



# LESE

LABORATORY FOR EARTHQUAKE AND STRUCTURAL ENGINEERING

FACULTY OF ENGINEERING, UNIVERSITY OF PORTO  
PORTUGAL

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# Newsletter

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## Editorial

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*There are grounds for cautious optimism that we may now be near the end of the search for the ultimate laws of nature.*

*Stephen Hawking\**

\* A Brief History of Time: From the Big Bang to Black Holes.

### LESE Research Group

**Head: Raimundo Delgado**

### LESE Laboratory

**Executive Director: António Arêde**

### LESE Newsletter Board

#### Editors

**Xavier Romão**

**Nuno Pereira**

#### Collaborators

**Pedro Costa**

**Luís Macedo**



Transportation systems play a key role in modern societies given the fast and efficient mobility of both people and goods they provide, as well as their important contributions for the vitality and growth of the economy. Due to their energetic and environmental advantages, railway systems have been gaining relevance within the transportation systems. The high-speed railway system, in particular, has been indicated as the transport mode of the future because of its high quality

standards, safety and efficiency.

The Faculty of Engineering of the University of Porto (FEUP) began its research in the field of high-speed railways in 1992 with a research project related to railway bridges, led by Professor Raimundo Delgado. Within the framework of this research project, a model to analyse the train-bridge interaction was developed. Later, this model was the basis of several studies carried out for the upgrading of the Portuguese railway network.

In 2004 the LESE high-speed railway group was responsible for a protocol between FEUP and RAVE (Portuguese High-Speed Railway Network). Within the framework of this protocol, several activities were carried out which involved obtaining technical know-how, research and the advanced training of human resources. In 2009 the group was also responsible for the development of a protocol between FEUP and REFER (Portuguese Railway Network). The group was also an active part on the creation of the CSF (Centre of Railway Knowledge) at FEUP which aims to gather FEUP's Civil, Mechanical and Electrical engineering researchers with technical expertise in the field of railways.

The strategic activities of the high-speed railway group are connected to the development of advanced methodologies, both numerical and experimental, for the assessment of the dynamic behaviour of critical elements of the infrastructure (bridges, transition zones), the track, the noise and vibration induced by traffic nearby railway lines and also to the development of maintenance optimization models. In this field, the group has carried out several advanced consultancy works and has lead numerous research projects sponsored by FCT (Portuguese Foundation for Science and Technology), AdI (Innovation Agency) and private companies. Thanks to the recognition of the quality of the research developed, both nationally and internationally, the group has been included in several consortia for projects sponsored by the European Commission and is currently leading a European project with 17 partner institutions.

In a time where railway systems are the focus of global interest, FEUP, through LESE's high-speed railway group and CSF, can provide a significant contribution to this field by carrying out advanced studies and developing innovative solutions and technologies which increase the reliability, the capacity and the maintainability of railway infrastructures.

Rui Calçada

## LESE News

Between the second and the present issue of the LESE Newsletter, LESE was visited by several researchers and Lecturers from international universities: Dr. Mohammed Hussein, Lecturer at the University of Nottingham (UK), Mr. Munemasa Tokunaga, researcher at RTRI (Japan), Dr. Maria Todorovska, Research Professor at the University of Southern University (US) and Dr. Marcial Blondet, Lecturer at the Pontificia Universidad Católica del Perú (Peru). These researchers presented some of the ongoing studies of their research groups and contacted also with the reality of the LESE ongoing research. This issue also refers the participation of several LESE researchers in the 15<sup>th</sup> World Conference on Earthquake Engineering, with particular relevance on the organization and coordination of parallel events such as the Lisbon in Motion workshop and the Special Session devoted to "The role of architecture and urban planning. Cross disciplinary engagement of professionals, in Earthquake-resilience of cities". Four researchers and PhD students from LESE participated also in the Bauhaus Summer School, particularly in the course on "Model Validation and Simulation" which involved more than 50 researchers from all over the world. In the present issue, special attention is also addressed to the **LESE TECHNICAL REPORTS**, a new internal publication that will disseminate the LESE studies and make them available in an extended format.



*João Francisco Rocha, João Miguel Rocha, Joel Malveiro and Pedro Montenegro were part of the group of 50 researchers and students from all over the world that participated in the "Model Validation and Simulation" course held at the Bauhaus Summer School*



*The discussions and concepts were driven from theory to practice in a program that includes in situ tests.*

## LESE at the Bauhaus Summer School

Between the 6<sup>th</sup> and 17<sup>th</sup> of August 2012 João Francisco Rocha, João Miguel Rocha, Joel Malveiro and Pedro Montenegro, LESE members, participated in the "Model Validation and Simulation" course held as part of the [Bauhaus Summer School 2012](#) that took place in the Bauhaus-Universität Weimar, in Germany. Through a challenging and demanding series of lectures, as well as seminars and project work, presented with state-of-the-art information and communication technology, this project seeks to impart knowledge and to combine research with a practical context. To enable participants to understand and use the presented concepts in their further professional career, the main part of the summer school is devoted to interdisciplinary project work. Discussions and the exchange of ideas with professors, research associates and other participants during and after classes enhanced the personal experience and brought benefits to all participants. The course offered participants six different topics and projects. João Miguel Rocha, Joel Malveiro and Pedro Montenegro participated in the project Models in Structural Engineering: System Identification, Model Updating and Simulation, coordinated by Dr. Volkmar Zabel (Bauhaus-Universität Weimar) and Dr. Peter Van den Broeck (KU Leuven). João Francisco Rocha participated in the Wind-induced Vibrations of Long-span Bridges: Long-span Bridge Aeroelasticity project, coordinated by Guido Morgenthal (Bauhaus-Universität Weimar). During the Course, Pedro Montenegro made a presentation to all the participants about his ongoing PhD studies which address the topic of "Running Safety Evaluation of Trains Moving over Bridges shaken by Earthquakes".

## Keynote Lecture by Dr. Mohammed Hussein

Modelling ground-borne vibration from railways: new developments and validation

On July the 20<sup>th</sup>, LESE received the visit of Dr. Mohammed Hussein, Lecturer of the Civil Engineering Department of the University of Nottingham, United Kingdom. Dr. Mohammed Hussein is an expert on numerical modelling of vibrations induced by traffic in subway systems. His lecture, entitled “Modelling ground-borne vibration from railways: new developments and validation”, highlighted the most recent advances on the topic of numerical simulation of the dynamic behaviour of railway systems without forgetting the need for experimental validation of the proposed models. Regarding this latter aspect, Dr. Hussein showed that the centrifuge testing is a powerful technique for physical simulation of the mechanisms of wave propagation generated by railway traffic in tunnels.

This initiative, promoted by Prof. Pedro Alves Costa from LESE, was a great opportunity to exchange ideas with Dr. Hussein and aimed to strengthen the collaboration between both research groups in order to allow for the development of joint research activities in the near future.



*Dr. Mohammed Hussein highlighted the most recent advances on the topic of numerical simulation of the dynamic behaviour of railway systems without forgetting the need for experimental validation of the proposed models*

## Visit by Mr. Munemasa Tokunaga

Introduction of Japanese Railways: an overview of research topics in RTRI - Railway Technical Research Institute.

On September the 26<sup>th</sup>, Munemasa Tokunaga, a researcher from the Railway Technical Research Institute (RTRI) in Tokyo, Japan, visited the Faculty of Engineering of the University of Porto (FEUP) after his participation in the 15<sup>th</sup> World Conference on Earthquake Engineering, in Lisbon. During his stay at FEUP, Mr. Tokunaga made a presentation about the general research topics he is undertaking at RTRI. His current research focuses in the dynamic interaction between railway vehicles and bridges subjected to earthquake actions. The software DIASTARS (Dynamic Interaction Analysis for Shinkansen Train and Railway Structure), developed by Prof. Tanabe from the Kanagawa Institute of Technology together with several members of RTRI was also presented. This software is capable of performing a nonlinear train-structure interaction analysis without a large computational effort thanks to a modal transformation of the train and railway structure displacements which decreases significantly the duration of the analysis. Finally, the presentation also featured a general overview of the global research activities at RTRI, focusing several aspects related to train-running quality and dynamic response in special structures such as the Sannai-Maruyama Bridge in Japan.



*Mr. Munemasa Tokunaga during his visit to LESE, with Professor Rui Calçada and Mr. Pedro Montenegro. An overview of the research performed by Mr. Tokunaga at RTRI was presented.*

## Keynote Lecture by Dr. Maria Todorovska



*Dr. Maria Todorovska highlighted the most recent advances on Wave Travel Time Based Methodology for Structural Health Monitoring and Early Earthquake Damage Detection in Buildings*

Recent Advances in Wave Travel Time Based Methodology for Structural Health Monitoring and Early Earthquake Damage Detection in Buildings

Dr. Maria Todorovska, a research professor from the University of Southern California, visited FEUP on the 1st of October. Dr. Todorovska develops research in several subjects in Earthquake Engineering and Engineering Seismology fields.

While at FEUP she had the opportunity to visit the LESE laboratory and to interact with several researchers. Dr. Todorovska presented some of her recent research through a presentation entitled “Recent Advances in Wave Travel Time Based Methodology for Structural Health Monitoring and Early Earthquake Damage Detection in Buildings”.

## Keynote Lecture by Dr. Marcial Blondet

Desempeño sísmico de edificios de adobe – 30 años de experiencia en la PUCP



*Professor Marcial Blondet, from the Pontificia Universidad Católica del Perú (PUCP) during his presentation at the University of Aveiro, with Prof. Humberto Varum.*

On October the 4th, Prof. Marcial Blondet, a researcher from the Pontificia Universidad Católica del Perú (PUCP), whose work on the study of the seismic performance of adobe constructions is internationally acknowledged, presented a lecture at the University of Aveiro, by invitation of the Civil Engineering Department. In his lecture, Prof. Marcial Blondet started by describing the deficient behaviour of unreinforced adobe constructions when subjected to seismic actions, presenting examples of the devastating effects of earthquakes that occurred recently in the Peruvian territory. In addition, Prof. Marcial Blondet presented the work that has been developed at PUCP over the past 40 years regarding the study of the seismic behaviour of adobe constructions, and for the development of effective retrofitting solutions.

The lecture ended with the description of the efforts that have been made in order to disseminate and promote the retrofit solutions among the Peruvian territory, involving the population.

## LESE in Motion: the Lisbon in Motion workshop

The Lisbon in Motion workshop, also known as LiMo, an initiative boosted by young Portuguese Earthquake Engineering researchers, was a 4-day innovative case-study program focused on earthquake risk reduction by multi-cultural and workgroup sessions developed in a friendly and informal environment. The workshop participants were challenged to plan and implement a team project, to bring awareness to a seismic risk problem facing the city of Lisbon. This initiative, supported by the 15th World Conference on Earthquake Engineering (15<sup>th</sup> WCEE), was held from 20-23 September 2012, prior to the 15<sup>th</sup> WCEE.

With a total of 55 participants, from 20 different countries and different backgrounds, 10 groups were constituted and the work that was developed addressed seismology and site effects, tsunami propagation and impacts, seismic vulnerability assessment at a local level, as well as the development of disaster mitigation actions. For this purpose, two specific buildings located in the Lisbon downtown (at Rua do Alecrim and Rua de S. Paulo) served as case-studies. The participants were involved in several technical visits to the buildings as well as in-situ experimental tests to measure the surface wave propagation.

All the participants worked efficiently, hardly, and even exceeded completely the main objectives and goals of the organizers. The participants presented interesting material and conclusions using several different methods to address the same problems. In the final day of the workshop, the groups presented their work and main conclusions. The best presentation and work among the 10 groups was voted as that of the group involving Eva Raka (Albania), Lucas Hogan (New Zealand), Nikos Pnevmatikos (Greece), Sonia Boschi (Italy) and Ulises Cazares (Mexico). The LESE members Alexandre A. Costa, Xavier Romão, Hugo Rodrigues, Romeu Vicente, Cristina Oliveira, Bruno Silva and Tiago Ferreira were part of this initiative, namely by organizing and coordinating the workshop, as well as in the presentation of lectures for to the participants.



*The Lisbon in Motion was organized by the 15WCEE Young Minds group. The 4-day innovative case-study program focused earthquake risk reduction and challenged the participants to plan and implement a team project bringing awareness to the seismic risk problem facing the city of Lisbon.*

## LESE at the 15<sup>th</sup> World Conference on Earthquake Engineering

The 15th WCEE held in Lisbon provided an excellent opportunity for many of the LESE members to promote their more recent work in earthquake engineering by attending the conference and contacting with other researchers. LESE published a total of 43 papers in the conference proceedings that addressed a wide variety of topics such as earthquake design methods, vulnerability, risk and loss assessment methodologies, and studies on the behaviour of structures under dynamic/earthquake loading using numerical analysis and/or experimental tests.

LESE was also present at the Portuguese Society for Earthquake Engineering booth in the Exhibition Area. Posters and a Powerpoint presentation illustrating some of the LESE research activities were displayed during the conference.

## Special Session at the 15<sup>th</sup> WCEE

"The role of architecture and urban planning. Cross disciplinary engagement of professionals, in Earthquake-resilience of cities"

On September 27<sup>th</sup>, the 15<sup>th</sup> WCEE Special Session "The role of architecture and urban planning. Cross disciplinary engagement of professionals, in Earthquake-resilience of cities", took place at the Lisbon Congress Centre. This Special Session was organized by LESE member Alice Tavares, Teresa Guevara Perez (Venezuela), Luke Allen (New Zealand), Antonio Aretxabala Díez (Spain) and Adriana Guisasola (Argentina). The session was attended by more than 70 participants from Algeria, Argentina, Bulgaria, Canada, Chile, Costa Rica, France, Greece, India, Iran, Israel, Italy, Japan, Macedonia, Malta, Nepal, New Zealand, Norway, Portugal, Rep. Korea, Rep. San Marino, Romania, Spain, Switzerland, Thailand, Turkey, UK, USA and Vietnam. The participants are engaged in Universities, Civil Engineering Laboratories, Seismology and Geology centres, World Bank, EERI, or with the industry with activities in the field of infrastructures management.

This Special Session was the first step of an international network under development, involving architects, civil/structural engineers, seismologists and geologists. Besides other discussions, it was concluded that a better communication and deeper cooperation between professionals involved in the assessment and retrofitting of constructions should be enforced, based on the adoption of earthquake-resilient design principles. A multidisciplinary approach should be enforced to gather and implement knowledge on these subjects. Means to foster communication and collaboration between engineers and other actors in the fields of design, planning, emergency management, policy makers and government, should be promoted.



*View of the special session organized during the 15<sup>th</sup> WCEE*

## LESE Publications

Varum, H., Pinto, A.V., Costa, A., Vila Real, P. (2012). Simplified models for assessment and optimal redesign of irregular planar frames. *Engineering Structures* **42**, Elsevier, 245-257.

Antunes, P., Travanca, R., Varum, H., André, P. (2012). Dynamic monitoring and numerical modelling of communication towers with FBG based accelerometers. *Journal of Constructional Steel Research* **74**, 58-62.

Rocha, J.M., Henriques, A.A. and Calçada, R. (2012). Safety assessment of a short span railway bridge for high-speed traffic using simulation techniques. *Engineering Structures* **40**, Elsevier, 141-154.

Ribeiro, D., Calçada, R., Delgado, R., Brehm, M., and Zabel, V. (2012). Finite element model updating of a bowstring-arch railway bridge based on experimental modal parameters. *Engineering Structures* **40**, 413-435.

Nicola Tarque, Helen Crowley, Rui Pinho, and Humberto Varum (2012). Displacement-Based Fragility Curves for Seismic Assessment of Adobe Buildings in Cusco, Peru. *Earthquake Spectra* 28 (2), 759-794

## LESE REPORTS

The LESE Reports comprise research studies in which LESE members have been involved. These reports, which can have additional files attached such as numerical models, pictures or any other type of data, aim to be complements or extended versions of the published material. Furthermore, some LESE reports will also make additional unpublished material available to the scientific community. The published reports will be made available at the LESEnews website (<http://lesenews.weebly.com>). The abstract of these reports will be published by the LESE Newsletter in order to disseminate the scope of the work and the main features of these studies.

### LESE 01/2012

#### Survey of churches damaged by the May 2012 Emilia-Romagna earthquake sequence

LESE REPORT 01/2012 presents an overview of the damage that was observed in fourteen churches that were hit by the May 2012 Emilia-Romagna earthquake sequence. The data was collected over the course of a two-day reconnaissance mission that took place on the 9th and 10th of July 2012, and that involved researchers from the Civil engineering Department of the Faculty of Engineering of the University of Porto and of the University of Aveiro, both institutions from Portugal.

### LESE 02/2012

#### Out-of-plane seismic response of stone masonry walls: Analytical study of real piers

LESE REPORT 02/2012 resumes the study of Tiago Ferreira (UA) and Alexandre Costa (FEUP) addressing the out-of-plane behaviour of masonry walls. In the report, the importance of the out-of-plane seismic response of URM walls is emphasized with a particular reference to the characteristics of URM buildings in Azores, Portugal. The application and calibration of a simplified displacement-based procedure is presented. The experimental results used in the calibration refer to an in-situ experimental campaign that involved the application of cyclic loads in URM walls using airbag systems.

## LAB activities performed in this trimester



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

- **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 rocking tests on sacco stone masonry walls (FCT research project on experimental characterization of masonry constructions under earthquake actions);

- **HB\_PIER:** Reinforced concrete hollow section bridge pier retrofitted with CFRP sheets testes under uniaxial lateral loading with constant vertical load (conclusion of previous testing campaign on cyclic behaviour of bridge piers)



- **SIPAV:** In-plane cyclic tests on reinforced concrete portal frames under constant vertical loads (ADI research project on high-speed railways bridge columns);

- **VC\_M:** Vertical compression tests on one leaf granite masonry walls (Celeste Almeida PhD research);

- **AVT\_COA:** An ambient vibration test of Coa railway bridge was performed. The experimental modal parameters (frequencies, mode shapes and damping coefficients) will be used for the calibration of a 3D finite element model of the bridge;



- **TRZ\_DYN:** In collaboration with LNEC, dynamic monitoring of several transition zones in the new Alcácer bypass was performed; the effect of incorporating resilient elements in the track was assessed for the passage of Alfa Pendular trains travelling at 220 km/h;

- **GVN\_HST:** A comprehensive measurement campaign was developed in the test field of Carregado. Track and Ground vibrations induced by traffic were measured for more than 80 passages of trains; receptance tests were performed allowing a deeper characterization of the dynamic behaviour of the track (FCT research project on Ground Vibrations and Noise induced by High-Speed Trains: Prediction and Mitigation);



- **TBI\_AVE:** Monitoring of track-structure interaction effects on a via duct of the new railway link to Aveiro harbour; rail and structure temperatures, rail stresses, track-structure relative displacements and structure displacements were measured; The experimental results will be used for the calibration of a 3D numerical model; Track buckling safety will assessed for several load scenarios.



## LAB activities performed at University of Aveiro

Test of a reduced-scale building (1:4) representative of the typical adobe houses in Aveiro. The model was tested on a tilting table to study the behaviour of this type of construction under lateral demands. A first test was made on the original model to assess the capacity of the structure and the type of damages expected under seismic actions. After the first test, the structure was repaired and strengthened. The retrofitted structure was then tested using the original testing sequence.



*Tilting table test of a reduced scale model of a typical adobe house from Aveiro performed at the University of Aveiro*

## 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:

- **VC\_M**: Completion of vertical compression tests on one leaf granite masonry walls (Celeste Almeida PhD research);
- **IP\_M**: In-plane cyclic tests on one leaf granite masonry walls (Celeste Almeida PhD research);
- **OP\_M**: Out-of-plane cyclic air-bag tests on sacco stone masonry walls (FCT research project on experimental characterization of masonry constructions under earthquake actions);
- **SIPAV**: cyclic tests on reinforced concrete portal frames under constant vertical loads (ADI research project on high-speed railways bridge columns);
- **RC\_U2X**: Reinforced concrete columns, retrofitted after previous testing, to be retested under monotonic biaxial bending with constant vertical load (FCT research project on biaxial bending of reinforced concrete columns);
- **GVN\_HST**: Development of innovative software for the analysis of SASW tests; Development of experimental skills regarding the SASW tests implementation. A drop height device was developed for that purpose (FCT research project on Ground Vibrations and Noise induced by High-Speed Trains: Prediction and Mitigation);
- **SIPAV**: tests on a prototype of a reinforced concrete slab track will be performed (ADI research project on innovative precast solutions for high-speed railway lines);

## Previous issues of the LESE Newsletter and the LESE Technical Reports

The previous issues of the LESE Newsletter as well as the LESE Technical Reports are available at <http://lesenews.weebly.com>.

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## Collaborations and partners



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## Contacts

### LESE – Laboratório de Engenharia Sísmica e Estrutural

Departamento de Engenharia Civil – Secção Estruturas  
Faculdade de Engenharia da Universidade do Porto

Rua Dr. Roberto Frias. s/n 4200-465, Porto, Portugal

[lese@fe.up.pt](mailto:lese@fe.up.pt)

<http://lesenews.weebly.com>.

