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## ISISE HIGHLIGHTS

This second issue of the ISISE Newsletter documents the recent activity of The Institute for Sustainability and Innovation in Structural Engineering. In this period, several new National and European R&D projects were started, together with the successful completion of some ongoing projects, demonstrating high activity in this field. ISISE has maintained strong outputs in specialized consultancy, organization of national and international events, concluded

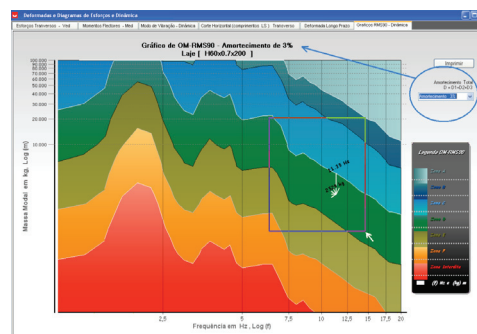
PhD theses and a strong intake of new PhD students.

Special focus to the start of the new Erasmus Mundus European Master in Sustainable Constructions under Natural Hazards and Catastrophic Events, due to start in Coimbra in September 2012 and the successful continuation of the Erasmus Mundus European Master in Structural Analysis of Monuments and Historical Constructions at the University of Minho.

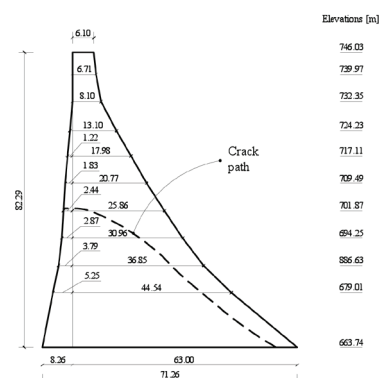
### CONFERENCE ON STEEL AND COMPOSITE CONSTRUCTION



### OPTIMIZATION OF COMPOSITE SLABS AND DEVELOPMENT OF DESIGN TOOLS



### DEVELOPMENT OF A DISCRETE ELEMENT MODEL FOR MASONRY GRAVITY DAMS ANALYSIS





## PHD COMPLETED

- > *Constitutive models for the material nonlinear analysis of concrete structures including time – dependent effects* – **António Ventura Gouveia** / Supervisors: Prof. Joaquim António Oliveira de Barros (University of Minho, Portugal) and Prof. Álvaro Ferreira Marques Azevedo (University of Porto, Portugal) – 20<sup>th</sup> December, 2011.
- > *Development of a Discrete Element Model for Masonry Gravity Dams Analysis* – **Eduardo Martins Bretas** / Supervisors: Prof. Paulo Barbosa Lourenço (University of Minho, Portugal) and Doutor José Antero Senra Vieira de Lemos (Laboratório Nacional de Engenharia Civil, Portugal) – 16<sup>th</sup> March, 2012.
- > *Behaviour of Building Columns in Fire* – **António José Moura Correia**, University of Coimbra, Supervisor: Prof. João Paulo Correia Rodrigues (University of Coimbra, Portugal) – 17<sup>th</sup> February, 2012.

## R&D STARTED PROJECTS

- > *MAINLINE – MAINTenance, renewAL and Improvement of rail transport infrastructure to reduce Economic and environmental impacts* – Prof. Paulo Jorge de Sousa Cruz – 155.340,00€ – MAINLINE (Nº 285121) – Funding Entity: European Commission – Principal Contractor: Union Internationale des Chemins de Fer – Participating Institutions: UM; Network Rail Infrastructure LDT; Cowi A/S; Mouchel Limited (from 01-10-2011 to 30-09-2014).
- > *WoodenQuark* – Prof. Jorge Manuel Gonçalves Branco – 147.477,59€ – WoodenQuark (Nº 21635) – Funding Entity: Adi – Principal Contractor: Portilame Engenharia e Madeira, Lda. – Participating Institutions: UM (from 01-01-2012 to 31-12-2014).
- > *IMPACTFIRE – Robust Connections for Impact and Fire Loading* – Prof. Aldina Santiago – 183.599,00€ – PTDC/ECM/110807/2009 – Funding Entity: FCT – Principal contractor: FCTUC, Portugal; Participating Institutions: SOCOMETAL, Portugal, LTU, Sweden (from 01-01-2011 to 31-12-2013).
- > *FRAMEUP – Optimization of frames for effective assembling* – Prof. Luis Simões da Silva, Prof. Carlos Rebelo – 1.558.533,00€ – RFS-PR-10121 – Funding Entity: EU – RFCS – Participating Institutions: TU Lulea, Sweden (coordenador); University of Liège, Belgium; Acciona, Spain; FCTUC, Portugal; Part AB, Sweden; RTWH, Germany; V&M Deutschland, Germany (from 01-07-2011 to 30-06-2014).

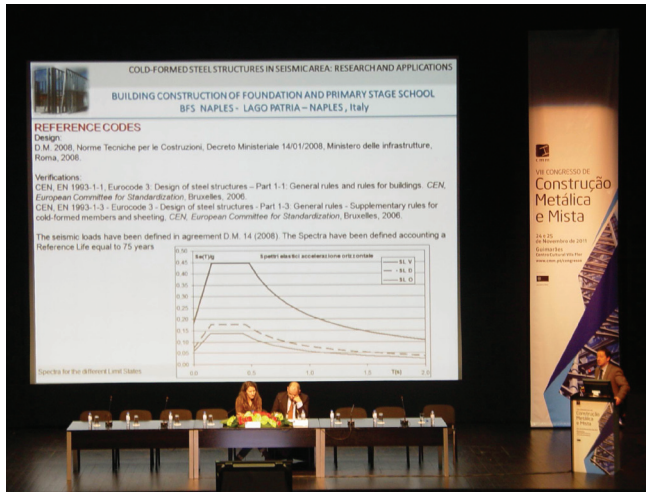






# EVENTS

## CONFERENCE ON STEEL AND COMPOSITE CONSTRUCTION – VIII CMM



The 8<sup>th</sup> edition of the Conference on Steel and Composite Construction was held on the 24<sup>th</sup> and 25<sup>th</sup> November 2011 in Guimarães, in “Centro Cultural de Vila Flor”, and organized by the Portuguese Steelwork Association. The event was attended by over 200 participants and aimed to promote the latest innovations in this type of construction, to make known the main ori-

entations of research in this field and disseminate the main innovations with the aim of promoting the potential of the steel and composite construction. It was also the ideal venue for exchange of ideas and experiences among various participants in the implementation of projects that represent this construction sector (owners, designers, steelwork contractors, etc.).

# R&D COMPLETED PROJECTS

> *Safety evaluation of timber structures through non-destructive methods and stochastic analysis* – Prof. Paulo B. Lourenço – 36.200,40€ – PTDC/ECM/66527/2006 – Funding Entity: FCT – Principal Contractor: LNEC – Participating Institutions: Instituto de Investigação Científica e Tropical; UM (from 2-1-2008 to 31-12-2011).

This research project had the main objective to develop a framework for reliability-based assessment of timber structures and members using data gathered from non-destructive test results. In a first step, non-destructive methods were used to assess the strength and stiffness of clear wood elements and structural size wood elements in service conditions. Two wood spe-



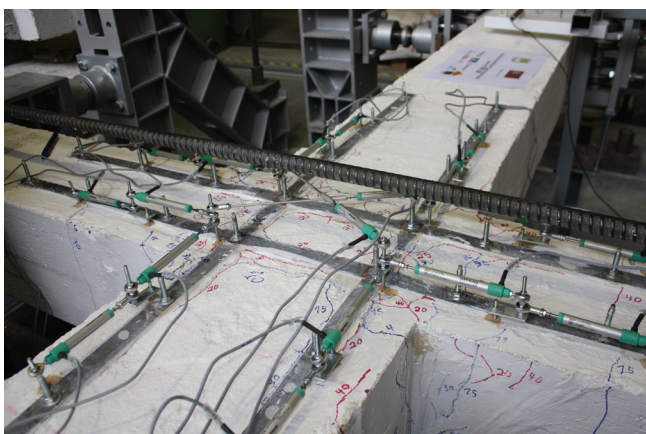
cies were studied, maritime pine (*Pinus pinaster*) and chestnut (*Castanea sativa* Mill.), being the compression parallel to the grain, density and the bending stiffness and strength the key properties



evaluated. These results were used for modeling an update of the mechanical characteristics of timber, using Bayesian methods. Moreover, degradation was taken into account through the calibration of existing deterioration models applied to specific key elements of the structure. Then, this methodology was tested in case studies in laboratory, on timber elements, and in-situ, on full-scale timber trusses. The main achievements of this research project have been presented and discussed in the international conference Structural Health Assessment of Timber Structures, which took place in Lisbon in 16<sup>th</sup> and 17<sup>th</sup> July 2011.

> *Seismic repair and strengthening reinforced concrete beam-column joints with multidirectional CFRP laminates* – Prof. José Manuel Sena Cruz – 129.500,00€ – PTDC/ECM/74337/2006 – Funding Entity: FCT – Principal Contractor: UM (from 01-01-2008 to 30-09-2011).

A new strengthening technique that uses multidirectional laminates of carbon fiber reinforced polymer (MDL-CFRP) was proposed. These laminates are simultaneously anchored and bonded to concrete. Additionally the anchors are prestressed. The research project included the development of the MDL-CFRP and the corresponding mechanical characterization. Experimental programs were carried out to study the bond behavior between the MDL-CFRP and concrete when the present technique is applied, being the number, diameter,



and prestressed level of the anchors the main variables analyzed. Experimental programs were also carried out to verify the potentialities of the technique for the seismic repair and strengthening of reinforced concrete (RC) beam-column joints. Full-scale RC joints, representative of interior and corner beam-column connections in buildings were used and submitted to a cyclic test inducing a damage pattern representative of a seismic event. Numerical simulations of the pullout tests and the RC joints were also developed. Additional information can be found in [www.sc.civil.uminho.pt](http://www.sc.civil.uminho.pt)

> *CUTINEMO – Carbon fiber laminates applied according to the near surface mounted technique to increase the flexural resistance to negative moments of continuous reinforced concrete structures* – Prof. Joaquim A. O. Barros – 170.000,00€ – PTDC/ECM/73099/2006 – Funding Entity: FCT – Principal Contractor: UM (from 01-01-2008 to 30-06-2010).



In this project the potentialities of the near surface mounted (NSM) CFRP laminates for the flexural strengthening of continuous reinforced concrete slabs were assessed in terms of load carrying and moment redistribution capacities, and ductility performance. Adopting a flexural strengthening strategy composed of CFRP laminates applied in both hogging and sagging regions, the increase of load carrying capacity has exceeded the target values (25% and 50%) and the moment redistribution capacity was not significantly affected. The





flexural strengthening performance was limited by the detachment of the concrete cover that includes the laminates at the hogging region. The developed Mindlin-shell layered model, able of simulating the material nonlinear behavior of concrete due to crack propagation and plastic deformation in compression, as well as the elasto-plastic behavior of steel bars, was capable of simulating with good accuracy the main relevant behavioral aspects of this type of structures up to failure.

> *ROBUSTFIRE – Robustness of car parks against localized fire* – Prof. Luis Simões da Silva – 1.266.395,00€ – RFS-PR-07039 – Funding Entity: EU – RFCS – Promoting Institutions: Univ. Liège, Belgium – Partner Institutions: Imperial College, UK; University of Coimbra, Portugal; ArcelorMittal, Luxembourg; CSTB, France; Greisch Ingenieure, Belgium; CTICM, France (from 01-07-2008 to 30-06-2011).

The European RFCS ROBUSTFIRE project investigated the behaviour of steel and composite open car parks subject to an exceptional localised fire. In this approach, the structure is designed in such a way that an unforeseen event does not lead to a



disproportionate structural collapse. On the other hand, the development, locally in the structure, of large deformations or displacements is accepted, as long as progressive collapse is prevented.

A design philosophy aiming at the economical design of car parks exhibiting a sufficient robustness under localised fire was developed and practical design guidelines for the application of this design philosophy throughout Europe were derived. In order to reach this goal, experimental, numerical and analytical developments were achieved.

> *SEMI-COMP+ – Valorization Action of Plastic Member Capacity of Semi Compact Steel Sections – a more Economic Design* – Prof. Luís Simões da Silva – 333.659,00€ – RFS2-CT-2010-00023 – Funding Entity: EU – RFCS – Partner Institutions: TUGraz; Austria (coordinator); Univ. Liège, Belgium (from 01-07-2010 to 31-12-2011).





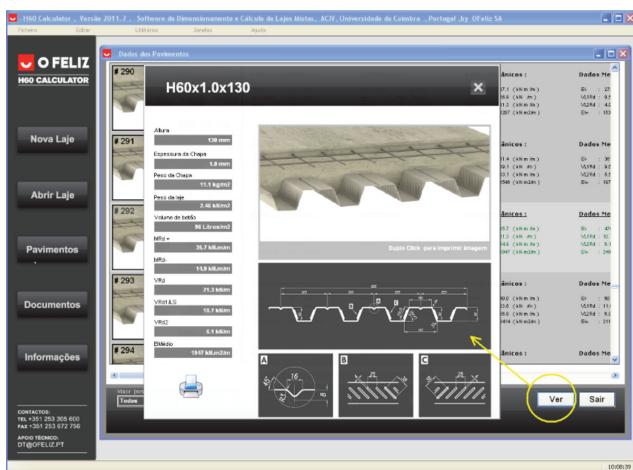
# ISISE TECHNOLOGIES

**PROJECT:**  
OPTIMIZATION OF COMPOSITE SLABS  
AND DEVELOPMENT OF DESIGN TOOLS  
**STEELWORK COMPANY:**  
O FELIZ, METALOMECÂNICA S. A.

A composite slab is a structural element composed by a cold formed steel sheeting acting together with the concrete. The design of a composite slab may be governed by one of the following modes: vertical shear, longitudinal shear, bending moment or serviceability conditions. Eurocode 4 provides analytical formulations to evaluate the previous modes; however, the methods for prediction the longitudinal shear resistance depend of a set of parameters calibrated experimentally.

In the scope of this consultancy activity, the Steel and Composed Mixed Technologies Group of ISISE developed an analytical and experimental study to established all the required parameters for the design of composite slabs with sheet profiles produced by a portuguese steelwork company – O Feliz, Metalomecânica S.A.; it involved the following activities:

- i) development of design tables;
- ii) optimization of the shape of steel sheeting;
- iii) evaluation of the dynamic behaviour;
- iv) development of a design software – H60-Calculator.



# ISISE'S THESES

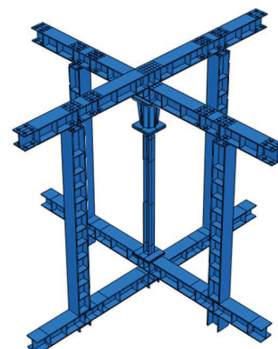
**FIRE RESISTANCE OF STEEL AND  
COMPOSITE STEEL-CONCRETE COLUMNS**

The purpose of this work was to study the influence of several parameters. Contact with brick walls, stiffness of the surrounding structure, load level, and slenderness of the columns, on the fire resistance of steel and composite columns in buildings. Experimental tests were performed on steel H columns embedded on walls, bare steel H columns and composite steel-concrete partially encased H columns with restrained thermal elongation. Results of the experimental tests were compared with numerical studies, with the purpose of providing valuable data for the development or improvement of analytical designing methods.

A geometrical and material non-linear analysis with imperfections was performed with the finite element code ABAQUS.

The major outcomes of this research work were proposals for the assessment of the temperature evolution within the cross-section of unevenly heated steel columns in contact with walls, proposals for the calculation of the critical temperatures and fire resistance of steel bare column, and plastic axial force – bending moment diagrams for steel beam columns at elevated temperatures.

**CV António José Pedroso de Moura Correia**, born in 26/06/1970, in Coimbra. Graduated in Civil Engineering by the Faculty of Science and Technology of the UC in 1993, and Master of Science in Civil Engineering in 1997 by the same University. Professor in the Polytechnic Institute of Coimbra, researcher on Structures in Fire, author of several papers in Conference Proceedings and Scientific Magazines, participated in several research projects in the field of Fire Resistance of Structures.



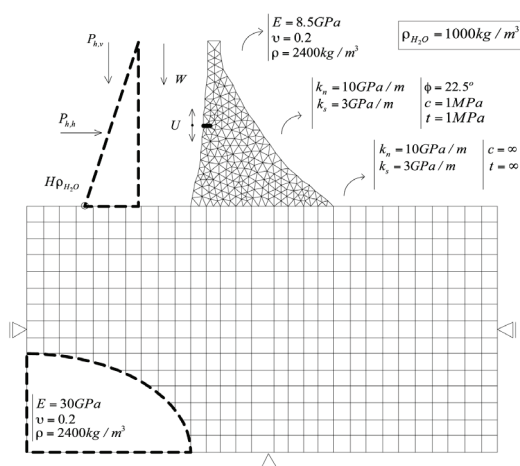




## DEVELOPMENT OF A DISCRETE ELEMENT MODEL FOR MASONRY GRAVITY DAMS ANALYSIS

The majority of the masonry gravity dams was constructed between 1850 and 1950. Many of these dams present insufficient structural safety that reflects the knowledge available in this period. Nowadays, the exploitation of these dams is challenging, since the structural safety should be achieved according to modern regulations. Many of the numerical applications in the market do not allow to model actual failure mechanisms typical of masonry gravity dams. A tailored numerical application using the Discrete Element Method was developed. This application allows performing static, dynamic and flow analyses, with hydro-mechanical coupling, in addition to analyzing the process of grouting and structural strengthening with anchors. This numerical application has been used with success for the evaluation of structural safety conditions of several dams. One example is the study of the Bhandardara Dam, India, including grouting and application of active and passive anchors, as a sequence of the severe cracks exhibited. A comprehensive set of static and dynamic analyses was carried out, so that adequate safety levels and repair and strengthening solutions could be established.

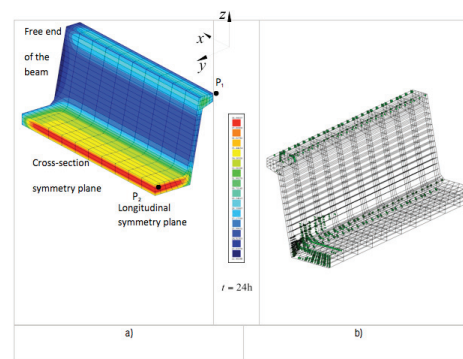
**CV Eduardo Martins Bretas** is a Civil Engineer and a PhD student of the Department of Civil Engineering, at University of Minho. He has developed his project at LNEC, Department of Concrete Dams.



## CONSTITUTIVE MODELS FOR THE MATERIAL NONLINEAR ANALYSIS OF CONCRETE STRUCTURES INCLUDING TIME DEPENDENT EFFECTS

Since most advanced cement based materials have relatively high binder content, the risk of cracking at an early age should be evaluated using models that can estimate the heat generated by the hydration of pozzolanic components and the induced stress fields. For this purpose, a heat transfer model was developed and integrated into a mechanical model (3D multi-directional smeared crack model) that can simulate the crack initiation and propagation in structures discretized with solid finite elements. The prediction of the behavior of the shear strengthened beams requires the use of crack constitutive models to simulate the decrease of the shear stress degradation with the crack opening evolution. Two numerical approaches are proposed to simulate this phenomenon. One is based on the use of a softening crack shear stress-strain diagram to model the fracture mode II, while in the other the total crack shear stress is obtained from the total crack shear strain adopting a crack shear modulus that decreases with the crack normal strain. The developed models also simulate the shrinkage and creep of cement based materials, and are implemented in the FEMIX 4.0.

**CV António Ventura Gouveia** was born in Kaiserslautern, Germany and graduated in Civil Engineering by University of Minho (UM) in 1996. He is a teacher in the Polytechnic Institute of Viseu, a researcher in ISISE, UM, Portugal and finished his PhD in December 2011. His research interests are in fiber reinforced concrete and in the development of constitutive models for the material nonlinear analysis of concrete structures, including time dependent phenomena.



a) Temperature field and b) crack pattern at t=24h of the transient analysis.



## UPCOMING EVENTS

15<sup>th</sup> International Brick/Block Masonry Conference, Florianópolis, Brazil, 3<sup>rd</sup> – 6<sup>th</sup> June, 2012.  
www.15ibmac.com

ISISE day-out and 4<sup>th</sup> Workshop, 5<sup>th</sup> and 6<sup>th</sup> July, 2012, Ofir, Portugal.

1<sup>st</sup> Conference Luso-African of Sustainable Steel Construction, University Agostinho Neto, Luanda – 27<sup>th</sup> July 2012. www.cmm.pt/congresso

8<sup>th</sup> RILEM International Symposium on Fibre Reinforced Concrete: Challenges and Opportunities, Guimarães, 19<sup>th</sup> – 21<sup>th</sup> September, 2012.  
www.befib2012.civil.uminho.pt

8<sup>th</sup> International Conference on Structural Analysis of Historical Constructions, Wroclaw, Poland, 15<sup>th</sup> – 17<sup>th</sup> October, 2012. www.sahc2012.org

## MASTER COURSES

> **SAHC** – <http://www.msc-sahc.org/>

- > 1<sup>st</sup> Phase: until 20<sup>th</sup> January
- > 2<sup>nd</sup> Phase: until 20<sup>th</sup> May
- > 3<sup>rd</sup> Phase: until 20<sup>th</sup> August

> **Master Program SCS/Suscós**  
<http://www.dec.uc.pt>

- > 1<sup>st</sup> Phase: 1<sup>st</sup> until 12<sup>th</sup> March
- > 2<sup>nd</sup> Phase: 1<sup>st</sup> until 12<sup>th</sup> July
- > 3<sup>rd</sup> Phase: 1<sup>st</sup> until 12<sup>th</sup> September

## PHD COURSES

> **Doctoral Program Civil Engineering**  
<http://www.eng.uminho.pt/> and  
<http://www.dec.uc.pt/>

- > 1<sup>st</sup> Phase: 23<sup>rd</sup> May until 14<sup>th</sup> June
- > 2<sup>nd</sup> Phase: 8<sup>th</sup> August until 6<sup>th</sup> September
- > 3<sup>rd</sup> Phase: 3<sup>rd</sup> until 28<sup>th</sup> January

> **Doctoral Program Steel and Composite Structures** – <http://www.dec.uc.pt>

- > 1<sup>st</sup> Phase: 1<sup>st</sup> until 12<sup>th</sup> March
- > 2<sup>nd</sup> Phase: 1<sup>st</sup> until 12<sup>th</sup> July
- > 3<sup>rd</sup> Phase: 1<sup>st</sup> until 12<sup>th</sup> September

