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## Review

# Assessment of heritage timber structures: Review of standards, guidelines and procedures

Mariapaola Riggio<sup>a,\*</sup>, Dina D'Ayala<sup>b</sup>, Maria Adelaide Parisi<sup>c</sup>, Chiara Tardini<sup>c</sup>

<sup>a</sup> Oregon State University, Department WSE, 236 Richardson Hall, Corvallis, OR 97331, United States

<sup>b</sup> University College London, Department CEGE, G16b UCL Chadwick Building, Gower Street, London WC1E 6BT, UK

<sup>c</sup> Politecnico di Milano, Department ABC, Piazza Leonardo da Vinci, 32, 20133 Milano, Italy

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## ABSTRACT

This paper reviews the official documentation (standards, guidelines and procedures) available for the assessment of heritage timber structures. The subsequent discussion does not catalogue all relevant technical literature. Instead, it intends to convey the state of background knowledge, recommendations and code rules using some illustrative examples. A specific focus is given to visual inspection as a fundamental first step for all different scopes and levels of assessment. The objectives of this review are to: (1) highlight the gaps and limitations in the currently available tools as well as the need for standardization; (2) contribute to the definition of an ontological approach, relating the scope of the assessment, information required and necessary procedures, (3) identify guidance for the different scopes of the assessment. The variety of timber species, architectural typologies and structural solutions, together with the varied response of these structures to climatic and other natural and man-made hazards, warrant a multifaceted and integrated assessment methodology that accounts for the hierarchical nature of timber structures behaviour and the multitude of agents affecting such behaviour. A review of existing standards and guidelines illustrates the need for a tool to consistently record the assessment process and the final decision taken, which will serve to constitute the knowledge base for the development of the next generation of more integrated and heritage specific guidelines.

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## 1. Introduction

Timber is one of the oldest building materials; heritage timber structures are witnesses to a rich tradition of craftsmanship, structural and material knowledge, and sustainable practices (e.g., Fig. 1).

The ability to conduct an assessment of the condition of heritage timber structures mandates a deep understanding of their past and current states, including aspects of their conservation, maintenance and use. The motivations for conducting such an assessment can be very diverse. For example, assessment might be required to produce accurate documentation of the structure in order that it be archived for future memory and conservation, or the collection of data from a number of different structures may be aimed at creating the knowledge base for a particular timber construction type.

Structural assessment is also the first step towards an intervention that might itself range from mere preservation of an artistic artifact to the full rehabilitation of a structural function, in order to preserve it or adapt it for future use. Each of these situations brings along with it specific needs and formal requirements. While in principle such requirements are not different from those connoted with traditional or historic structures made of other materials [1–3], there are factors specific to timber structures, or of primary importance for the understanding of their behavior, which make their assessment a complex and distinct operation. Such factors are all fundamentally related to the organic nature of timber, as opposed to other construction materials, and while diverse, they are all strictly interdependent in their effect on the structural response of timber structures. For example, material properties and conditions of timber are strongly depend on biological factors and are highly variable. Thus, carpentry evolved first on the basis of intuition, and eventually on heuristic and empirical rules, all while depending significantly on region and individual carpenters' knowledge and workmanship. Finally, a timber structure is highly affected by the internal and external environmental conditions it is subjugated to; hence, its hygrothermal loading history, which is highly dependent

\* Corresponding author.

E-mail addresses: [mariapaola.riggio@oregonstate.edu](mailto:mariapaola.riggio@oregonstate.edu) (M. Riggio), [d.dayala@ucl.ac.uk](mailto:d.dayala@ucl.ac.uk) (D. D'Ayala), [maria.parisi@polimi.it](mailto:maria.parisi@polimi.it) (M.A. Parisi), [chiara.tardini@polimi.it](mailto:chiara.tardini@polimi.it) (C. Tardini).



Fig. 1. Examples of heritage timber structures. Prinkipo Palace (Büyükkada, Turkey, 1903) – upper panel – Church of the Guardian Angels (Fermo, Italy, 1871. Arch. G. B. Carducci) – lower panel.

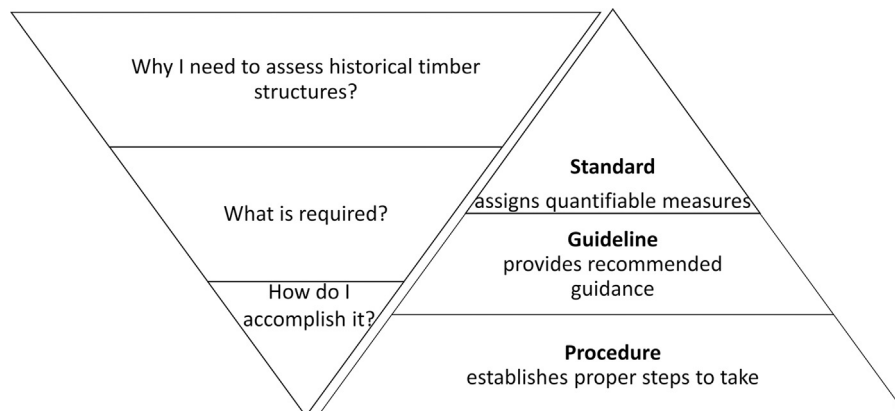


Fig. 2. Hierarchical levels of the decision-making and operational process.

on user habit and local climate, has a fundamental effect on its structural health.

Due to these complexities, a range of experts is generally needed to carry out a thorough assessment of an historic timber structure, encompassing the fields of wood science and technology, structural engineering, architecture, conservation, among others. The availability of assessment and decision tools based on a common ontology, providing a unique, unambiguous and unanimous way of reporting observations and assessment, forms an essential requirement for effective communication and sharing of information in such multidisciplinary teams.

This paper presents a review of methodological, normative and operational tools, which provide the professional knowledge framework, which should underpin such decisional tools.

The aims of this review are to:

- highlight the gaps and limitations in the currently available tools as well as the need for standardization;

- propose an ontological approach, which relates scope of the assessment, information required and necessary procedures;
- identify guidance available for experts for the different scopes of the assessment.

Fig. 2 highlights the relationship between the proposed ontology and the hierarchical framework that regulates the field of structural assessment, broadly corresponding to the hierarchical levels of both the decision-making and the operational process. This same structure is reflected in the organization given to the review carried out in this manuscript. To better qualify and clarify what is intended for each of the levels in the outlined hierarchy, the corresponding definitions provided by the Merriam-Webster dictionary can be taken as reference: a standard [4] is defined as “something established by authority (...) as a model (...)”, “with quantifiable low level mandatory controls”; a guideline [5] is “a rule or instruction that shows or tells how something should be done”; a procedure [6] is referred as “a series of actions that are

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