Organized by:

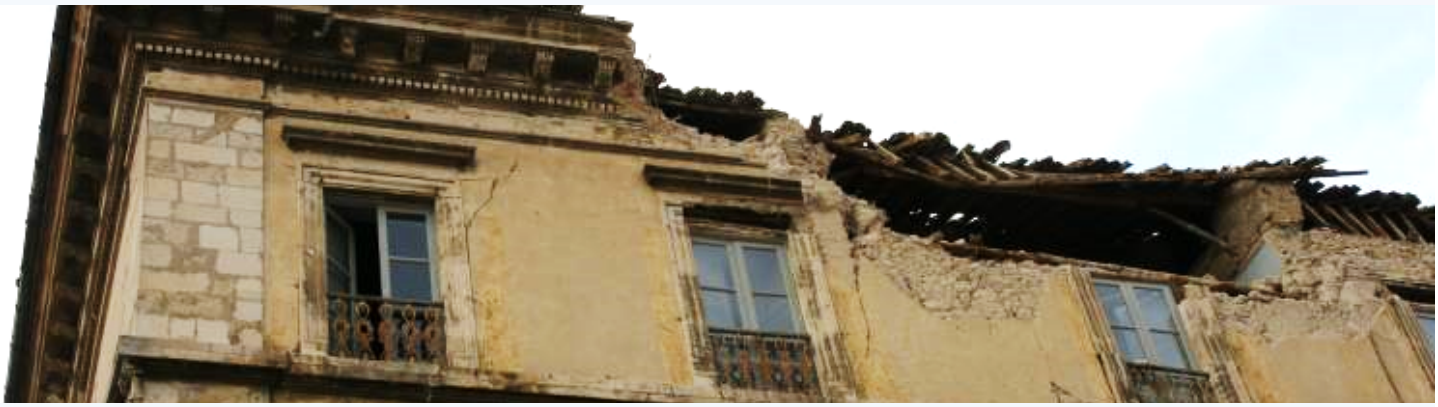
ROMA TRE UNIVERSITY
Department of Engineering
Structures Research Unit

ENEA Casaccia Research Centre
Laboratory of technologies for sustainable Innovation - SSPT-USER-SITEC

Supported by:

Ministero degli Affari Esteri

Shake table tests of masonry walls



Two full-scale walls, one in stone masonry and one in tuff blocks, will be tested on the shake table. Scaled natural accelerograms will be applied in both horizontal and vertical directions, with increasing scaling factor up to collapse. The walls are provided with a top beam in reinforced brickwork, whose horizontal displacement is constrained by a steel frame connected with the shake table. Test setup is designed to investigate the out-of-plane seismic capacity of the two types of masonry, that will be tested simultaneously, to allow comparisons between their seismic behaviour. The tests will be carried out on:

Monday 19 December from 2.00pm to 5:00pm
Tuesday 20 December from 10.00am to 2:00pm

The experimental tests will be shared in real time by DySCO Virtual Lab at the following address:

http://connect.portici.enea.it/tavibr

For attending the tests click on “guest” and write your name, surname and your company name.

For further information, contact Prof. de Felice at the following address: **defelice@uniroma3.it**

Background

The recent seismic events in central Italy caused the loss of entire historic hamlets, generating the doubt on the effective capacity of historic buildings to withstand seismic actions. Is it sufficient to fulfil the rule of the art of masonry for ensuring a sufficient seismic protection? …. or the recourse to new technologies and innovative materials is needed?

From a survey of seismic damages on masonry structures, it appears that most of collapses are caused to either the disaggregation of masonry or the out-of-plane bending of the wall. However, no experimental evidences are yet available that provide a reliable estimate of the out-of-plane seismic capacity of stone masonry walls.

Experimental investigation

The present experimental campaign aims at filling this gap, investigating the seismic behaviour of full scale masonry walls through shake table tests. Moreover, the research project aims at developing and assessing the efficacy of innovative and sustainable solutions for the retrofitting and the structural strengthening of masonry.

Two full-scale walls, 3.7m high and 25cm thick, one in **stone masonry** and one in **tuff blocks**, will be tested on the shake table. The walls are provided with a **top beam in reinforced brickwork**, provided with high strength steel textiles in the bed joints and with steel connectors to the walls. The testing setup includes a steel frame connected to the shake table that prevents the horizontal displacement of the top beam, leaving free rotations and upward displacements.

After the tests, the walls will be **repaired and retrofitted** with externally bonded mortar-based composites. The new test session on the reinforced walls will take place in spring 2017.

Wall specimens on the shake table during testing setup preparation

Numerical simulation

The project includes the development of new computational tools for assessing the seismic behaviour of masonry under seismic actions [1,2], that have been applied to simulate the experimental tests.

Scientific coordination

The research project is led by Prof. Gianmarco de Felice of the **Department of Engineering of Roma Tre University**, while the experimental tests will be carried out at the **ENEA Casaccia Research Centre**, under the coordination of Dr. Gerardo De Canio.

Seismic inputs

Based on previous experience on shaking table tests with masonry specimens [3,4] a set of five natural records have been selected amongst some of the most severe Italian earthquakes of the last 40 years. They will be applied with increasing scaling factor up to the collapse of the specimens.

Event	Record	PGA (horizontal)	PGA (vertical)
Iripinia earthquake, 1980	Bagnoli BGI	0.187g	0.101g
Emilia earthquake, 2012	Mirandola MRN	0.262g	0.303g
Amatrice earthquake, 2016	Amatrice AMT	0.376g	0.399g
Umbria-Marche earthquake, 1997	Nocera Umbra NCR	0.423g	0.406g
L'Aquila earthquake, 2009	L'Aquila AQV	0.657g	0.496g

Innovative monitoring with the 3DVision system

An **innovative 3D motion optical system** named **3DVision** [5] will be used in addition to accelerometers and displacement transducers, to measure displacements during the shake table tests. 3DVision system makes use of wireless passive spherical retro-reflecting markers positioned on several points of the specimen, whose spatial displacements are recorded by near-infrared digital cameras. Analyses in the time domain will allow the monitoring of the deformations of the walls and the detection of the fundamental frequencies and modal shapes.

Piezoelectric accelerometer and retro-reflecting marker for 3DVision application

Cooperation and Financial support

The experimental investigation is carried out within the following partnerships:

- **ENEA Casaccia Research Centre**, Laboratory of technologies for sustainable Innovation (SSPT-USER-SITEC)
- **Ministero degli Affari Esteri e della Cooperazione Internazionale** (Italian Ministry for Foreign Affairs), Direzione generale per la promozione del sistema Paese. ITALY – USA Science and Technology Cooperation Project Nr. PGR00234 "*Composites with inorganic matrix for sustainable strengthening of architectural heritage*"
- **Regione Lazio**. Progetto COBRA "*Sviluppo e diffusione di metodi, tecnologie e strumenti avanzati per la Conservazione dei Beni culturali, basati sull'applicazione di Radiazioni e di tecnologie Abilitanti*"
- **Rilem Technical Committee 250-CSM** "*Composites for the Sustainable Strengthening of Masonry*".
- **Kerakoll SpA**. Research Agreement "*Seismic retrofitting of masonry structures with composites*"
- **Reluis-DPC** Executive Projects 2006/2016 "*Assessment and Mitigation of Seismic Vulnerability of Existing Masonry Structures*"

References

[1] Mauro A., de Felice G., DeJong M. (2015) The relative dynamic resilience of masonry collapse mechanisms, Engineering Structures, 85: 182-194.

[2] de Felice G., De Santis S., Lourenço P.B., (2016) Mendes N. Methods and challenges for the seismic assessment of historic masonry structures. International Journal of Architectural Heritage, to appear.

[3] AlShawa, O., de Felice, G., Mauro, A., and Sorrentino, L. (2012). Out-of-plane seismic behaviour of rocking masonry walls. Earthquake Engineering & Structural Dynamics, 41(5):949-968.

[4] De Santis S., Casadei P., De Canio G., de Felice G., Malena M., Mongelli M., Roselli I. (2016) Seismic performance of masonry walls retrofitted with steel reinforced grout. Earthquake Engineering & Structural Dynamics, 45(2):229-251.

[5] De Canio G., de Felice G., De Santis S., Giocoli A., Mongelli M., Paolacci F., Roselli I. (2016) Passive 3D motion optical data in shaking table tests of a SRG-reinforced masonry wall. Earthquakes and Structures, 10(1):53-71.