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EDITORIAL

Special issue on "existing timber structures"

Timber structures are an important part of the Architectural and Cultural Heritage. Therefore, any action concerning the conservation, repair, retrofit, and monitoring of the built heritage cannot prescind from understanding how timber structures behave from the material level to the whole structure. The selection of manuscripts included in this special issue aims at supplementing the existing knowledge on the topic. The articles cover a wide variety of aspects, from the material assessment and structural analysis to the design and evaluation of retrofit strategies.

In order to promote the preservation of the cultural heritage by favoring minimal-impact restoration strategies, it is very important to know how the structures were originally supposed to behave. To this regard Tardini (2018) presents an interesting review on the evolution process undergone by design principles for timber elements, from heuristic rules and geometric proportions to scientific-based criteria. A particularly important role in this process to which contributed people of the caliber of Andrea Palladio, Galileo Galilei, and Claude-Louis Navier, just to name a few, was played by Pierre Bullet's table as clearly evidenced in the article.

A large portion of the timber-built heritage is composed of the roofs and diaphragms present in unreinforced masonry buildings that include an extremely wide range of typologies, differing from each other in many aspects such as the layout and arrangement of the components, the type of decking, framing system and carpentry joints. Faggiano et al. (2018) present an inventory of roof and floor structural typologies used in monumental heritage buildings by referring to the iconic case-study of the Royal Palace of Naples built in the 17th century. Ten hall rooms have been analyzed by the authors, focusing on six roof types and three floor types. Blaha et al. (2018) report a peculiar example of cultural contamination regarding timber roof structures in Czech Republic. The authors studied the unique case of a building in Prague where the original Gothic roof was replaced with an Italian Baroque roof (by architect Martino Allio in 1685). The comparison of the Gothic roof and the Italian Baroque roof to a typical Czech Baroque roof resulted in some very interesting findings.

It appears evident that the possible scenarios when intervening on timber-built heritage are potentially countless. Therefore, in addition to being effective and reliable, assessment procedures and analysis models need to be characterized by simplicity and versatility. In the article by Bertolini Cestari and Marzi (2018), a multi-disciplinary analysis of the issues related to the conservation of heritage timber roof structures is presented. The authors' considerations and remarks stem from the experience acquired during thirty years of working on research projects. Ten case-studies located in northern Italy (five of which are included on the UNESCO World Heritage List) are analyzed to support the authors' point of view. Mosoarka and Keller (2018) present instead a new procedure for the assessment of historic timber roof structures. The methodology relies on a multi-disciplinary and transdisciplinary approach that, in addition to providing a cost-effective condition assessment, aims at regulating future interventions based on a priority list. Macchioni and Mannucci (2018) focused their attention on the "*triangular truss*" which is the most representative structural assemblage of historical roofs in Italy. The article, after a thorough description of the most common features of the Italian trusses, analyses in detail all the aspects of the assessment procedure, from the viewpoint of the wood technologist. The discussion is further developed by addressing some case studies. Sousa and Neves (2018) investigated the application of structural reliability concepts to existing timber structures. Traditional semi-probabilistic methods usually adopted for the design of new structures are compared with probabilistic methods. For a better understanding, the target reliability indexes, defined by the authors by balancing costs and hazards, are illustrated by using a case study.

Reliable and effective assessment/intervention procedures can only stem from accurate knowledge of the mechanical behavior of the various components. To this extent, invaluable insight is certainly provided by experimental testing performed both onsite and in laboratory. Branco et al. (2018) performed onsite

testing on an existing traditional *queen post truss*. The main goal of the study was to investigate the behavior of the timber truss under different vertical loading conditions Amorim et al. (2018) studied the in-plane behaviour of on Portuguese traditional *tabique* walls, where the wooden bone-structure made of horizontal laths nailed to vertical boards is covered by plaster or mud. The outcome from both monotonic and cyclic testing is reported in the article.

Several of the research works reported in the articles presented herein are devoted to the analysis and evaluation of strengthening methods. Kunecký et al. (2018) concentrated their attention on the suitability of using "all-wooden" scarf joints for the retrofit (e.g., by replacing excessively decayed element portions with new material) of historical timber structures in Central Europe. Stiffness and capacity of the scarf joints is analyzed, together with possible alterations of the force distribution within the structural elements. Similarly to Kunecky et al. (2018), Fajman and Maca (2018) studied scarf joints used in the renovation of roof trusses. The effects on the retrofitted structure produced by the shape of the joint and the type/number of connectors have been carefully analyzed. A simplified analytical model predicting the joint behavior is also proposed by the authors. In the work presented by Lima et al. (2018), strengthening solutions aimed at improving the flexural behavior of timber elements by relying on externally induced stress states are investigated. Specifically, three solutions (that are based on the use of steel plates, steel rebars, and steel cables) have been tested and presented as an alternative to the pre-stressed cable technique reported in literature. In the last decade, timber-to-timber solutions for improving the out-of-plane performance of timber floors has gained support among researchers, with several examples in literature of diaphragms retrofitted with timber slabs (made from either CLT or Glulam) fixed to the joists to create a composite structure. In Roensmaens et al. (2018), a variation of the technique is presented and analyzed. The floor bending stiffness is maximized by inserting an additional layer of timber blocks between the CLT slab and the existing joists. Shear force transfer between the blocks and the joists is ensured by inclined screws that behave similarly to the diagonal elements in a Pratt truss. The goal of the research work by Latteur et al. (2018) is the proposal of a graphical tool for the assessment of existing timber structures. Ultimate and serviceability limit state criteria are reformulated by referring to a single dimensionless parameter Z_d that can be represented through the Z_d *curves* function of the element geometry. The application of the method is illustrated within the article by adopting a simple supported beam as an example.

The topics addressed by the articles contained in the present issue are not limited to European construction techniques. In fact, two articles deal with the seismic behavior of the Dieh-Dou system, a frame-based system that was widely used for the construction of historic timber structures present in East Asia. In the Dieh-Dou system, a complex timber bracket system known as Dou-Gon, transfers the heavy-roof load to the column and helps engage the column restoring action (column rocking response) and dissipate energy (due to sliding of the wood surfaces and local wood crushing) when the structure is subjected to lateral loading. Beam-column carpentry connections also contribute to determine the earthquake response in the Dieh-Dou system. Yeo et al. (2018) carried out an experimental campaign on three full-scale specimens whose design reproduce an existing traditional Dieh-Dou timber frame that was once part of the Entrance Hall of the Chung Family Ancestral Hall, at Ping-tung County, in southern Taiwan. Based on the outcomes of the testing, a new theoretical model was proposed by the authors to predict the global behavior of Dieh-Dou frames. Xie et al. (2018) presented a study aimed at enhancing the seismic performance of the base Dou by replacing the traditional wood peg connecting the Dou to the column with super-elastic alloy and high strength steel bars. The outcome of an experimental campaign performed on the base Dou system that reproduces an ancient structure in Sichuan Province, in China, is reported by the authors.

The variety of aspects analyzed by the articles described in the previous paragraphs, as well as their geographical provenance, are emblematic of an increasingly widespread interest of the scientific community to timber-related issues, which matches the growing attention shown by practitioners from many countries around the World. The invited editors strongly believe that the topics covered by the articles included in this themed issue will be of sure interest to the readers of the *International Journal of Architectural Heritage*.

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