Foreword

Seismic Assessment and Rehabilitation of Historic Structures

Recent earthquakes, such as the Abruzzo one of 2009 or the Tōhoku one of 2011 have caused significant damage and even destruction to a large number of heritage structures. In addition to the risk posed to people lives, such destruction brings the loss of important cultural landmarks providing identity to cultures, countries and towns and the disappearance of important testimonies of their historical past and ancient knowledge. Structural engineering may largely serve to a successful seismic protection of the architectural legacy. Nonetheless, the seismic assessment of monuments is a very challenging task due to the complexity of the seismic action and the potential and often unexpected effects that earthquakes may produce on existing masonry buildings. Due to this, any action oriented to the safeguarding of historical buildings must be based on a deep understanding of the structural response and the real effect of the envisaged retrofitting solutions.

The study of the seismic resistance of historic structures experienced a significant development at the end of the last century thanks to the outstanding contributions of Antonino Giuffrè and other pioneering researchers. Antonino Giuffrè’s insights opened the door to a new understanding based on the investigation of the intrinsic construction qualities of historic buildings and the ensuing seismic performance. Further scientific research and technical experience, gathered in large part during the study of the consequences of past earthquakes, have given place to a new approach fully based on a careful and accurate characterization of the properties and expected structural response of historical buildings. In other words, the modern understanding is largely based on acquiring deep knowledge on the true response of the structure.

One of the aims at gathering this knowledge is found in the possibility of implementing a minimal intervention which, while providing the targeted structural reliability level, causes the minimum alteration to the structure and the minimum possible loss of cultural value. The minimal intervention is defined by Annex I on “Heritage Structures” of the ISO 13822 standard as the intervention that balances safety requirements with the protection of character-defining elements and ensures the least harm to the heritage values. The modification of the building layout is limited to the extent necessary to assure the required performance. Whenever possible, it must respect the original construction and structural features.

This new regard on the seismic assessment of historic buildings has been in large part motivated by the appreciation of the structure as a valuable cultural attribute of the monument. Not so long time ago, the structure was often regarded as only a technical artefact that could be freely modified to sat-
isfy whatever new requirements. Often, large transformations were undertaken that caused substantial and unnecessary cultural losses. Our attitude towards the structure has changed greatly during the last decades. We regard it today as a very valuable part of the monument and a precious testimony of past knowledge. A live document, in fact, whose authenticity is best preserved by still letting it perform its resistant mission in a way consistent with its original layout and construction qualities.

In fact, respect towards the intrinsic qualities of the structure is not only desirable because of the preservation of its authenticity and cultural value. The respect towards the structural layout is also convenient because of at least two other relevant reasons. First, the seismic response of highly altered structures is in some cases difficult to predict and may involve deleterious effects. Some strengthening solutions favoured in the past, such as injected reinforcements, have shown to cause important detrimental consequences. Second, solutions involving large alteration may be difficult or impossible to remove and may therefore compromise later improvements or future interventions.

The structural verification of historic buildings is a challenging engineering problem involving three different concerns, namely the safety of the people at risk, the integrity of the cultural and artistic contents, and the preservation of the structure as cultural heritage object. Compared to modern building design, where the focus lays on the safety of people, and without undervaluing this most important priority, the study of a historical building also needs to consider the integrity of the artistic contents (especially, paintings, frescoes and other fixed artistic assets) and, as much as possible, the preservation of the heritage values of the structure.

The seismic assessment of heritage buildings still faces many difficulties due to the intrinsic complexity of their mate and overall organization. Masonry is indeed a very complex material due to its composite character and non-tension resisting nature. Moreover, masonry may show significant variation and large scattering across a single structure. In spite of very significant developments, the description of masonry response by means of efficient computer models still deserves significant attention and research effort. The geometry of many historical structures shows large complexity due to the presence of curved 2D or 3D elements and the multiplicity of parts composing them. Determining the internal morphology of structural members such as piers or walls without causing unacceptable damage to them constitutes yet another challenge that is today addressed by advanced non-destructive inspection technologies. Accurate identification and modelling of construction details poses significant difficulties because of the complex mechanical and contact phenomena that may be involved. Due to all these difficulties, the study of a historical structure is often hindered by insufficient information. The resulting engineering problem is often characterized by very limited data in comparison with the complexity involved.

Notwithstanding these difficulties, continuous technical developments are actually giving place to an enhanced protection of heritage buildings. Progress in structural analysis methods and inspection technologies is allowing a more accurate structural verification and a more definite identification of the intervention needs. In turn, innovative retrofitting techniques allow more efficient and respectful interventions.

The varied contributions of this book are fully aligned with this vision. The book displays a general view of the present state-of-the-art and the more recent developments relevant to the seismic assessment of historical structures. Among the different subjects examined are the analysis of the structural vulnerability of different structural types (colonnades, churches, towers), the vulnerability and protection of
city centers, the non-destructive testing technologies, the numerical modelling and structural verification methods, the seismic intervention strategies and the innovative strengthening materials and techniques. The current state-of-the-art in structural verification and retrofitting is also illustrated through the discussion of a set of emblematic case studies. Given the information provided on both recent research findings and practical realizations, it is expected that the book will actually assist in the study and seismic protection of historical structures and monuments.

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