

STRUCTURAL ASSESSMENT OF HISTORIC TOWERS: THE KEY-ROLE OF OPERATIONAL MODAL ANALYSIS

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Abstract

Historical masonry towers are relevant architectural heritage often in strategic position within the city centres. Their height and position require specific controls in order to define the state of preservation. The paper describes the investigation procedures developed by the Author in selected case studies. According to the timing and to the complexity of the structure, the approach requires preliminary visual inspections, geometric, crack pattern survey supplemented by historical research and stratigraphic survey. Operational modal testing evaluates the overall structural behaviour, indicating eventual local (or global) problems to study in deep by monitoring or further local tests. Emergency operations, like controls after earthquakes, could require prompt procedures. In this case, the combination of visual inspection, geometric and damage survey with dynamic testing is a reliable procedure for the structural assessment. Additional investigation increases the knowledge of local problems or gives information for further activity like structural modelling. For instance, relevant data are the evaluation of the masonry quality or the control of the local state of stress to estimate through non-destructive or minor destructive testing in selected positions. Nevertheless, such activities require accurate projects of the investigation too, planning and localising the several tests in order to solve the problems detected in the preliminary steps of the diagnosis process.

Highlights

- The assessment of historic structures is a challenging task.
- It required multidisciplinary approach, merging information from several topics.
- In structural assessment, operational modal testing is a powerful tool for the data merging.
- Operational modal testing involves the evaluation of the overall structural behaviour, indicating eventual local (or global) problems to study in deep by monitoring or further local tests.
- Operational modal testing has primary importance for the calibration of structural models.

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Antonella Saisi is Associate Professor at the Politecnico di Milano and PhD in Earthquake Engineering. The research activity deals with evaluation of the seismic behaviour of ancient masonry buildings, dynamic tests and continuous dynamic monitoring of historic bridges and structures, diagnosis of historic structures, calibration and application of non destructive tests to masonry buildings, material characterisation and study of the intervention and repair techniques applied to masonry building, architectural preservation. Coordinator of the Research Unit of Politecnico di Milano in several national and international projects including:

- EC project NIKER – New Integrated Knowledge based approaches to the protection of Cultural Heritage from Earthquake-induced Risk, 2010-2012
- National project COFIN 2004 "VINCES - Vibrations in Civil Engineering Structures: source of damage and discomfort, diagnostic and safety assessment tool"

Member of technical commissions as RILEM TC SAM (Site Assessment of Masonry Structures), RILEM TC MSC (Masonry Strengthening with Composite Materials), RILEM DHM (Design and application of hydraulic grouts for repair and strengthening of historic masonry structures).

Since 2004, member of the SSBAP Board, the Specialisation Course on Architectural and Landscape Heritage, of the Politecnico di Milano, teaching Strengthening of Historic Buildings - Investigation and Structural Diagnosis. Since 2005, member of the University Board of the Preservation of Architectural Heritage PhD program at the Politecnico di Milano.

Editor of Construction and Building Materials - Elsevier.

Referee of several national/international institutions and international journals (MIUR, Research Foundation Flanders – FWO, Katholieke Universiteit Leuven; International Journal of Cultural Heritage, Engineering Structures, Non Destructive Testing and Evaluation International - Elsevier; International Journal of Architectural Heritage, Conservation, Analysis and Restoration - Taylor & Francis; Materials and Structures, Springer - RILEM 6, Journal of Materials in Civil Engineering, ASCE, etc.).

Member of the Scientific Committee/Advisory Board of several international conference (SAHC - International Conference on Structural Analysis of Historical Constructions, IBMAC - International Brick-Masonry Conference, IMC – International Masonry Conference, ETNDT - Emerging Technologies in Non-destructive Testing, ...).

Author of the contribution awarded as Best Paper by a University Researcher at the International Conference on Structural Faults and Repair 2016.

Author or co-author of more than 220 scientific papers.

Selected papers

1. C. Gentile, A. Ruccolo, A. Saisi, Continuous Dynamic Monitoring to Enhance the Knowledge of a Historic Bell-Tower, International Journal of Architectural Heritage, 2019, vol. 13(7), pp. 992-1004 (DOI: 10.1080/15583058.2019.1605552).
2. A. Cabboi, C. Gentile, A. Saisi, From continuous vibration monitoring to FEM-based damage assessment: Application on a stone-masonry tower, Construction and Building Materials, Elsevier, Vol. 156, 2017, pp. 252-265.
3. A. Saisi, C. Gentile, A. Ruccolo, Pre-diagnostic prompt investigation and static monitoring of a historic bell-tower, Construction and Building Materials, Elsevier, Vol. 122, 2016, pp. 833-844.
4. A. Saisi, C. Gentile, M. Guidobaldi, Post-earthquake continuous dynamic monitoring of the Gabbia Tower in Mantua, Italy, Construction and Building Materials, Elsevier, Vol. 81, 2015, pp. 101-112.
5. C. Gentile, A. Saisi, A. Cabboi, Structural Identification of a Masonry Tower Based on Operational Modal Analysis, International Journal of Architectural Heritage: Conservation, Analysis, and Restoration, Taylor & Francis, Vol. 9(2), 2015, pp. 98-110.
6. A. Saisi, C. Gentile, Post-earthquake diagnostic investigation of a historic masonry tower, Journal of Cultural Heritage, Elsevier, Vol. 16, 2014, pp. 602-609.
7. C. Gentile, A. Saisi, Ambient Vibration Testing of Cultural Heritage Structures, Encyclopaedia of Earthquake Engineering, Springer Berlin Heidelberg, 2014, pp. 1-25.
8. C. Gentile, A. Saisi, Ambient vibration testing and condition assessment of the Paderno iron arch bridge (1889), Construction and Building Materials, Elsevier, Vol. 25, Issue 9, September 2011, pp. 3709-3720.
9. C. Gentile, A. Saisi, Ambient vibration testing of historic masonry towers for structural identification and damage assessment, Construction and Building Materials, Elsevier, Vol. 21, Issue 6, 2007, pp. 1311-1321.
10. L. Binda, A. Saisi, C. Tiraboschi, Investigation procedures for the diagnosis of historic masonries, Construction and Building Materials, Elsevier, Vol. 14, n. 4, June 2000, pp. 199-233.