



# LESE

LABORATORY FOR EARTHQUAKE AND STRUCTURAL ENGINEERING

FACULTY OF ENGINEERING, UNIVERSITY OF PORTO

PORTUGAL

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# Newsletter

Summer 2012

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*Never express yourself  
more clearly than you are  
able to think.*

*Niels Bohr\**

\* As quoted in Values of the Wise : Humanity's Highest Aspirations (2004) by Jason Merchev, p. 63

## LESE Research Group

**Head: Raimundo Delgado**

## LESE Laboratory

**Executive Director: António Arêde**

## LESE Newsletter Board

### Editors

**Alexandre A. Costa**

**Xavier Romão**

### Collaborators

**Luís Macedo**

**Nuno Pereira**

## Editorial



*Aníbal Costa - Head of  
the LESE group at the  
University of Aveiro*

The field of construction conservation and rehabilitation is one of the most recent additions to the education programmes offered by many universities, as well as also being one of the most prominent areas of research. The Faculty of Engineering of the University of Porto (FEUP) has been working in this field since 1999 and developed several cooperation protocols with governmental agencies, namely with the (now closed) General Directorate for Buildings and National Monuments (DGEMN). These protocols were established in order to assess the structural safety of heritage buildings and monuments in the northern region of Portugal, and to define specific procedures and strengthening/repair techniques for their conservation and rehabilitation. When DGEMN was shut down, a new cooperation protocol was established with the following governmental agency, the Northern Regional Directorate of Culture, which is still in effect.

Starting the referred protocols provided the necessary conditions to carry out numerous applications of field and laboratory research, and contributed also to the development of the Laboratory for Earthquake and Structural Engineering (LESE) at FEUP. Part of the LESE activities aim to provide a better understanding of the structural behaviour of monuments and heritage constructions by studying construction techniques and construction systems found in old buildings. Research in this field also includes experimental studies on the efficiency of several rehabilitation and strengthening solutions.

Simultaneously, the Rehabilitation Nucleus of the Construction Institute (IC) was also created at FEUP. The main objective of the Rehabilitation Nucleus was to provide technical consultancy services to the protocols and to other public or private entities requiring such type of work.

Since 2003, LESE and IC have been collecting both technical means and human resources to be able to carry out static or dynamic tests in reinforced concrete, steel, stone masonry or timber structures. Currently, LESE and IC possess specialized human and laboratory resources to carry out the necessary works in the specific domain of the behaviour analysis of existing constructions which involve technical inspections, laboratory tests, in situ tests, and the development of expert reports.

In a time where society is increasingly showing interest in the subject of urban rehabilitation, FEUP, by means of LESE and IC, can provide significant contributions in developing studies and innovative procedures to define adequate solutions for the preservation of monuments and heritage constructions, as well as of most of our older constructions.

## LESE News

Between the first and this second issue of the LESE Newsletter, three members of the LESE research group got their PhD. The first one was Bruno Silva at the University of Brescia, Italy, in structural rehabilitation of historical buildings. Then, in May, both Hugo Rodrigues and Cristina Ribeiro got their PhD degrees. Hugo Rodrigues concluded his PhD at the University of Aveiro (UA) in seismic behaviour of reinforced concrete members while Cristina Ribeiro concluded her PhD at FEUP and studied the behaviour of high-speed railway lines.

The book "Manual de apoio ao projecto de reabilitação de edifícios antigos" (Technical support manual for the design of rehabilitation interventions in old buildings) that involves several book chapters from LESE members was released by the Portuguese Association of Civil Engineers. The book provides a series of guidelines and design aids for the adequate retrofit and rehabilitation of old buildings.

Several LESE members were also involved in earthquake reconnaissance missions after the recent earthquakes in Italy. A team of LESE members from FEUP and UA went to L'Aquila, Italy, at the beginning of July for a second visit (the first visit was in 2009, just days after the 2009 earthquake) to observe the retrofitting operations that were carried out over the past three years and to see how the region has recovered. The visit was then extended to the Emilia-Romagna region to observe the damages caused by the May earthquake sequence.

Previous issues of the LESE Newsletter will be available at <http://lesenews.weebly.com/index.html>.

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## LESE Doctorate – Bruno Silva



*Dr. Bruno Silva and graduation colleagues, with the jury committee. From left to right: Prof. Giovanni Plizzari, Dr. Cristina Zanotti, Dr. Rita Franceschinis, Dr. Facconi Luca, Prof. Ezio giuriani, Prof. Pietro Gambarova, Prof. Paulo Lourenço, Dr. Bruno Silva, Dr. Consuelo Beschi, Prof. Paulo Riva, Dr. Sara Mostosi*

### Diagnosis and strengthening of historical masonry structures: numerical and experimental analyses

On April 4th 2012, the PhD examination of Dr. Bruno Silva took place at the "Aula Riunioni" of the Department of Civil, Architectural, Environmental and Land Planning Engineering (DICATA), University of Brescia.

The main objectives of this PhD research were (i) to gather a deeper knowledge on the static and dynamic behaviour of three-leaf stone masonry structures and elements (for reinforced and unreinforced conditions) through an extensive destructive and non destructive experimental campaign; (ii) to assess and validate the effectiveness of injecting hydraulic lime-based grouts as a reinforcement technique; (iii) to calibrate a non-linear numerical behaviour model and an analytical model for the simulation of stone masonry sub-structures and building models.

## LESE Doctorate – Hugo Rodrigues

### Biaxial seismic behaviour of reinforced concrete columns

On May 16th 2012, the PhD examination of Dr. Hugo Rodrigues took place at the University of Aveiro (UA).

This PhD research presented a comprehensive study of the behaviour of reinforced concrete columns under biaxial cyclic loads. The main objectives were (i) to develop an experimental study of uniaxial and biaxial horizontal behaviour of reinforced concrete columns with constant axial loads (ii) to compare different numerical models for the assessment of biaxial behaviour and (iii) to develop a global model to represent the effects of cyclic biaxial flexure of reinforced concrete columns.



*Dr. Hugo Rodrigues and the jury committee. From left to right: Prof. João Lemos Pinto, Prof. António Arêde, Prof. Humberto Varum, Dr. Alfredo Campos Costa, Dr. Hugo Rodrigues, Prof. Aníbal Costa, Prof. Patrício Rocha, Prof. Nelson Vila Pouca and Prof. José Jara Guerrero.*

## LESE Doctorate – Cristina Ribeiro

### Transitions from embankment to structure in high speed railway lines: experimental and numerical analysis

On May 18th 2012, the PhD examination of Dr. Cristina Ribeiro took place at the great hall of the Civil Engineering department, at the Faculty of Engineering, University of Porto (FEUP).

The main objective of this PhD research was to contribute for the understanding of the short and long term dynamic behaviour of railway transition zones (from embankment to structure) based in numerical models that were calibrated and validated by experimental results.



*Dr. Cristina Costa and the jury committee. From left to right: Prof. M. Matos Fernandes, Dr. Eduardo Fortunato, Prof. Constança Rigueiro, Prof. Felipe Gabaldón Castillo, Prof. Raimundo Delgado, Dr. Cristina Ribeiro, Prof. Rui Calçada and Prof. Cecília Vale*



MANUAL DE APOIO AO PROJECTO  
DE REABILITAÇÃO DE EDIFÍCIOS ANTIGOS

COORDENAÇÃO  
VASCO PEIXOTO DE FREITAS



*“Manual de apoio ao projecto de reabilitação de edifícios antigos”:  
Book cover*

## Book: Manual de apoio ao projecto de reabilitação de edifícios antigos (Technical support manual for the design of rehabilitation interventions in old buildings)

In May 10th, the book release of the “Manual de apoio ao projecto de reabilitação de edifícios antigos” (Technical support manual for the design of rehabilitation interventions in old buildings) took place at the Salão Árabe of the Palácio da Bolsa, Porto. The book, which is only available in Portuguese, was written by researchers from FEUP and UA, coordinated by Prof. Vasco Peixoto de Freitas, and with the support of the Northern Section of the Portuguese Association of Engineers. The book addresses several technical issues related to the rehabilitation of older buildings in Portugal. The book provides extensive structural and non-structural design aids and guidelines for several different types of interventions that may be required. The main contributions of the LESE members are related to the structural assessment of older structural systems and to the definition of rehabilitation and strengthening design guidelines.

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## Technical visit: The Emilia Romagna Earthquake of May 2012

A team of researchers from FEUP (João Guedes, Xavier Romão, Esmeralda Paupério and Alice Ruano) and from UA (Aníbal Costa, Humberto Varum, Romeu Vicente and Hugo Rodrigues) carried out a two-day reconnaissance mission to the Emilia-Romagna region, Italy, affected by the recent earthquakes of the 20th and the 29th of May. The team has observed significant damages in historical constructions, churches and industrial buildings (namely under the guidance of engineering consultant Alberto Dusi from Numeria Consulting). A field report prepared after the mission that addresses the damages found in churches has been submitted to the EERI Emilia Earthquake Clearinghouse (<http://www.eeclearinghouse.org/2012-05-20-italy/>).



*Pictures of the damage found in precast industrial and heritage buildings in Emilia-Romagna taken by the team*

## Emilia-Romagna Earthquakes - EPICENTRE missions

José Melo (member of LESE and PhD student at UA) has participated in two earthquake reconnaissance missions to areas affected by the recent earthquakes in the Emilia-Romagna region, Italy. These missions were coordinated by the EPICentre. The first reconnaissance mission took place one week after the Mw 5.9 earthquake of the 20th May. The second mission was carried out four days after the Mw 5.8 earthquake of the 29th May. Reports of both missions are available at <http://www.epicentreonline.com/news>.

## Technical visit: L'Aquila three years after the Earthquake

Several LESE researchers visited the L'Aquila region, Italy, to observe the evolution of the recovery operations after the 2009 earthquake. Part of the historical centre of L'Aquila was visited under the guidance of architect Corrado Marsili who provided access to several constructions currently being retrofitted. Corrado Marsili is an architect from the Superintendence for Architectural Heritage and Landscape for Abruzzo (Italian Ministry of Heritage and Culture) that was a guest lecturer at the ARP 2010 Seminar "Avaliação de Risco em Património: Necessidade ou Luxo?" that took place at FEUP in 2010. The researchers, that also carried out a reconnaissance mission to this region three years ago after this earthquake, are currently preparing a field report to describe the more important findings and to provide important data for the management of an earthquake event in Portugal.



*The team of researchers with architect Corrado Marsili near Palazzo del Governo, in L'Aquila, one of the many buildings affected by the 2009 Earthquake.*



## Award

The LESE member of LESE Tiago Ferreira, from UA, was awarded with the [annual best formal internship report](#) given by the Ordem dos Engenheiros, the Portuguese Association of Engineers. The award was presented due to the report entitled "Avaliação da vulnerabilidade sísmica de núcleos urbanos antigos: Aplicação ao núcleo urbano antigo do Seixal" which addresses the seismic vulnerability assessment of the older building stock of Seixal, Portugal.

## LESE Sessions

Two LESE sessions took place in May and in June. The first presentation was made by Luís Macedo, which addressed the seismic design of steel structures. The second presentation was made by André Monteiro, which addressed his studies on the design of precast reinforced concrete columns for high speed railway bridges considering the specificities of the seismic action.

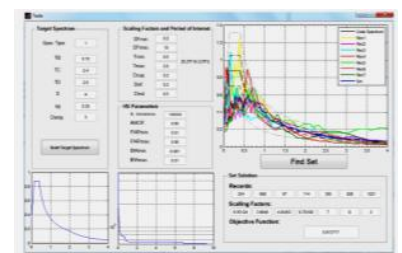
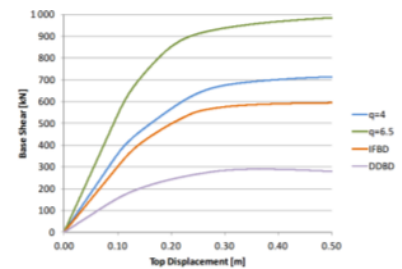
### LS05/2012 – Luís Macedo

#### Contributions to the seismic design of steel structures

Steel moment-resisting frames are well known for their ductile and stable hysteretic behaviour. Therefore, they are attractive structural solutions for seismic regions. The research of Luís Macedo focuses on the seismic behaviour of steel structures, namely the study of the specific measures required for the seismic design of these structures.

The presentation showed results regarding panel zone design and discussed several alternative proposals and the development of existing criteria. A short review of forced-based and displacement-based design methodologies was also presented along with an ongoing parametric study. Comparisons of the required steel weight obtained with each design procedure were shown and the main difficulties of each approach were highlighted.

Additionally, a tool developed for the search of sets of natural earthquake records compatible with design code spectra criteria was also presented. The key features of the procedure, which uses a heuristic optimization methodology, were discussed and future developments of the tool for earthquake ground motion selection were also highlighted.



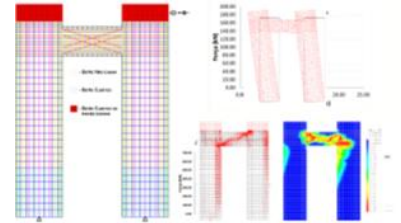
*Existing methodologies for the seismic design of steel structures were discussed, and a new platform for the selection of sets of natural ground motions compatible with design code spectra criteria was presented.*

## LS06/2012 – André Monteiro

### Portal frame configurations for high speed railway bridge columns: seismic behaviour of precast systems

High-speed railway lines (HSRL) present some very specific demands regarding track alignment and its geometrical conditioning, as well travel quality related issues such as passenger comfort, which tend to require the design of bridge piers with high structural stiffness in order to guarantee reduced levels of deformation. Nevertheless, for bridges located in seismic areas, a ductile response is required and the same structural elements should be able to accommodate the resulting deformation with a hysteretically stable performance, which is difficult to guarantee in very stiff structures. As such, a balance should be achieved between the stiffness required to comply with HSRL deformations criteria, and the ductility demand during a seismic event. The study of André Monteiro addresses this particular issue, in the context of designing HSRL bridge piers well-suited for precasting, also as part of a larger research program named SIPAV – Soluções Inovadoras Pré-Fabricadas para Vias de Alta Velocidade (Innovative Precast Solutions for HSRL).

On that subject, a reduced scale portal frame with two very stiff columns connected by a small span beam was studied and a first test was performed at the LESE laboratory. Since severe shear forces were expected to develop, and in order to facilitate a ductile behaviour while promoting the development of energy dissipation mechanisms in the beam, the first specimen used a steel reinforcement layout designed for coupling beams of shear walls. The design strategy for both the specimen and the test setup were presented and discussed, as well as some preliminary results and accompanying numerical simulations.



*A discussion about the conception and design of precast portal frame columns was presented, merging high speed railway demands, seismic ductility and the specificity of precast techniques*

## LESE Publications

Antunes, P., Travanca, R., Rodrigues, H., Melo, J., Jara, J., Varum, H., André, P. (2012) Dynamic Structural Health Monitoring of Slender Structures using Optical Sensors. *SENSORS*, MDPI AG, **12** (5), 6629-6644.

Da Porto, F., Silva, B., Costa, C., Modena, C (2012) Macro-scale analysis of damage to churches after earthquake in Abruzzo (Italy) on April 6, 2009. *Journal of Earthquake Engineering* **16**(6), 739-758.

Romão, X., Costa, A., Delgado, R. (2012) Statistical characterization of structural demand under earthquake loading. Part 1: Robust estimation of the central value of the data. *Journal of Earthquake Engineering* **16**(5), 686-718.

Romão, X., Costa, A., Delgado, R. (2012) Statistical characterization of structural demand under earthquake loading. Part 2: Robust estimation of the dispersion of the data. *Journal of Earthquake Engineering* **16**(6), 864-896.

Tavares, A., Costa, A., Varum, H. (2012) Adobe and Modernism in Ílhavo, Portugal. *International Journal of Architectural Heritage* **6**(5), 525-541.

Vicente, R., Rodrigues, H., Varum, H.; Costa, A., Mendes da Silva, J.A.R. (2012) Performance of masonry enclosure walls: Lessons learnt from recent earthquakes. *Earthquake Engineering and Engineering Vibration* **11**(1), 23-34.



## Activities at the LESE Laboratory

### LAB activities performed in this trimester

Over the second trimester of 2012, several activities occurred at the LESE lab, namely:

- **IP\_M**: In-plane cyclic tests on one leaf granite masonry walls (Celeste Almeida PhD research);
- **RC\_U2X**: Reinforced concrete columns under monotonic uniaxial and biaxial bending with constant vertical load (FCT research project on biaxial bending of reinforced concrete columns);
- **3P\_T**: Three-point bending test on strengthened timber floor joists (with the collaboration of STAP – Reparação, Consolidação e Modificação de Estruturas, s.a., and Rotho Blaas, Ltd.);
- **2R\_M**: Two-sided free rocking tests on sacco masonry wallettes (part of a FCT research project on experimental characterization of masonry constructions under earthquake actions);



### Expected LAB activities in the following trimester

Over the next three months, more experimental tests are expected to be performed in the LESE lab, namely:

- **IP\_M**: In-plane cyclic tests on one leaf granite masonry walls (Celeste Almeida PhD research);
- **VC\_M**: Vertical compression tests on one leaf granite masonry walls (Celeste Almeida PhD research);
- **RC\_U2X**: Reinforced concrete columns under monotonic uniaxial and biaxial bending with constant vertical load (FCT research project on biaxial bending of reinforced concrete columns);
- **OP\_M**: Out-of-plane cyclic tests on sacco stone masonry walls (FCT research project on experimental characterization of masonry constructions under earthquake actions);
- **SIPAV**: In-plane cyclic tests on reinforced concrete portal frames under constant vertical loads (FCT research project on high-speed railways bridge columns);



## LAB activities performed at University of Aveiro



- **Characterization and strengthening of traditional wooden trusses:** collaborative research program with the University of Minho, on three full-scale timber trusses (13 m span) rescued from the roof structure of an old industrial building (one as-built, and two with strengthening solutions);
- **Mechanical behaviour of masonry walls,** for accommodating electrical wiring and similar installations in buildings often chases are cut in infill masonry walls
- **Characterization and strengthening of “Pombalino” walls:** a collaborative research program with the University of Trás-os-Montes e Alto Douro, consisting of cyclic tests on four full-scale “Pombalino” walls.

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## Collaborations and partners

### Current partners



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## Contacts

### LESE – Laboratório de Engenharia Sísmica e Estrutural

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