



LESE

LABORATORY FOR EARTHQUAKE AND STRUCTURAL ENGINEERING

FACULTY OF ENGINEERING, UNIVERSITY OF PORTO
PORTUGAL

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Newsletter

Spring 2012

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*Research is never
finished, only abandoned.*

*Adapted from Leonardo da
Vinci*

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Message from the LESE Director

Earthquake Engineering is one of the most recent fields of Engineering and firmly established itself as a science during the first half of the XXth century. The first quantitative seismic design recommendation was made after the 1908 Messina, Italy, earthquake that caused more than 80.000 deaths. The recommendation was that building storeys should be designed for horizontal forces representing fractions of the weight above them.

The first shaking tables for the dynamic analysis of structural engineering models were developed after the 1925 Santa Barbara, USA, and the 1923 Kanto, Japan, earthquakes, while in the beginning of the 1930s, Richter's work provided the basis for the two most commonly used earthquake intensity scales: the Richter scale and the Modified Mercalli Scale

In 1955, the "Symposium on the Action of Earthquakes" held in Lisbon marked the beginning of earthquake engineering research in Portugal. Until the 1970s, research was mostly carried out by the National Laboratory of Civil Engineering (LNEC) with special emphasis on the work developed by Ferry Borges, mentor of Portuguese earthquake engineering and a paramount figure in earthquake engineering worldwide.

In 1983, the Regulation of Safety and Actions on Building Structures and Bridges is published in Portugal and introduces the fundamentals for structural seismic design using dynamic analysis, following the worldwide trends on this matter. By that time, earthquake engineering research at the Faculty of Engineering of the University of Porto (FEUP) was also starting. In 1985, the first FEUP PhD thesis on the subject was completed and an undergraduate Structural Dynamics course also began. The research group which started then has been growing since and involves researchers mostly from FEUP and the University of Aveiro. The field of research of the group has now become wider by including other areas of structural engineering where dynamic behaviour is also important, e.g. research on High Speed Railways and on Built Heritage, and areas such as Organic Prestressing.

After moving to new facilities in 2000, a modern structural engineering laboratory was formed at FEUP which enabled the development of experimental research on a more regular basis.

In order to integrate all the research activities being developed, the research group was recently renamed Laboratory for Earthquake and Structural Engineering (LESE). The LESE team of researchers, which has currently more than 20 PhD members and more than 30 graduate researchers and collaborators, is one of the more active structural engineering research groups in Portugal, with a significant international outreach also.

Raimundo Delgado

LESE Newsletter – Structure and Objectives

The LESE newsletter is a quarterly publication that will disseminate information related to the LESE research group. The newsletter will publish the main activities and goals achieved individually and/or in joint research programmes over the four main research areas addressed by LESE (earthquake engineering, rehabilitation of existing structures, high-speed railways and structural engineering).

The editorial board of the newsletter is made of LESE members and will be renewed annually. All interested LESE members can take part and contribute to the development of the newsletter.

LESE News

Over the first trimester of 2012, three LESE members got their PhD. The PhD public examinations of Xavier Romão and Alexandre Costa took place at FEUP, while Catarina Fernandes got her PhD examination at the University of Aveiro.

Several LESE members were involved in the development of the Special Issue of The Bulletin for Earthquake Engineering addressing “Old Masonry under Seismic Loading”. Among the masonry construction studies that were published, several ones are co-authored by LESE researchers.

Finally, efforts have been made to start the *LESE Report Series* aiming to publish research studies made in specific areas, usually associated to the partial fulfilment of PhD studies. This report series aims to disseminate information that is usually not included in final PhD theses or reports of research projects. Hence, the LESE Report Series aims to share and spread information that would otherwise be lost. The first LESE report is expected to be published soon as a result of research performed by Tiago Ferreira (University of Aveiro).



Dr. Xavier Romão and the jury committee. From left to right: Dr. Alfredo C. Costa, Prof. João Azevedo, Prof. Paolo Franchin, Prof. Raimundo Delgado, Dr. Xavier Romão, Prof. M. Matos Fernandes, Prof. Aníbal Costa, Prof. António Arêde

LESE Doctorate – Xavier Romão

Deterministic and Probabilistic Methods for Structural Seismic Safety Assessment

On March 5th 2012, the PhD examination of Dr. Xavier Romão took place at the great hall of the Civil Engineering department, at FEUP. The jury committee (in the left photo) approved unanimously with honour the PhD degree.

The main objective of this PhD research was to develop probabilistic methodologies for the seismic safety evaluation of existing reinforced concrete structures.

LESE Doctorate – Alexandre A. Costa

Seismic Assessment of the Out-of-Plane Performance of Traditional Stone Masonry Walls

On March 15th 2012, the PhD examination of Dr. Alexandre A. Costa took place at the great hall of the Civil Engineering department, at FEUP. The jury committee (in the right photo) approved unanimously with honour the PhD degree.

The main objective of this PhD research was to provide experimental data and numerical tools for the analysis and simulation of the out-of-plane performance of existing masonry buildings.



Dr. Alexandre A. Costa and the jury committee. From left to right: Prof. Paulo B. Lourenço, Prof. M. Matos Fernandes, Dr. Andrea Penna, Prof. Sergio Lagomarsino, Dr. Alexandre A. Costa, Prof. João M. Guedes, Dr. Alfredo C. Costa, Prof. António Arêde

LESE Doctorate – Catarina Fernandes

Cyclic Behaviour of RC Elements with Plain Reinforcing Bars

On March 20th 2012, the PhD examination of Dr. Catarina Fernandes took place at the University of Aveiro. The jury committee approved the PhD degree.

The main objective of this thesis was to investigate the influence of the bond-slip mechanism on the cyclic behaviour of reinforced concrete structural elements with plain bars, through experimental campaigns and nonlinear numerical studies.



Dr. Catarina Fernandes during her PhD defence with the jury committee: Prof. Humberto Varum, Prof. Aníbal Costa, Prof. António Correia, Prof. Daniel Oliveira, Prof. Pedro Delgado and Prof. Nelson Vila Pouca

Special Issue – Bulletin of Earthquake Engineering – January 2012

The Special Issue of the Bulletin of Earthquake Engineering collects improved versions of some of the papers presented at the *International Seminar on Seismic Risk and Rehabilitation*, which took place at Faial, Azores, from 9 to 13 July 2008. This Special Issue is also complemented with two recent relevant study cases dealing with vulnerability and retrofit, in a total of 15 papers.

Several LESE members were involved in this special issue, with special emphasis to Prof. Aníbal Costa, guest editor of this issue with Prof. Carlos Sousa Oliveira from *Instituto Superior Técnico* (Lisbon, Portugal).



With a selection of links for journals, thesis repositories, tools and earthquakes, SeismoSafety is a shortcut for those who start or deal with earthquake studies every day.

The SeismoSafety website

SeismoSafety (<http://seismosafety.weebly.com/>) was created for knowledge sharing, discussion and debate about earthquake related issues, emphasizing topics such as Earthquake Engineering and Design, Seismology, Emergency Preparedness and Response, Safety Assessment and Loss Estimation. The website, developed by Xavier Romão and Nuno Pereira, is regularly updated with new sources of information and aims to provide a database of international research resources for earthquake engineering.

SeismoSafety has currently 6 main sections. The first points to post-earthquake information, with links to reconnaissance reports, photos and published information. A second section presents links to theses repositories from various universities and earthquake research institutions. The third section provides a list of selected journals with earthquake engineering and seismology related research. The next section presents a list of research institutions and researchers' webpages, followed then by a section of tools linking to freeware programs for seismic analysis, scripts and general files. In the future, the site will host a database of structural analysis files and of pre/post processors.



Prof. Jason Ingham, from the University of Auckland, New Zealand, during his keynote lecture

Keynote lecture by Prof. Jason Ingham

Prof. Jason Ingham, from the Department of Civil and Environmental Engineering of the University of Auckland, New Zealand, visited us on February 3rd 2012.

By his own words, Jason enjoyed his tour of the campus and was particularly interested in several experimental programs currently running in the laboratory. He found particularly interesting the projects addressing traditional northern Portugal constructions of granite stone masonry, the characterization of mechanical properties of timber beams extracted from historic buildings, the structural testing of glass panels, and the testing of precast concrete hollowcore floor panels.

Jason's lecture addressed several concrete-related research projects currently running or recently completed in New Zealand. These projects included research on topics such as the use of waste glass and waste paint in concrete, cement-stabilised earth constructions, the manufacture of concrete using lightweight pumice aggregates, the seismic testing of precast concrete systems including walls attached to end columns and beam-column joints with synthetic fibres and no conventional reinforcement and, finally, the testing of corroded precast prestressed concrete bridge beams to determine their residual strength.

It was a great opportunity to exchange ideas with Jason Ingham, which is currently strongly involved in the reconstruction process of Christchurch that was severely damaged during the 2010 and 2011 earthquakes

LESE Sessions

The concept of informal exchange of ideas

The LESE sessions are monthly events that take place on the first Friday of every month. This activity, which is organized by José Miguel Castro, Pedro Costa and Xavier Romão, started in December 2010 and consists of research presentations usually made by LESE PhD students or by invited speakers. The sessions can be seen to be an important discussion forum within the LESE research group, providing valuable input for the presenters, particularly for PhD students. Since the first session in December 2010, a number of topics have been discussed ranging from earthquake engineering issues related with the seismic behaviour and assessment of masonry and reinforced concrete buildings to high speed railway issues. A list of the past sessions is presented below:

After 14 presentations, the LESE Sessions are now a reference to present and to gather opinions and ideas from the entire LESE group about research studies currently running.

LS12/2010	Non-destructive tests in stone masonry	Luís Miranda
LS01/2011	Track Geometry quality influence on the dynamic behaviour of railways and on the optimization of the maintenance planning	Cecília Vale
LS02/2011	Seismic vulnerability of historical constructions	Catarina Costa
LS03/2011	Interpretation of the mechanical properties of historical building structures by diagnostic techniques applied in seismic areas	Lorenzo Cantini
LS04/2011	Advanced methodologies for fatigue analysis in railway bridges	Carlos Albuquerque
LS05/2011	Cyclic bi-directional behaviour of reinforced concrete columns	Hugo Rodrigues
LS06/2011	Out of the plane behaviour of masonry walls	Alexandre A. Costa
LS10/2011	Assessment of a small span bridge for high-speed rail traffic Safety	João Miguel Rocha
LS11/2011	NIKER - New Integrated Knowledge Based Approaches to the Protection of Cultural Heritage from Earthquake-Induced Risk	Bruno Silva

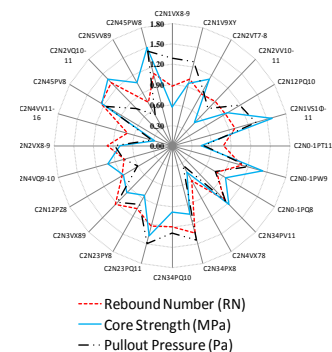
In the following LESE Newsletter issues, a short description of the recent LESE Sessions will be presented, where it will be possible to follow the research areas of several LESE members.

In the present Spring Issue, the LESE session presentations by Nuno Pereira, Pedro Montenegro and Celeste Almeida are summarized, which highlight the multidisciplinary research capabilities of LESE.

LS01/2012 – Nuno Pereira

Uncertainty assessment of RC existing buildings according EC8-3

Seismic safety assessment of existing reinforced concrete buildings requires that knowledge about the building characteristics is available or can be obtained, for example, by carrying out survey operations. However, the detail and the level of confidence that can be achieved about the required knowledge will inevitably vary from structure to structure. Due to several different reasons, which may range from the excessive cost of the survey operations to the fact that conducting survey operations in buildings that are in use will limit the amount of information that can be obtained, this lack of information, as well as the lack of confidence in that information, may not be overcome. In this context, EC8-3 presents a methodology based on the use of parameter called Confidence Factor (CF) which aims to reflect the expected variability of the properties of the structure. The applicability of this approach was discussed by Nuno Pereira in his presentation, highlighting the difficulties associated to the variability of the material properties and of the results obtained from different types of tests.



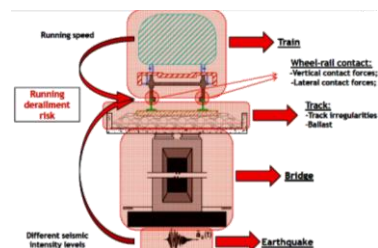
A discussion about the Eurocode 8 - Part 3 procedure for uncertainty treatment was made, highlighting some difficulties associated to the variability of in situ test results.

LS02/2012 – Pedro Montenegro

Running safety evaluation of trains moving over bridges shaken by earthquakes

The running safety analysis of railway vehicles during earthquakes is one of the major concerns in railway engineering. This problem takes bigger proportions if the train is moving over a bridge. Several statistics elaborated in Japan concluded that 25% of the derailments in railway bridges were caused by transverse vibrations of the deck originated by earthquakes that didn't provoke significant structural damage. Such facts suggest that the running safety can be compromised, not only for intense shaking, but also for low-intensity earthquakes that have a higher probability of occurrence.

Therefore, to account for the effects of the transverse vibrations in the running safety of railway vehicles, it is necessary to develop a suitable train-structure interaction model capable of evaluating the wheel-rail contact interaction, including the development of the vertical, lateral and longitudinal wheel-rail contact forces. The work presented by Pedro Montenegro focused the development of an assessment framework which accounts for the train-structure interaction based on normal and longitudinal contact problems. Future updates of the method, namely to include the correlation between seismic intensity levels and derailment criteria, were also presented



The influence of lateral contact in the stability of high-speed trains was addressed.

LS03/2012 – Celeste Almeida

Physical characterization and behaviour of one leaf stone masonry walls

Old buildings in the north of Portugal, particularly in the Oporto's metropolitan area, are characteristically made of granite single leaf stone masonry walls.

Celeste Almeida is focusing her PhD studies in this type of structural systems, addressing the need to understand old construction techniques and its behaviour in order to preserve cultural heritage, in particular the Oporto historical centre, a UNESCO World Heritage Site.

The study involves the typological classification and the mechanical characterization of single leaf stone masonry walls. In this presentation, a typological classification was proposed which addressed the geometric characteristics of the stones and its distribution over the length of the wall. Experimental compression and shear-compression tests carried out at the LESE laboratory on real wall elements extracted from old buildings and on walls constructed according to traditional construction techniques were discussed along with the behaviour results that were obtained. Alongside these experimental tests, the numerical simulation of the behaviour of this type of walls has been also performed to analyse the possibility of reproducing the experimental tests and to calibrate existing numerical analysis tools.



The heterogeneity of Oporto's traditional masonry walls and their in-plane resistance for vertical and horizontal loads was discussed in this session.

LESE Publications

André, P. S., Varum, H., Antunes, P., Ferreira, L., and Sousa, M. G. (2012). Monitoring of the concrete curing process using plastic optical fibers. *Measurement: Journal of the International Measurement Confederation* **45**(3), 556-560.

Arêde, A., Costa, A., Moreira, D., and Neves, N. (2012). Seismic analysis and strengthening of Pico Island churches. *Bulletin of Earthquake Engineering* **10**(1), 181-209.

Coelho, M., Fernandes, P., Melo, J., Sena-Cruz, J., Varum, H., Barros, J., and Costa, A. (2012). Seismic retrofit of RC beam-column joints using the MF-EBR strengthening technique. *Advanced Materials Research* **452-453**, 1099-1104.

Costa, A. A., Arêde, A., Costa, A., Guedes, J., and Silva, B. (2012). Experimental assessment, numerical modelling and strengthening of a stone masonry wall. *Bulletin of Earthquake Engineering* **10**(1), 135-159.

Costa, A. A., Arêde, A., Costa, A., and Oliveira, C. S. (2012). Out-of-plane behaviour of existing stone masonry buildings: experimental evaluation. *Bulletin of Earthquake Engineering* **10**(1), 93-111.

Delgado, P., Arêde, A., Vila-Pouca, N., Rocha, P., Delgado, R., and Costa, A. (2012). Retrofit of RC hollow piers with CFRP sheets. *Composite Structures* **94**(4), 1280-1287.

Kausel, E., and Barbosa, J. (2012). PMLs: A direct approach. *International Journal for Numerical Methods in Engineering* **90**(3), 343-352.

Neves, F., Costa, A., Vicente, R., Oliveira, C. S., and Varum, H. (2012). Seismic vulnerability assessment and characterisation of the buildings on Faial Island, Azores. *Bulletin of Earthquake Engineering* **10**(1), 27-44.

Neves, N., Arêde, A., and Costa, A. (2012). Seismic analysis of a building block. *Bulletin of Earthquake Engineering* **10**(1), 235-267.

Paiva, A., Pereira, S., Sá, A., Cruz, D., Varum, H., and Pinto, J. (2012). A contribution to the thermal insulation performance characterization of corn cob particleboards. *Energy and Buildings* **45**, 274-279.

Rodrigues, H., Varum, H., Arêde, A., and Costa, A. (2012). A comparative analysis of energy dissipation and equivalent viscous damping of RC columns subjected to uniaxial and biaxial loading. *Engineering Structures* **35**, 149-164.

Rodrigues, H., Varum, H., and Costa, A. (2012). A simplified shear model for reinforced concrete elements subjected to reverse lateral loadings. *Central European Journal of Engineering* **2**(1), 136-145.

Silveira, D., Varum, H., Costa, A., Martins, T., Pereira, H., and Almeida, J. (2012). Mechanical properties of adobe bricks in ancient constructions. *Construction and Building Materials* **28**(1), 36-44.

Neves, S., Azevedo, A., Calçada, R. (2012). A direct method for analyzing the vertical vehicle–structure interaction. *Engineering Structures* **34**, 414-420.

Alves Costa, P., Calçada, R., Silva Cardoso, A. (2012) Track–ground vibrations induced by railway traffic: In-situ measurements and validation of a 2.5D FEM-BEM model. *Soil Dynamics and Earthquake Engineering* **32**(1), 111-128.

Almeida, C., Guedes, J., Arêde, A., Costa, C., Costa, A. (2012) Physical characterization and compression tests of one leaf stone masonry walls. *Construction and Building Materials* **30**, 188–197.

Activities at the LESE Laboratory

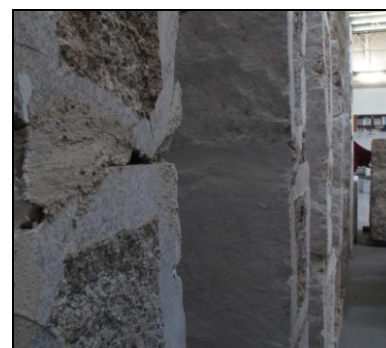
LAB activities performed in this trimester

Over the first three months of 2012, several activities occurred at the LESE lab. Several different specimens were constructed and/or transported to the LESE lab, namely:

- 6 reinforced concrete columns to be tested under biaxial bending with constant vertical load (FCT research project on biaxial bending of RC columns);
- 1 new reinforced concrete frame, replica of a bridge frame-type pier (SIPAV research project);
- 2 series of a 1-leaf granite masonry wall, similar to Oporto's traditional masonry, each one sawn in 6 different specimens (Celeste Almeida PhD research).

In addition, in-plane cyclic tests were performed on a frameless glazing panel to assess the in-plane capacity of the glass and to analyse the efficiency of its connection to the main structure. This test was requested by FACAL, Engenharia de Fachadas, Lda.

A new control program, named as PECAXIAL, developed by the LESE staff was implemented and tested for in-plane cyclic tests with constant and variable axial loading. The program was tested for the in-plane shear-compression test of a single leaf granite stone masonry wall.



Finally, the SIPAV reinforced concrete frame was tested under in-plane cyclic loads with constant axial force, making use of a new testing setup especially developed for this purpose.

Expected LAB activities in the following trimester

Over the next three months, several 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 RC 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.);
- **IP_G**: In-plane cyclic tests on frameless glazing panels (requested by FACAL, Engenharia de Fachadas, Lda.);
- **2R_M**: Two-sided free rocking tests on sacco masonry wallettes (in the research fields of Alexandre A. Costa also included in the FCT research project on experimental characterization of masonry constructions under earthquake actions);
- **OP_M**: Out-of-plane cyclic tests on sacco stone masonry walls (FCT research project on experimental characterization of masonry constructions under earthquake actions);



Collaborations and partners

New collaborations

Following the strong research in the characterization of the behaviour of stone masonry constructions, the LESE lab would like to acknowledge Fassa Bortolo S. p. A., and SECIL Martingança, s.a., for their support.

These partners provided fabric and clay mortar to be used for the construction of one-leaf stone masonry specimens, associated to the PhD research of Celeste Almeida. In the end, masonry panels will be tested under vertical compression and in-plane shear tests.

Further collaborations and partners will boost the LESE lab activities, providing a win-win collaboration where partners can develop and test their current and/or new materials and/or structural solutions.



Current partners



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