Editorial

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Biographical notes: Francesco Fabbrocino is an Aggregate Professor of Solid and Structural Mechanics and Structural Design at the Pegaso University. He was and is involved in several national and international research projects. He is editorial board member and reviewer of numerous international journals. He is author of more than 66 scientific papers, published on national and international journals and conference proceedings. He received several awards and public acknowledgements for his scientific research activity.

Antonio Formisano is an Aggregate Professor of Structural Design at the University of Naples Federico II. Habilitated as Associate Professor since 2017, he is author of about 300 papers, dealing with steel and aluminium structures, monumental masonry constructions, seismic and volcanic vulnerability, retrofitting, robustness and sustainability, published in national and international journals and proceedings of conferences, where he participated as speaker and chairman. He is member of the editorial and scientific committee of many national and international conferences. He participated as a member and coordinator to numerous national and International research projects. He is member of the editorial board and reviewer of numerous national and international scientific journals. He was consultant for the development of technical and seismic regulations on steel and aluminium alloy structures and connections. He received several awards in the fields of steel structures, conservation and restoration of constructions and green building.

The target of this special issue is to outline design procedures, techniques and materials used from ancient times to today for the structural analysis and restoration of historical buildings and monuments in seismic prone areas.

Historical and monumental structures represent a high percentage of existing constructions in numerous regions affected by earthquakes, especially in Europe. A large number of historical buildings belongs to our cultural heritage and include the building art at their erection time. These structures deserve special care because of their individual historical or architectural meaning, since they are living representatives of earlier constructive traditions.

Most of the existing European historical monumental structures are made of masonry. Seismic events have often caused either massive damage or the destruction of these structures having great cultural significance. Examples can be found in past earthquakes, which affected most of such types of constructions. Also recent seismic events also caused great damage to religious temples and other monumental buildings. Unlike modern structures, where the seismic vulnerability can be assessed by means of existing codes and analysis methodologies, the seismic behaviour evaluation of old masonry structures does not have a proper scientific background.

The seismic vulnerability evaluation of such structures depends on reliable numerical simulations of their seismic response. Numerical modelling of the seismic behaviour of masonry structures represents a very complex problem due to the constitutive laws of structural materials and their highly non-linear behaviour when subjected to strong ground motions. Whatever method is used to investigate these structures, their mechanical behaviour, essentially different from a continuum, should be considered. Therefore, the numerical modelling methods available for the study of historical structures and monuments under seismic actions are reviewed in this special issue. In particular, other than the traditional analysis techniques, new methodologies for the assessment of the seismic behaviour of monumental masonry structures are inspected. On one hand, they allow for the modelling of their response up to collapse, corresponding to large displacements and a high geometrical non-linear behaviour, and, on the other hand, the modelling of the mechanical non-linear behaviour of both structural blocks and their interfaces, the identification of failure patterns and the control of internal stresses and deformations vs. the seismic input are permitted. To this purpose, some new analysis methods, i.e., the discrete elements method, are examined in this special issue, since they allow for large displacements and rotations (including sliding) among blocks, the crack opening and the complete detachment of blocks, as well as the detection of new contacts as the calculations go on. Moreover, the difficulty in performing a reliable assessment of the actual structural conditions of monumental constructions, due to the difficulty in the numerical prediction of their seismic behaviour, makes very complicate the execution of consistent seismic retrofitting projects.

Generally speaking, the problem of restoration of these buildings differs radically from repairing and strengthening of ordinary constructions. Structural restoration is a highly specialised operation, where the collaboration of specialists in many scientific disciplines, strongly supported by computational methods and well equipped laboratories, is strongly required.

For monumental buildings, emphasis is in fact given to the preservation of their aesthetic and historical values, while the task to remain in use may be considered of minor importance.

When structural interventions are of interest, the preservation and revealing of monument aesthetic and historical values, as well as the respect for original materials and authentic technical documentations, represent the restoration aim. This imposes to the specialists involved into restoration interventions an obligation to consider appropriate techniques and materials for repairing and strengthening. The key of the choice of materials and techniques is related to the method classification into two main categories, namely reversible and irreversible. Materials used in reversible interventions usually impose very limited restrictions. Contrary, materials used in irreversible interventions require both the compatibility of the new materials with the original ones and the very-long-term durability of new materials. These restrictions necessitate a systematic knowledge of properties of original materials, so that they can be used as a guide to the choice of materials for repairing and strengthening interventions. It is generally accepted that the best way to satisfy the compatibility and durability requirements is to choose 'traditional materials' for restoration. However, the possibility to take profit of new materials available from the modern technology allows for new intervention techniques that deserve the attention of designers.

On the basis of these premises, in the current special issue particular attention is dedicated to the use of both old and new materials and ancient and modern restoration techniques addressed to evaluate 'pro' and 'cons' of restoration interventions with the main goal to establish, according to Restoration Charters, the best retrofitting measures for preserving and revealing the aesthetic and historical values of monumental masonry buildings.

In particular, this thematic issue on the seismic analysis of existing masonry constructions and their widespread and innovative rehabilitation methods comprises five contributions from different research groups. Such contributions cover a wide range of analysis methods on historical constructions and, at the same time, highlight the attention on novel retrofitting and strengthening techniques used to improve their behaviour under both design and exceptional actions.

Belliazzi et al. (2018) developed textile reinforced mortars systems as a sustainable way to retrofit structural masonry walls under tsunami loads after an earthquake textile reinforced mortar (TRM) represents a new sustainable strengthening solution for existing masonry buildings in the conservation field. This system offers a good balance between strength provided by fibres and compatibility of mortars given by matrix. In the presented work fast assessment tools for the effects of tsunami actions, with particular reference to the inundation depth main parameter, on masonry structures were provided. Moreover, a speedy analysis tool to design retrofit interventions with innovative strengthening systems was delivered. The peculiar multilinear behaviour of fibrous systems with inorganic matrices was accounted for and some design equations and charts were provided by taking into account both the material property variability and the potential uncertainty of the substrate masonry.

In the paper of Cecchini et al. (2018) a novel numerical approach to the analysis of the displacement field of a Composite pentamode metamaterial was developed. Two different approaches to the solution of the system of equations, namely an exact iterative approach and a discrete one based on FEM models, were taken into account. The single beam elements materialising the composite pentamode were hollow and included a non-Newtonian fluid (NNF) Core. In particular, shear-thickening fluids (STFs) were selected as materials for the core, as they were capable of converting into heat a large quantity of the kinetic energy deriving from the dynamic forces applied to the structure. In order to study the viscoelastic properties of the material considered, a two-step rheological analysis was carried out. Finally, the previous equations were solved and the results obtained for the various methods were compared.

The seismic-volcanic vulnerability of a cultural heritage masonry palace in the Vesuvius area was addressed by Formisano et al. (2018a), who set up maintenance and retrofitting measures for upgrading its structural safety. After the construction seismic behaviour was investigated through modal dynamic and pushover analyses developed, volcanic analyses under quake and tephra loading conditions were performed respectively through static non-linear and linear analyses with the purpose to implement a building multi-risk investigation. Finally, aiming at improving the palace behaviour under seismic and volcanic actions, retrofitting and energetic interventions based on the use of metal elements and rock wool insulator, respectively, were designed and applied, their effectiveness being evaluated by numerical way.

In the paper presented by Formisano et al. (2018b) the experimental and numerical activities related to in-situ Ambient Vibration Tests performed on a monumental masonry building placed in Castelnuovo of San Pio, a district of L´Aquila (Italy), were illustrated and discussed. The obtained experimental results, able to identify the dynamic characteristics of the investigated palace, were successively reproduced by means of a building FEM model through the ABAQUS calculation code. Numerical frequency analysis was also performed on the original building model aiming at evaluating its reduction in stiffness due to earthquake. Finally, appropriate retrofitting interventions were proposed, their effectiveness being proved by numerical analyses on the improved FEM model of the palace.

Iannuzzo et al. (2018) presented a paper dealing with the fracture identification analysis of a generic masonry structure subjected to both loads and kinematical actions (settlements, distorsions). The masonry was composed of normal rigid no – tension material (NRNT), that is a Heyman's material treated as a continuous body. An energy minimum criterion was used to solve the equilibrium problem, using continuous displacement fields and adopting a classical finite element approximation for the geometrical description. The way the approximate method detects crack patterns in some simple cases was finally illustrated. In conclusion, the method, though more cumbersome from the numerical point of view, exhibited great efficiency in the identification of the exact location and orientation of the cracks compared to methods based on discontinuous displacement fields.

Mongelli et al. (2018) developed the ENEAGRID high performance computing infrastructure, used to transform 2D digital imaging to finite element analysis, for the preservation of historical masonry structures. In order to improve the collaboration among scientific communities working in laboratories differently distributed on the territory, the complexity of data streaming process and the difficulties with integrating heterogeneous instruments of different groups of researchers. This paper showed the "ENEA Staging Storage Sharing" (E3S) architecture, which promotes the technology transfer to small and medium-sized companies for the conservation of cultural heritage reducing time needed to obtain experimental results by means real time data streaming functions. This architecture was set up for the shaking tables at the Sustainable Innovation TEChnologies (SITEC) ENEA Casaccia R.C. laboratory and it was used during experimental tests on two masonry walls made up of stone and tuff blocks, to verify the behaviour of innovative anti-seismic reinforcement techniques.

The guest editors of the special issue on “Seismic analysis and rehabilitation methods of monumental masonry constructions: from past procedures to future advances” would like to express their profound gratitude to all the participating authors, as well as to the international reviewers, who made possible this publication. In conclusion, they would also like to thank the Editor-in-Chief and the team of the *International Journal of Masonry Research and Innovation* for their valuable support and guidance in preparing and finalising the current special issue.