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Remarkable historic timber roofs. Knowledge and conservation practice. PART 2 - Investigation, analysis, and interventions

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Cover illustration: Auxiliary truss for the strengthening of the roof of San Giovanni Battista church (architectural design by P. Castelnovi, structural design by E. Zamperini with the collaboration of G. Sacco), Borno, Brescia, Italy, 1771-81/2020 by E. Zamperini. © Emanuele Zamperini (2020)

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EDITORIAL
REMARKABLE HISTORIC TIMBER ROOFS. KNOWLEDGE AND CONSERVATION PRACTICE
Part 2 - Investigation, analysis, and interventions

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Following the first volume – published in November 2022 – which contains the contributions on construction history, this second volume of the TEMA special issue on remarkable historic timber roofs is focused on investigations, analyses, and interventions for preservation.

The topic in question has been the subject of an impressive growth of interest in recent decades, consequent to a significant change in the approach to the material authenticity of architecture. The theories of restoration inspired by neo-idealistic or phenomenological philosophy – prevailing at least until the early 1980s – gave an absolute pre-eminence to the image of architecture, to the detriment of its material consistency, especially with reference to all those parts – such as usually happens to the timber roofs – which are hidden from view.

Still in the year 1990, Roberto Di Stefano – an authoritative Italian professor of architectural restoration, at the time president of ICOMOS (International Council on Monuments and Sites) – in his book on structural strengthening for restoration [1], cited as a virtuous example of restoration the complete demolition of the 14th-century timber roof of the Cathedral of Naples. In line with the aforementioned theories of restoration, the roof replacement with steel trusses carried out between 1969 and 1972 was declared admissible because the wooden structures «did not interest the interior architectural spaces».

However, as early as the 1970s, innovative intervention techniques for the restoration of timber structures had begun to be elaborated: both punctual interventions for the reintegration of decayed wood [2–3] and interventions for the strengthening of beams, trusses [4–5], or structural complexes. Whether they were interventions based on the use of innovative materials (e.g., prostheses made with the use of synthetic resins and composite materials) or the rediscovery and reinterpretation of historical techniques (e.g., the trussed beam [6]), they required laboratory and in situ analyses to evaluate their effectiveness. These studies launched a new research sector that could make use of the recent progress of the investigations on newly produced wooden elements for structural use, which in those years were advancing due to the requests connected to the new methods of assessing the safety of the structures.

In 1975, ICOMOS established its International Wood Committee, which has organized a series of international symposia. More recently, other international conferences have been held, like the one organized in Florence in February 2005 on Conservation of Historic Wooden Structures and the SHATIS series (Structural Health Assessment of Timber Structures), which since 2011 have usually taken place every two years.

From a technical point of view, the progressive increase of interest in existing timber structures, the accumulation of a significant amount of research, and international collaboration have led to the affirmation of reliable investigation methods and the drafting of a European standard containing guidelines for the on-site assessment of timber structures (EN 17121:2019). From a cultural point of view, in October 1999 – during the *12th General Assembly* of the ICOMOS held in Mexico City – the extension of interest in wooden structures heritage led to the adoption of a document drafted by the ICOMOS International Wood Committee (chaired by the late Gennaro Tampone between 2005 and 2016), entitled *Principles for the preservation of historic timber structures*. In December 2017, thanks to the contin-

uous attention to the theme, the document was updated – with the new title *Principles for the conservation of wooden built heritage* – and adopted by ICOMOS at the *19th General* Assembly held in Delhi (India).

While having a significant function in disseminating culturally and methodologically valid approaches, these international documents – as all other restoration charters – are not exempt from accusations of cultural relativism: being written as a methodological tool to be used throughout the world, they do not take a clear-cut position on the intervention philosophy underlying the restoration or reinforcement works.

Indeed, if the investigation techniques are usually perceived as characterized by certain technical-scientific objectivity and the controversies on the preference to be attributed to one or another are limited to the diagnostic experts, the restoration and strengthening interventions are often the subject of lively discussions. These debates rise between two different – in some ways opposite – points of view on restoration. On one side, those who consider it more important to preserve the conception and behavior of the roof structure unaltered, even at the cost of partially sacrificing its material authenticity (among them, in Italy, we can mention Franco Laner). On the other side, there are those who, instead, believe that the material constituting the structure is the only guarantee of its authenticity and must therefore be preserved in its entirety, even when partially decayed (among these, we cannot forget the aforementioned Gennaro Tampone). The latter approach brings about the consequent need to modify the structural behavior of the existing structure with the addition of all those elements that are necessary to obviate its shortcomings.

Far from proposing a unified vision or an overall picture of the subject, this special issue of the scientific journal TEMA intends to propose a series of interesting studies on investigations, analyses, and interventions for the preservation of timber structures.

The article by Martina Diaz, Louis Vandenabeele, and Stefan Holzer offers the report of an articulated system of investigations on the timber domes of the Basilica of St. Anthony in Padua, which passes from an extensive geometrical survey of the entire church (carried out with laser scanning of the whole building and traditional hand-measurements of joints, repairs and other traces), to laboratory analyses, to a thorough examination of historical documentary sources. The investigations carried out make it possible to reconstruct the events relating to the construction and restoration of the wooden structures of the domes, also in relation to the underlying masonry structures and the more general technical and economic context of the region, and to provide a fundamental contribution for future preservation and strengthening works.

Davide Prati, Angelo Massafra, and Luca Guardigli present some conclusions they have been able to draw from research they have been carrying out for years on wide-span timber trusses in the area of Bologna. Also, in this case, the starting point is an accurate digital survey (made with a laser scanner) integrated by the in situ collection of other geometric and construction data and by the archival investigation. Thanks to 3D parametric modelling software, they could elaborate a series of analyses on the deformations of the timber trusses and then draw considerations on their stability in and out of the plane. The comparison of the various case studies also allowed them to reflect on the relationship between the geometric proportions of the structures and their structural efficiency.

Paolo Vannucci instead offers us an interesting study on the static behaviour of the Gothic age timber roof structures in France; starting from a static analysis of the roof of the church of Notre-Dame in Paris – tragically destroyed by the fire of 2019 – he elaborates some hypotheses on how medieval carpenters conceived the three-dimensional structural behaviour of the large timber roofing complexes built according to the so-called *chevrons formant ferme* system.

A series of articles proposes projects for the strengthening of specific timber roof structures, some of which have already been concretely realized. All these studies present a correct methodology which starts from the integration of the results of the historical study, of the geometric survey – as accurate as possible in relation to the concrete situation of the places before the intervention – of the recognition of the wood species, of the estimation of the material strength and decay, in order to define the most suitable preservation and reinforce-

ment interventions. These articles are particularly interesting due to the variety of the investigation techniques used and – most of all – in relation to the construction types of the analyzed buildings and their histories, from which the variety and specificity of intervention techniques follow.

Lia Ferrari presents the case study of the 16th-century Palazzo Costabili in Ferrara (Emilia-Romagna, Italy). It is a large palace whose uncommon roof structures are the expression of local building techniques. The presence of strengthening interventions carried out at the end of the 1990s – that the author studied thanks to archival documents – and the damages suffered by the building in the 2012 earthquake make the structure even more complex and so its assessment and particularly interesting the designed strengthening intervention.

The article by Marco Zerbinatti, Alessandro Grazzini, Sara Fasana, and Giovanni Vercelli presents the realized strengthening work on the roof of a 16th-century chapel at the Sacro Monte of Orta (Piedmont, Italy), a UNESCO site. The geometric articulation of the chapel's hipped roof and the building stratifications that have occurred over time have determined a complicated structure, a few parts of which were decayed due to fungal attack. The strengthening work described is exemplary of the complexity that even the intervention on a small building can present.

Tanja Marzi, Clara Bertolini-Cestari, and Olivia Pignatelli wrote about the case study of diagnosis, dendrochronological dating, and strengthening intervention on the roof of the 16th-century church of San Giovanni Battista in Salbertrand (Piedmont, Italy). One aspect on which the authors focus their attention is that knowledge of historical construction techniques can be an important source for drawing inspiration for the development of intervention techniques. Indeed, the technique used for the strengthening of the ridge beam of the church is the trussed beam invented by Poloncceau (1839) and described together with its variations by the handbook authors at least until the beginning of the 20th century. Since then, it gradually fell into oblivion with the extensive diffusion of steel and reinforced concrete structures. The investigations described in the article were carried out in the late 1990s and the strengthening works in the early 2000s; far from being a negative point, this allowed the authors to critically evaluate the diagnostic operations carried out more than twenty years ago, verifying their persistent methodological validity – despite the obsolescence of some of the instruments and techniques used – and to test the effectiveness of the strengthening techniques used over time.

The research presented by Marta Casanova, Stefano Musso, and Stefano Podestà in their article deals with the investigation, analysis, and project for the restoration of the roof structure of a part of the Albergo dei Poveri in Genoa. This part of the building – the men's oratory – is particularly interesting due to the simultaneous presence of masonry arches and timber structures supporting a vault made of plastered reed mats. The knowledge of this vault's construction technique – very problematic due to the inaccessibility of the attic – was obtained thanks to thermography and taking advantage of the holes in the vault caused by the collapse of small portions of the reed mats. The proposed reinforcement project starts from the deficiencies and vulnerabilities highlighted by the investigations – particularly the poor reliability of the connection between reed mats and superior structures – and is based on the principle of minimum intervention.

The contribution written by Jorge Branco, Filipa Serino, Eleftheria Tsakanika, and Paulo Lourenço is an interesting and systematic review, although non-all-encompassing, given the limited space available, about the reinforcement methodologies for timber elements in historic roofs.

The positive picture shown in this special issue could lead to being overly optimistic about the future of historic timber roof structures: the real challenge for the future is to move from scientific research and a design activity conducted by a few specialized professionals – mostly linked to the academic world – to the reality of current professional practice. This can only happen through an improved connection between university and extra-university teaching activities in the sector of historic timber structures, which – at least in Italy – are still largely neglected in academic course programs in favour of masonry, reinforced concrete and steel structures.

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