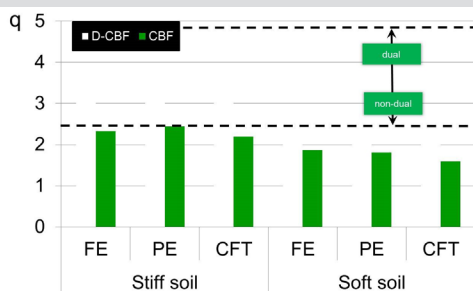
Funding Entity: EU-RFCS

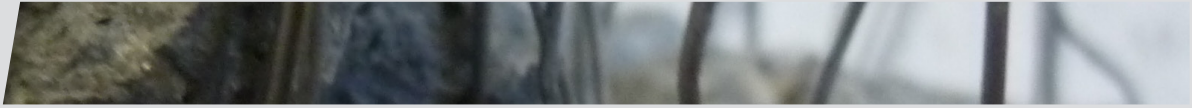
Principal Contractor: UP Timisoara, Romania

Participating Institutions: UP Timisoara, Romania (coordinador); Univ Naples, Italy; Univ. Stuttgart, Germany; University of Ljubljana, Slovenia; University of Liège, Belgium; RIVA, Italy; Ruuki, Finland; GIPAC, Portugal

Date: June 2013

Summary: The aim of the project was to investigate and evaluate the seismic performance of dual-steel building frames, built of two different steel grades: Mild Carbon Steel (MCS) and High Strength Steel (HSS). These type of dual-steel structural systems, in which MCS is used in dissipative members while





HSS is used in non-dissipative “elastic” members, has shown to be reliable and cost efficient. Composite steel-concrete sections were used in the columns. The main outcomes of the project consist in coherent performance based design methodology and relevant design criteria for ductility and overstrength of both members and joint components, as well as joint detailing rules. Different structural typologies (e.g. moment-resisting frames, concentrically braced frames, eccentrically braced frames) and connection detailing for dual-steel building frames were studied. Validation of different joint typologies was done by testing and advanced numerical simulation. Relevant design parameters (i.e. behaviour factor q , overstrength factor Ω) were obtained and are included in design guidelines that can be easily implemented in further versions of EN 1998.

> **ALVEST - Development of Structural Solutions for Masonry Walls**

ISISE Principal Investigator: Paulo Lourenço

Budget: Global: 421.558,33 € / ISISE-UM: 219.568,03 €

ID: 5456

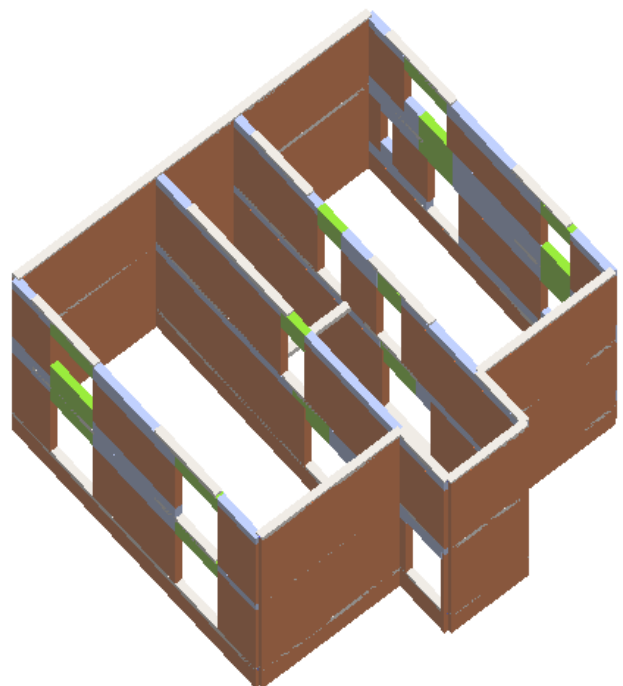
Funding Entity: ADI

Principal Contractor: Abel Luís Nogueiro & Irmãos Lda

Participating Institutions: Costa e Almeida, LDA, Instituto Superior de Engenharia, Universidade do Minho

Date: March 2012

Summary: The project ALVEST had as main goal the development of a constructive/structural system in reinforced masonry that is able to be adopted successfully in the Portuguese construction market. More than the conception of the concrete block, encompassing the selection of the adequate shape and size and the selection of the adequate raw materials, it was essential to define an integrated constructive system with information of constructive details, mechanical and physical characterization as well as with the information about the design and technical sustainability. As the main achievements, it should be stressed: (1) the seismic behaviour assessment of the concrete block structural masonry based on shaking table tests on unreinforced reduced scale building models. Different geometries were considered to evaluate the influence of geometry complexity on the seismic behaviour; (2) the design of different building systems based on macro-element approach and assessment of the construction technology through the demonstration of the constructability of a designed housing masonry building; (3) the definition of design and construction guidelines useful for end-users and decision makers.



R&D STARTED PROJECTS

> FRISCC – Fire Resistance of Innovative and Slender Concrete Filled Tubular Composite Columns

ISISE Principal Investigator: João Paulo Rodrigues
Budget: Global: 1.717.688,00 € / ISISE- UC: 375.615,00 €
ID: RFSR-CT-2012-00025
Funding Entity: EU- RFCS
Principal Contractor: UPVLC, Spain

Participating Institutions: UPVLC, Spain (coordinator); CTICM, France; LUH, Germany; Imperial College London, UK; UC, Portugal; AIDICO, Spain; Condesa, Spain

> INFASO+ – Valorisation of Knowledge for Innovative Fastening Solutions between Steel and Concrete

ISISE Principal Investigator: Luís Simões da Silva
Budget: Global: 626.981,00 € / ISISE- UC: 119.912,00 €
ID: RFS-P2-11097
Funding Entity: EU-RFCS
Principal Contractor: University of Stuttgart, Germany
Participating Institutions: University of Stuttgart, Germany (coordinator); GIPAC, Portugal; ECCS, Belgium

> BARRIER PLUS – One Component Waterborne Barrier Coatings

ISISE Principal Investigator: Luís Simões da Silva
Budget: Global: 3.127.957,00 € / ISISE- UC: 689.253,00 €
ID: FP7-SME-2012-2-304758
Funding Entity: EU-FP7
Principal Contractor: European Convention of Construction Steelwork (ECCS)

Participating Institutions: European Convention of Construction Steelwork (ECCS); Norsk Stalforbund, Norway; FB DV, Netherland; Federation Europeene

Corrosion, Belgium; Univ. Lyon, France; Univ. Surrey, United Kingdom; WC Co Ltd, United Kingdom

> TAPERSTEEL – Design of Non-uniform Element Fire Resistance

ISISE Principal Investigator: Luís Simões da Silva
Budget: Global: 118.952,00 € / ISISE- UC: 75.772,00 €
ID: PTDC/ECM-EST/1970/2012
Funding Entity: FCT
Principal Contractor: University of Aveiro (UA)
Participating Institutions: University of Aveiro; University of Minho

> EcoSteelPanel, Thermal and Acoustic Comfort

ISISE Principal Investigator: Luís Simões da Silva
Budget: Global: 689.938,00 € / ISISE- UC: 161.325,00 €
ID: QREN SI I&DT N°24804
Funding Entity: IAPMEI
Principal Contractor: CoolHaven SA
Participating Institutions: UC, CoolHaven SA

> FRPreDur – Short and Long-term Structural Behaviour of Concrete Elements flexuRally Strengthened with Prestressed CFRP Laminates

ISISE Principal Investigator: José Sena Cruz
Budget: Global: 169.406,00 € / ISISE-UM: 169.406,00 €
ID: PTDC/ECM-EST/2424/2012
Funding Entity: FCT
Principal Contractor: University of Minho

> BE-EARTH - BEhaviour characterization and rehabilitation of EARTHen construction

ISISE Principal Investigator: Daniel Oliveira
Budget: Global: 116.376,00 € / ISISE-UM: 46.248,00 €
ID: PTDC/ECM-EST/2396/2012
Funding Entity: FCT
Principal Contractor: University of Aveiro
Participating Institutions: Instituto Superior Técnico; University of Minho



> **Inotec - Innovative Material of Ultra-high Ductility for the Rehabilitation of the Built Patrimony**

ISISE Principal Investigator: Joaquim Barros

Budget: Global: 482.441,20 € / ISISE-UM: 341.786,01 €

ID: 23024

Funding Entity: ADI

Principal Contractor: Civitest – Pesquisa de novos materiais para a engenharia civil

Participating Institutions: University of Minho

> **UrbanCrete - Fibre Reinforced Concrete of Enhanced Properties of Durability for Urban Furniture and Infra-Structures**

ISISE Principal Investigator: Joaquim Barros

Budget: Global: 595.928,84 € / ISISE-UM: 278.710,47 €

ID: 30367

Funding Entity: ADI

Principal Contractor: Francisco Pereira Marinho & Irmãos, S.A.

Participating Institutions: University of Minho

> **SEISMIC-V - Vernacular Seismic Culture in Portugal**

ISISE Principal Investigator: Graça Vasconcelos

Budget: Global: 116.376,00 € / ISISE-UM: 47.088,00 €

ID: PTDC/ATP-AQI/3934/2012

Funding Entity: FCT

Principal Contractor: FCO - Fundação Convento da Orada

Participating Institutions: University of Minho; University of Aveiro

PHD THESES COMPLETED

> **Numerical models for the simulation of the cyclic behaviour of RC structures incorporating new advanced materials**

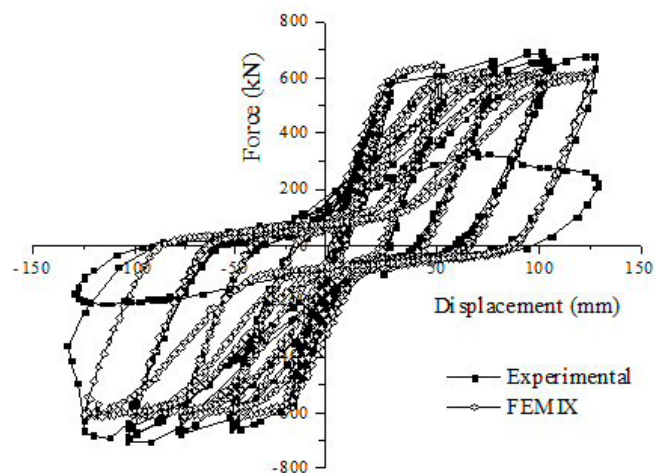
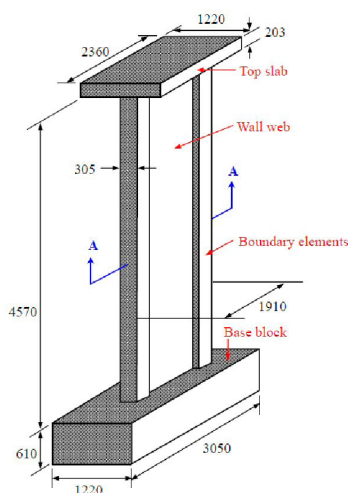
Author: Rajendra Varma

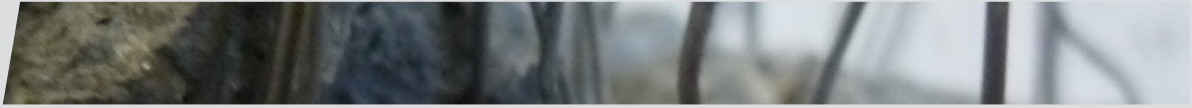
Supervisors: Joaquim Barros and José Sena-Cruz

Date: March 13, 2013

Summary: This work deals with material modelling and numerical implementation for nonlinear finite element analysis of reinforced concrete (RC) structures. The uniaxial constitutive laws of concrete, steel and CFRP confined concrete were implemented in FEMIX. The analytical relationship was proposed for uniaxial constitutive model of CFRP confined concrete under monotonic and cyclic loading. A parametric study was undertaken to study the effect of post-cracking behaviour of FRC sections. A biaxial concrete model under the framework of the fracture mechanics was developed, to simulate the RC elements under plane stress field. Equivalent uniaxial stress-strain relationships of the concrete are used in orthogonal direction in scope of the rotating crack model. To supplement it, a smeared reinforcement model for steel bars is also developed, in context of plane stress/Mindlin shells elements.

CV: **Rajendra Kumar Varma** was born in Rajgarh district of India, earned Bachelor of Technology from IIT Guwahati in 2005, and currently is working as a bridge design engineer in India. His research interests are numerical simulation of reinforced concrete, development of constitutive models and design of bridges.





> **New Methodologies for Seismic Design of Unreinforced and Confined Masonry Structures**

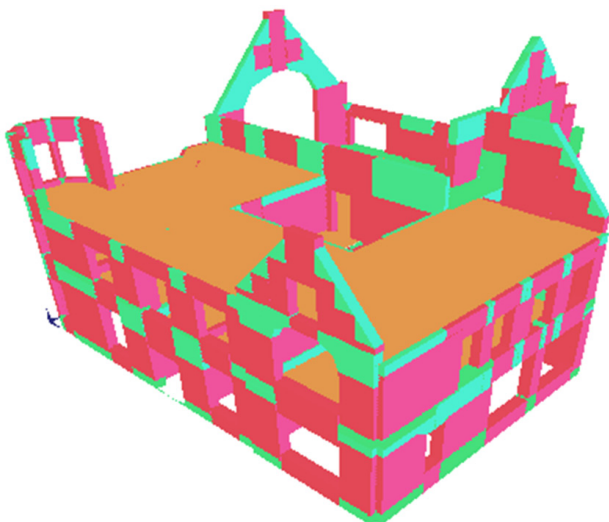
Author: Rui Filipe Pedreira Marques

Supervisor: Paulo P. Lourenço

Date: February 22, 2013

Summary: This work addresses the possibilities of construction and modern design for earthquake-resistant masonry structures. A benchmarking of software for design of masonry buildings is made with emphasis to tools based on macro-element modelling and pushover analysis, from which a simplified method for global analysis of buildings is proposed that considers the inelastic capacity of masonry structures. After, the confined masonry typology is studied as an improvement to the masonry structures, by developing numerical/analytical models for seismic design. Finally, case studies are presented regarding the seismic assessment of the Old Municipal Chambers building in Christchurch, the comparison of structural typologies for construction of modern housing, and the application of design tools for new masonry buildings. The used tools present reliability and computational efficiency, which allowed verifying the practicability and advantages of structural masonry, aiming at a more sustainable future.

CV: **Rui Marques** (Monção 1980) is postdoc fellow at PUCPerú in the field of adobe/stone structures. He is graduated, MSc and PhD in Civil Engineering by University of Minho. Rui has worked in areas of artificial intelligence applied to geotechnical/structural problems, and design/seismic analysis of masonry constructions focusing on macroelement approaches. He collaborated in 10 R&D studies and has 30 publications.



> **Flexural and shear strengthening of RC elements**

Author: Gláucia Maria Dalfré

Supervisor: Joaquim Barros

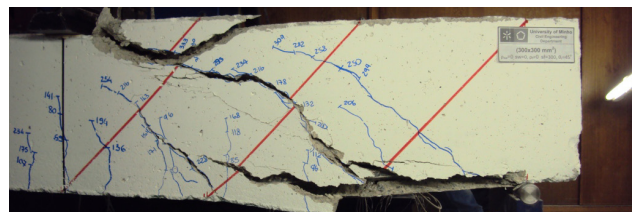
Date: February 28, 2013

Summary: The potentialities of the NSM technique for the increase of the load carrying capacity of two spans continuous RC slab strips strengthened with Carbon Fibre Reinforced Polymer (CFRP) laminates, applied according to the NSM technique in both hogging and sagging regions, were explored. In this context, experimental, numerical and analytical investigation were carried out and it was verified the possibility of increasing the load carrying capacity in 25% and 50%, maintaining a relatively high level of moment redistribution, when correct NSM flexural strengthening arrangements



are used. According to the results, the increase of the load carrying capacity of the strengthened slabs can, however, be limited by the formation of a shear failure crack in the hogging region. To avoid the occurrence of this brittle failure mode, a new technique, designated Embedded Through Section (ETS) was also developed.

CV: **Gláucia Dalfré** graduated in Civil Engineering by EEP/Brazil in 2004, Master of Science in Civil Engineering by USP/Brazil in 2007, a researcher at ISISE in University of Minho and finished her PhD in February 2013 by the same University. Professor at UNILA/Brazil. Her research interests include structural analysis and modelling, fiber-reinforced composites, including repair and retrofit of civil infrastructures.





> **Fibre reinforced concrete: applications and inspection and strengthening techniques for structural elements affected by fire**

Author: Lúcio Lourenço

Supervisor: Joaquim Barros

Date: January 23, 2013

Summary: The use of FRC has been increasing in the Construction market. The use of fibres has been extended to self-compacting cement based materials in order to obtain a composite material (FRSCC) that can combine the benefits of fibre reinforcement with self-compacting requisites. The addition of fibres, mainly those of synthetic nature, is also especially suitable to enhance fire resistance. This PhD work aims to contribute for the increase of the knowledge on the technology of FRC/FRSCC, the characterization of its behaviour from experimental tests, on its use on innovative structural systems and on the structural rehabilitation. Advanced numerical tools were used in order to explore the post-cracking benefits provided by fibre reinforcement for the load carrying capacity of FRC structures before and after high temperature exposure. The applicability of NDT for the assessment of the material and structural behaviour of damaged structures was also assessed. Finally, a methodology for the rehabilitation of a RC building submitted to a fire using FRSCC was described.

CV: **Lúcio Lourenço** obtained his 5-year Civil Engineering degree in 2003, MSc in 2005 and PhD in 2013 at the University of Minho. Nowadays he is a Invited Assistant in the Department of Civil Engineering at University of Minho and Civil Engineer at CiviTest company, focusing on the technology of FRC, the characterization of its behaviour from experimental tests and on the structural rehabilitation.



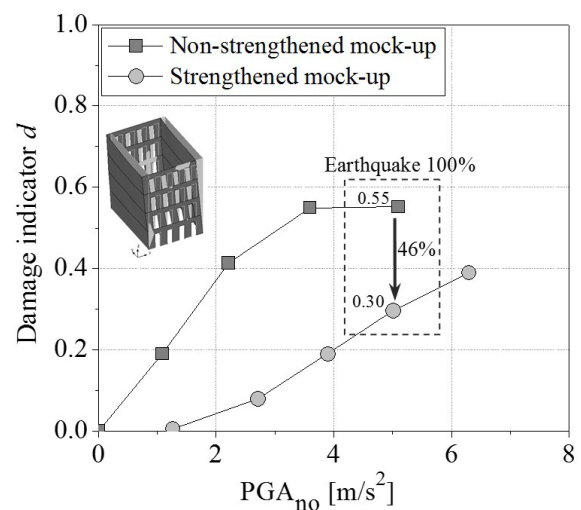
> **Seismic Assessment of Ancient Masonry Buildings: Shaking Table Tests and Numerical Analysis**

Author: Nuno Mendes

Supervisor: Paulo Lourenço

Date: December 21, 2012

Summary: The Portuguese housing stock consists of several building typologies in which some of them present construction features associated with poor seismic performance. Thus, it is necessary to intervene in these buildings with the purpose of reducing their seismic vulnerability. The present thesis aims at evaluating the seismic vulnerability of the “gaioleiro” buildings and proposing a strengthening technique to reduce it. Two mock-ups were built: non-strengthened and strengthened mock-ups; and tested at LNEC. In the strengthened mock-up steel elements were used to improve the connection between walls and floors, and ties in the upper storeys. A numerical model of the non-strengthened mock-up was calibrated and a sensitivity analysis was carried out. The strengthening technique improved significantly the seismic behaviour and a reduction of the damage indicator of about 50% was obtained, leading to the conclusion that it was efficient in the reduction of its seismic vulnerability.



CV: **Nuno Mendes** was born in Braga, Portugal and went to University of Minho, where he studied civil engineering and obtained his 5-years degree in 2006. He obtained his PhD at University of Minho in 2012. He is interested in everything related to inspection, diagnosis and advanced analysis of historical construction, earthquake engineering and structural dynamics.

> **Experimental Analysis of Lime-Based Grouts for the Injection of Ancient Masonry**

Author: Eduarda Cristina Pires Luso

Supervisors: Paulo Lourenço and Rui Miguel Ferreira (VTT, Finland)

Date: December 21, 2012

Summary: The research was focused on injection grouts for consolidating and strengthening old stone masonry walls.

Part of the research was devoted to the study of pre-mixed commercially available grouts. In addition, a study of different lime based grouts using commercially available raw materials was undertaken in the laboratory with the intention of defining some compositions as potential replacements for commercial grouts, while simultaneously satisfying the requirements these products are subjected too. Subsequently, an experimental campaign addressing the behaviour of stone masonry walls, when subject to injection grouting, was performed. The analysis of this mechanical behaviour was carried out based on the experimental results of uniaxial compression tests. The influence of strengthening by injection grouting was analysed consideration of two types of grouts. A comparative analysis was performed between among the walls tested based on strength, stiffness and peak strain.



CV: **Eduarda Luso** is graduated in Civil Engineering by the Faculty of Sciences and Technology of the University of Coimbra in 1997, Master of Science in Civil Engineering in 2002 in University of Minho, a researcher at ISISE, and finished her PhD in December of 2012 by the same University. She has been teaching at Polytechnic Institute of Bragança since 2000.

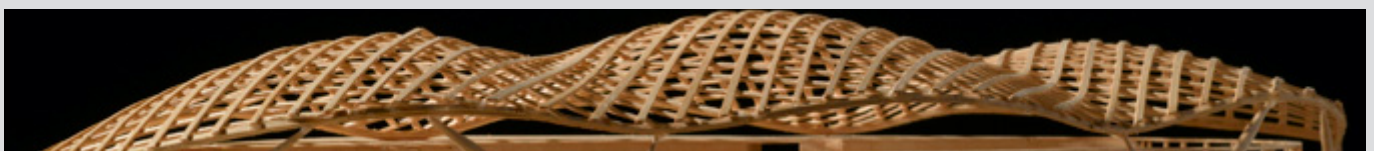
EVENTS

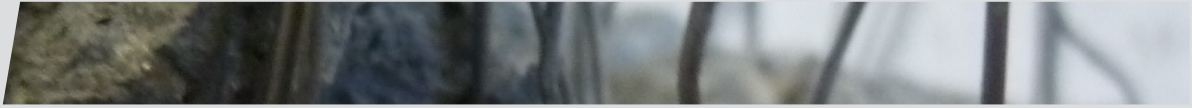
SEMINÁRIO CASAS DE MADEIRA

Place: Auditorium of LNEC, Lisbon, Portugal

Date: April 17, 2013

Summary: For the second year, ISISE organized a one-day seminar on the field of timber engineering. The seminar provided a forum for discussion of ideas and solutions in the field of timber houses, with the presentation of the latest trends, allowing a bridge to the more traditional solutions and some reflections on technical aspects of performance, energy efficiency and sustainability in construction.





BUILDING INFORMATION MODELING: POTENCIALIDADES E DESAFIOS PARA A ARQUITECTURA E ENGENHARIA

Place: Auditorium B1.10, Azurém, University of Minho

Date: December 12, 2012

Summary: The seminar "BIM - Building Information Modeling: challenges and possibilities for Architecture and Engineering" took place in the 12th December 2012 at Auditorium B1.10 of the School of Engineering of the University of Minho. The event was organized by the ISISE members Miguel Azenha and José Carlos Lino, aiming to the academic community of the Schools of Engineering and Architecture of the University of Minho. Several invited speakers have participated, representing active companies that use BIM in the scope of Architecture, Engineering desing and Construction, as well as software houses.

More than 200 participants attended the seminar, highlighting the relevance of the topic for the academic

community. The event also kick started the creation of the BIMCLUB (www.bimclub.pt).

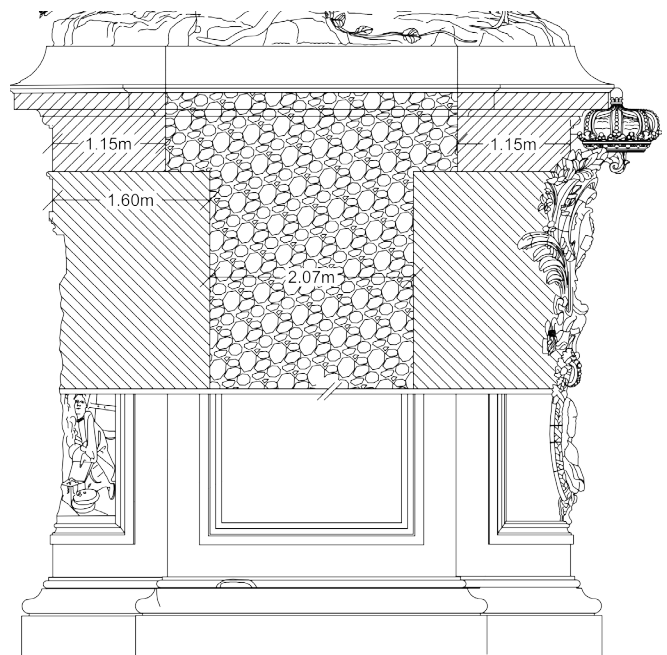


ISISE TECHNOLOGIES

ASSESSMENT OF THE D. JOSÉ I STATUE

The statue of D. José I, located in the Praça do Comércio, in Lisbon, is currently, undergoing conservation works. One major objective is to understand the way the various elements stand together, especially, how the statue fixes into the stone base and the dimensions of the stone elements of the base. Georadar was used to determine the geometry of the stones and connectors between stones. The way the statue connects to the stone was also verified. The use of antennas with 500, 800 and 1600 MHz allowed to successfully verify the geometry of the stones that were accessible. The radargrams showed also the existence of vertical metallic connectors that connect successive stone layers.

Fernandes, F., Lourenço, P.B. (2013) "Inspection of the statue of D. José I, located in the Comércio Square, Lisbon, Portugal, by the use of the georadar" Report no. 13-DEC/E-05, University of Minho, Guimarães, Portugal, pp. 17.





UPCOMING EVENTS

> ASCP-2013, 3º Congresso Nacional sobre Segurança e Conservação de Pontes

Place: Porto, Portugal

Date: 26-28 June, 2013

Website: ascp2013.ascp.pt

> FRPRCS-11: 11th International Symposium on Fibre Reinforced Polymer for Reinforced Concrete Structures

Place: Guimarães, Portugal

Date: 26-28, June, 2013

Website: www.frprcs11.uminho.pt

> II Congresso Luso - Africano de Construção Metálica Sustentável

Place: Maputo, Mozambique

Date: 19th, July, 2013

Website: www.cmm.pt/cla

> ICSA2013: 2nd International Conference on Structures and Architecture

Place: Guimarães, Portugal

Date: 24-26, July, 2013

Website: www.icsa2013.arquitectura.uminho.pt

> IX Congresso de Construção Metálica e Mista e I Congresso Luso-Brasileiro de Construção Metálica Sustentável

Place: Porto, Portugal

Date: 24-25, October 2013

Website: www.cmm.pt/congresso

MASTER COURSES

> **SAHC – www.msc-sahc.org**

> 1st Phase: until 20th January

> 2nd Phase: until 20th May

> 3rd Phase: until 20th August

> **Master Program SCS/Suscos**
www.dec.uc.pt

> 1st Phase: 16th February until 15th April

> 2nd Phase: 15th June until 15th July

> 3rd Phase: 15th until 31st August

PHD COURSES

> **Doctoral Program Civil Engineering**
www.pdec.civil.uminho.pt and
www.dec.uc.pt

> 1st Phase: 23rd May until 14th June

> 2nd Phase: 8th August until 6th September

> 3rd Phase: 3rd until 28th January

> **Doctoral Program Steel and Composite Structures – www.dec.uc.pt**

> 1st Phase: 16th February until 15th April

> 2nd Phase: 15th June until 15th July

> 3rd Phase: 15th August until 30th September

