NUMERICAL TECHNIQUES FOR THE STUDY OF HISTORICAL MASONRY STRUCTURES

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The focus of the research is the development and application of theoretical models and numerical methods for the structural analysis of historic structures.

The actual research activity encompasses a large number of structural issues involving historical buildings, in particular:

- development of coupled multiphase models for the hygrothermal analysis of masonry structures aimed at the evaluation of the stress induced by crystallization of salts;
- development of advanced constitutive models of the mechanical behavior of masonry;
- analysis of the seismic vulnerability of masonry structures, considering both in-plane and out-of-plane mechanisms;
- assessment of the carrying capacity of masonry structures and reserves of security against the stresses might be required as a result of the execution of works of consolidation and restoration;
- development, investigation and evaluation of new methodologies for the integrated, multi-physics modelling of built cultural heritage with the target to support the development of energy efficiency interventions which minimize the primary energy consumption in historic buildings, taking into full account the preservation tasks.

Further research topic concerns the development of multiscale approaches for the structural analysis of masonry buildings in the presence of degradation due to environmental actions, such as capillary suction and crystallization of salts.
The multiscale approach allows to accurately capture most of the degradation process - often accompanied by localization of damage in narrow zones, which ultimately leads to failure – still remaining computationally efficient for large-scale structural computations.

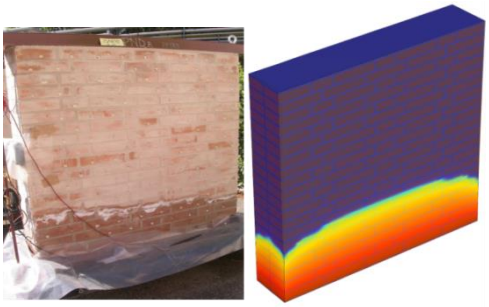

Fig. 1. Rising moisture: numerical model and experimental evidence (left: Colla, right: Castellazzi).

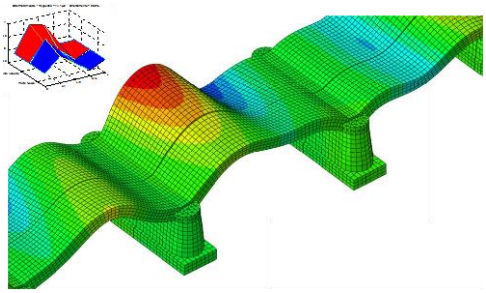

Fig. 2. Linear dynamic analysis: modal identification of an historical bridge (Castellazzi).

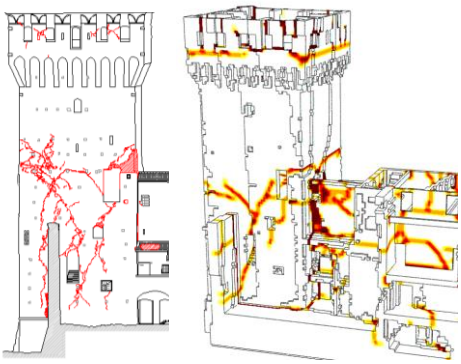

Fig. 3. Nonlinear Response History Analyses (RHA) using natural accelerograms of the San Felice sul Panaro (Italy) fortress, hit by the Emilia earthquake in 2012 (Castellazzi).

MAIN PUBLICATIONS

Castellazzi G., D'Altri A.M., de Miranda S., Tralli A.M. (2016). On the seismic behavior of the main tower of the San Felice sul Panaro (Italy) fortress, *12th International Conference of Computational Methods In Sciences And Engineering (ICCMSE2016)*

Castellazzi G. D'Altri A.M., Bitelli G., Selvaggi I., Lambertini A., (2016). From laser scanning to finite element analysis of complex buildings by using a semi-automatic procedure, *Sensors* 15 (8), 18360-18380.

Bovo M., Mazzotti C., Savoia M. (2013). Structural behaviour of historical stone arches and vaults: experimental tests and numerical interpretation. *Studi e Ricerche* 32.

Castellazzi G., Gentilini C., Nobile L. (2013). Seismic vulnerability assessment of an historical church: limit analysis and non-linear Finite Element analysis. *Advances in Civil Engineering*. art. num. 517454

Landi L., Gabellieri R., Diotallevi P.P. (2015). A model for the out-of-plane dynamic analysis of unreinforced masonry walls in buildings with flexible diaphragms. *Soil Dynamics and Earthquake Engineering*, vol. 79, pag. 211-222.

Castellazzi G., de Miranda S., Mazzotti C. (2012). Finite Element Modelling Tuned on Experimental Testing for the Structural Health Assessment of an Ancient Masonry Arch Bridge. *Mathematical Problems in Engineering* art. no. 495019.

Castellazzi G., Colla C., de Miranda S., Formica G., Gabrielli E., Molari L., Ubertini F. (2013). A coupled multiphase model for hygrothermal analysis of masonry structures and prediction of stress induced by salt crystallization. *Construction and Building Materials* 41, 717-731.

Castellazzi G., de Miranda S., Formica G., Molari L., Ubertini F. (2015). Coupled hygro-mechanical multiscale analysis of masonry walls, *Engineering Structures* 84, 266-278.

Colla C., Molari L., Gabrielli E., de Miranda S. (2012). Damp and salt rising in damaged masonry structures: numerical modelling and NDT monitoring. *RILEM Bookseries* 6, 1151-1156.

Colla C., de Miranda S., Ubertini F. (2011). Indagini in sito per la diagnostica strutturale dell'elevato: la Casa del Tramezzo di Legno ad Ercolano. In: *DHER, Domus Herculanensis Rationes*, Sito Archivio Museo – A. Coralini (a cura di), Vesuviana, AnteQuem- Studi e Scavi 30, Bologna, 145 – 161.

Ferretti E., Casadio E., Di Leo A. (2008). Masonry Walls under Shear Test: a CM Modeling, *Computer Modeling in Engineering & Science* 30, 163-190.

Castellazzi G., Custodi A., Sciortino L., Vagnetti A., Colla C., de Miranda S., Ubertini F. (2008). Modellazione e simulazione di strutture archeologiche in area vesuviana, *Convegno Internazionale VESUVIANA*, Bologna, January 14-16.

RESEARCH PROJECTS

3ENCULT – Efficient Energy for EU Cultural Heritage, FP7-2010, Collaborative EU project. Project Ref.: 260162.

SMooHS – Smart Monitoring of Historical Structures, FP7-2008, Collaborative EU project. Project Ref.: 212939.

KISADAMA - Kinetics of Salt Crystallization and Mechanical Damage in Historic Masonry (2013-2016), JPI - JOINT HERITAGE EUROPEAN PROGRAMME (www.kisadama.eu).

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