

# Report on the Collaborative Science and Technology Workshop on “Seismic Fragility of Urban Buildings and Infrastructure”

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## Executive Summary

A workshop on the “Seismic Fragility of Urban Buildings and Infrastructure”, funded by the French Embassy, was held on the 10<sup>th</sup>-11<sup>th</sup> July 2013 in Room 102, Chadwick Building, University College London. The original aims of the workshop were:

- To promote collaboration on topics of seismic fragility assessment of urban buildings and infrastructure between UCL, BRGM, University Paris-Est Marne-la-Vallée and University of Strasbourg.
- To consolidate and build on existing collaborations between the Partners.
- To explore new research areas on non-earthquake and multi-hazard fragility assessment.
- To identify avenues of funding for future collaborative projects.

The workshop was attended by 5 academics and researchers from France, with 4 attending from BRGM and 1 from University Paris-Est Marne-la-Vallée. These were joined by 5 academics and 10 PhD students from different Departments within UCL. Unfortunately, Professor Meghraoui of Strasbourg University was unable to attend the workshop. The workshop is considered to have been extremely successful by all participants, with all the objectives having been achieved and with a substantial number of initiatives for future collaboration planned. Abstracts for joint publications have been submitted to a conference, and exchanges and a follow-up workshop in France have been established.



Figure 1: Photo of the workshop participants in the UCL main quadrangle. Note: Dr Dina D’Ayala took the photograph and Prof. Marek Ziebart, Prof. Peter Sammonds are not in the picture.

## Workshop Programme

*July 10th:*

14:00-14:10 Welcome from the Vice Dean for Research of the UCL Engineering Faculty, Prof. Marek Ziebart

14.10-18.00 Workshop 1: Capacity Assessment of Buildings

14.10-14.35 *FRACAS: FRAgility from Capacity spectrum ASsessment approach and programme* by T.Rossetto, S.Minas, A.Nassirpour (UCL) and P.Gehl (BRGM)

14:35-15:05 *The influence of ground-motion variability on fragility assessment* by J.Douglas (BRGM)

15:05-15:30 *Integrated risk assessment methods* by A.Mebarki (U. P-E M-I-V)

15:30-17.00 Discussion on how to further collaborate and extend the programme of work

17.00-19.00 Workshop 2: Vulnerability of Masonry Structures

17:00-17.25 *Tools for the fragility assessment of masonry buildings* by D.D'Ayala (UCL)

17.25-17.50 *BRGM work on Masonry fragility* by T.Ulrich (BRGM)

17.50-19.00 Q & A and discussion on future research

19.30-22.00 Dinner at Tas Restaurant, Gower Street

*July 11th:*

09:00-09.25 *Cascading Crises - Cobering Collaborations* by Professor Peter Sammonds, Director of the UCL Institute for Risk and Disaster Reduction

09.25-10.30 Workshop 3: Propagation of risk in the multi-hazard assessment of infrastructure

09.25-09.50 *SYNER-G and the UCL BRGM work* by P.Gehl (BRGM)

09.50-10.15 *The INFRARISK project* by D.D'Ayala (UCL)

10.15-10.30 Q and A

10:30-11:15 Parallel Discussion Sessions – Round 1

Session 1: Masonry Fragility

Session 2: Simplified Analysis Methods for Building Fragility

11:15-12:00 Parallel Discussion Sessions – Round 2

Session 1: Infrastructure Fragility

Session 2: Tsunami Fragility

12:00-13:00 Round-up discussions and Actions

13.00-14.00 Lunch

14.00 Departure

## Participant List

**Dr Dina D'Ayala**, Reader in Structures, CEGE Department at UCL, Head of Structures, co-Director of EPICentre Research Group.

*Research Interests:* Seismic vulnerability of existing low-engineered structures, field data collection, damage assessment, retrofitting and strengthening. Conservation of historic structures.

**Dr. John Douglas**. Expert in seismic hazard assessment at BRGM, in the Seismic and Volcanic Risks Unit, Risks and Prevention Division.

*Principal area of research:* Seismic hazard assessment, particularly ground-motion prediction

**Dr Philippe Duffour**, Lecturer in Structural Dynamics in CEGE Department at UCL.

*Research interests:* Structural dynamics, earthquake engineering, seismic performance of reinforced soils, adaptive structures.

**Dr. Evelyne Foerster**, Deputy Director of the Risks and Prevention Division, BRGM.

*Principal area of research:* Numerical methods and modelling for Geosciences.

**Pierre Gehl**, Research Engineer in seismic vulnerability at BRGM, in the Seismic and Volcanic Risks Unit, Risks and Prevention Division.

*Principal area of research:* vulnerability assessment, probabilistic approaches for seismic risk

**Dr Ioanna Ioannou**, post-doctoral researcher from the CEGE Department at UCL

*Research interests:* Empirical fragility and vulnerability, statistical modelling in structural analysis/reliability, fragility analysis under multiple hazards.

**Professor Ahmed Mebarki**, Prof. Civil Engineering, Risk and Reliability, Structural Analysis, University Paris-Est Marne-la-Vallée, France

*Research interests:* Structural vulnerability, structural analysis, risk & reliability analysis and simulations, integrated probabilistic framework & modelling, domino effect, optimization.

**Dr Abdelghani Meslem**, post-doctoral researcher from the CEGE Department at UCL

*Research interests:* Structural dynamics, analytical fragility and vulnerability.

**Dr Tristan Robinson**, Teaching Fellow in Fluid Mechanics and Post-doctoral researcher in UCL CEGE.

*Research interests:* Tsunami risk, fluid dynamics.

**Dr Tiziana Rossetto**, Reader in Earthquake Engineering the CEGE Department at UCL and Director of EPICentre Research Group.

*Research Interests:* Fragility of buildings and infrastructure systems to earthquake excitation, tsunami impact assessment, structural dynamics, earthquake risk perception.

**Professor Peter Sammonds**, Director of the UCL Institute for Risk and Disaster Reduction.

*Research Interests:* Seismology; Research into the mechanics of the Earth's crust and ice sheets through the study of fundamental physics and mechanics of geological materials; The impacts of climate change and natural hazards

**Thomas Ulrich**, Research Engineer at BRGM, in the Risks and Prevention Division

*Principal area of research:* vulnerability evaluation of existing buildings against seismic and landslide hazards, numerical modelling of masonry

**Professor Marek Ziebart**, Professor of Space Geodesy, Director of the Space Geodesy and Navigation Laboratory (SGNL) and Vice Dean for Research of the Faculty of Engineering Sciences

*Research Interests:* Space Geodesy including spacecraft orbit determination and prediction; high precision processing of GPS data (plate tectonics, earthquake cycle, tide gauge positioning); the definition of planet scale reference frames and reference surfaces (height datums, gravity field models, inertial and planet fixed reference frames); design and simulation of system architecture of navigation and positioning systems for other planets.

*PhD students:*

**Joakim Beck**, Department of Statistics, UCL.

**Arash Nassirpour, Stylianos Minas, Randolph Borg, Indranil Kongar, Joshua Macabuag, Tristan Lloyd, Viviana Novelli, Atiyeh Ardakanian and Daniel Pohoryles, CEGE Department, UCL.**

### **Initiatives for Future Collaboration**

*Specific research projects identified to take forward:*

- “FRACAS – Fragility assessment software”. This is a joint UCL-BRGM software that has just been developed and ideas for improving its functionality, as well as for its release to other academics and industry were discussed.
- “Assessing the importance of spatial variability on empirical fragility curves”. UCL and BRGM are to embark on a short term research project to explore this idea. The proposed methodology for carrying out the research has already been drafted and is being discussed.
- “Developing empirical fragility functions for storage tanks, for tsunami”. Data on storage tanks from Uni. Paris-Est will be used together with methods developed by UCL to construct empirical fragility functions
- “Assessing the seismic vulnerability of masonry building cluster”. UCL and BRGM have been working on this topic in the framework of the PERPETUATE project ([www.perpetuate.eu](http://www.perpetuate.eu)) by calibrating models performed by using the mechanical approach FaMIVE and the discrete element method 3DEC to simulate collapse of buildings due to in-plane failures. A proposal to expand the remit of this collaboration to investigate the effect of out of plane mechanisms on masonry building cluster and pounding effects between adjacent buildings, has been discussed and drafted during the workshop.

*Conference papers leading to journal papers:*

Four joint abstracts for conference papers, co-authored by UCL and BRGM have been submitted to the *Second International Conference on Vulnerability and Risk Analysis and Management (ICVRAM2014)* to take place on 13 - 16 July 2014, at the University of Liverpool, UK. These have the following titles and authors:

**“Sensitivity analysis of different capacity approaches to assumptions in the modeling, capacity and demand representations”** Tiziana Rossetto<sup>1</sup>, Pierre Gehl<sup>2</sup>, Stylianos Minas<sup>1</sup>, Arash Nassirpour<sup>1</sup>, Philippe Duffour<sup>1</sup>, Joshua Macabuag<sup>1</sup>, and John Douglas<sup>2</sup> (<sup>1</sup>*EPICentre, Department of Civil Environmental and Geomatic Engineering, University College London;*<sup>2</sup>*Department of Risks and Prevention, BRGM, 3 avenue Claude-Guillemin, Orléans, France*)

**“Investigating the use of record-to-record variability in static capacity approaches”**, Pierre Gehl<sup>2</sup>, John Douglas<sup>2</sup>, Tiziana Rossetto<sup>1</sup>, Joshua Macabuag<sup>1</sup>, Arash Nassirpour<sup>1</sup>, Stylianos Minas<sup>1</sup> and Philippe Duffour<sup>1</sup> (<sup>1</sup>*EPICentre, Department of Civil Environmental and Geomatic Engineering, University College London;*<sup>2</sup>*Department of Risks and Prevention, BRGM, 3 avenue Claude-Guillemin, Orléans, France*)

**“Assessing the seismic vulnerability of masonry aggregates with different numerical methods”**, Thomas Ulrich<sup>2</sup>, Viviana Novelli<sup>1</sup>, Dina D’Ayala<sup>1</sup>, Caterina Negulescu<sup>2</sup>, Evelyn Foerster<sup>2</sup>, (<sup>1</sup>*EPICentre, Department of Civil Environmental and Geomatic Engineering, University College London;*<sup>2</sup>*Department of Risks and Prevention, BRGM, 3 avenue Claude-Guillemin, Orléans, France*)

**“Parametric analysis of historic masonry building clusters subjected to pounding”**, Viviana Novelli<sup>1</sup>, Dina D’Ayala<sup>1</sup>, Thomas Ulrich<sup>2</sup>, Pierre Gehl<sup>2</sup>, (<sup>1</sup>*EPICentre, Department of Civil Environmental and Geomatic Engineering, University College London;*<sup>2</sup>*Department of Risks and Prevention, BRGM, 3 avenue Claude-Guillemin, Orléans, France*)

These will be further extended and submitted as journal papers.

Furthermore UCL members may be providing short contributions to the following publication of Professor Mebarki, University Pari-Est:

- A journal paper on Resilience for the special ASCE issue (coordinated by Gian-Paolo Cimellaro from Politecnico Torino)
- A chapter of a monograph on "Tsunamis: restoration and reconstruction".

#### *Researcher exchanges/employment for new research projects*

At the workshop it was agreed that the following researchers would spend time at one of the other institutions on particular projects

- Dr Ioanna Ioannou, UCL, will spend 1 week at BRGM at the end of August to work on the research project "Assessing the importance of spatial variability on empirical fragility curves". Ioana's subsistence and travel will be funded from one of Dr Rossetto's funded EPSRC projects.
- Viviana Novelli of UCL will apply for the Graduate School funding for Research Students provided by UCL to spend up to 3 months at BRGM in 2014 to work on the seismic vulnerability assessment of masonry building clusters
- Thomas Ulrich of BRGM will apply for CARNOT funding to spend 3 months at UCL in 2014, to work on masonry fragility
- Stylianos Minas will visit BRGM over the next year/2 years to collaborate on FRACAS development, funded by his PhD scholarship funds

In addition, the possibility of Mr Pierre Gehl of BRGM undertaking a PhD at UCL is currently being explored. Other opportunities for funding the exchange of students with University of Paris-Est will be explored also.

#### *Follow-up workshops*

A two day workshop on tsunami will take place at BRGM in November 2013. Dr Tiziana Rossetto, Mr Joshua Macabuag and Dr Tristan Robinson will attend the workshop from UCL.

#### *Funding opportunities to be explored for further exchanges/seed funds for projects:*

UCL Impact studentships: <http://www.ucl.ac.uk/beams/phd/funding/impact>

CARNOT funding for French researchers at BRGM

UCL Graduate School research project funding.

### **Finance**

The funds provided have been spent to pay for the travel and subsistence of the French participants (1 night). They have also been spent on lunch and refreshments for all workshop participants during the workshop and for the workshop dinner. Some funds were spent on printed materials and stationary for the meeting. The final costs have not yet been calculated as we are awaiting the receipts and expense claims from some of the French participants. These will be reported in a follow-up e-mail.

### **Final Remarks**

The authors of the report would like to sincerely thank the French Embassy for providing the funds for the workshop that have provided the opportunity to entertain technical talks with French researchers. The synergies between the participating institutions have already sparked new and exciting research ideas and initiatives that will form the foundations for a strong and long-lasting collaboration.