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RILEM Technical Committee on In-Situ Assessment of Structural Timber

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Abstract Timber is an intriguing structural material and the only one that is truly renewable. Being biodegradable, hygroscopic and non-isotropic, it presents special challenges when assessing its integrity in structures. The presented paper outlines the major issues related to in-situ evaluation of structural timber and summarizes the work of the RILEM Technical Committee 215-AST "In-situ assessment of structural timber". The committee was established in 2005 to bring together leading scientists and practitioners in the field of evaluation of timber in existing structures. Timber structures have been investigated for decades using numerous techniques that have been either developed specifically for the material or were transferred from other fields of investigation. A state-of-the-art report describing existing and emerging technologies and methods was prepared by the RILEM committee. The report describes the principles, the applications and the limitations of major evaluation techniques for in-situ assessment of timber. A brief discussion of codes standards and future research needs shows that much needs to be done in this area. As a present activity, harmonized test procedure recommendations are being prepared that will provide the engineering community with valuable guidance when evaluating timber structures.

Keywords: Timber structure, in-situ assessment, non-destructive, semi-destructive-technique

Introduction

Timber structures have been evaluated for decades since they are a significant part of cultural heritage and the need for their preservation is increasingly significant; furthermore, timber becomes an increasingly important structural material due to its renewability and economics. Timber is probably the most complex structural material; the large number of timber structures or components in historical buildings indicates the need for a systematic approach to their structural evaluation.

Quality assessment begins with the assessment of the members and components that make up the structure as a whole by means of a visual inspection where naturally occurring characteristics such as knots, slope of grain, seasoning checks and signs of deterioration including damage from insect infestation or fungal decay and potential damage due to progressive failure are recorded. Following the visual inspection, in situ grading provides a structural grade based on the size, number and location of growth characteristics according to the member's size and structural use.

The need for structural assessment arises from multiple motivations such as performance reports to address structural adequacy, historic preservation and change of building use. The time and cost spent on inspections is justified with the safety gained, the protection of capital investments and minimizing the structural maintenance.

For historic structures, quality assessments of members allow for the maximum retention of original material, which is often required by heritage regulations, since the preservation of original construction conserves the cultural significance of the building. Gaining additional understanding of building material durability, behavior and use, as well as building techniques and craftsmanship from existing structures provides knowledge that can be applied to present-day construction. For all these purposes, the Rilem technical committee AST 215 was established in 2005. The paper gives an update on the activities of the committee and the application of assessment methods.

Description of the Rilem TC AST

The RILEM technical committee AST 215 deals with the in-situ assessment of timber structural members and the evaluation of their physical and mechanical material characteristics [rilem.net 2010]. The physical properties include the species, size, grain orientation, age, moisture content, density and deterioration. The mechanical properties entail strength and elasticity parameters. The target phenomena that are studied include life expectancy, failure probability and durability of timber structures. Experimental studies include the validation of non-destructive-testing (NDT) and semi-destructive-testing (SDT) methods based on case studies where these methods are applied. The accompanying theoretical studies focus on the reliability of the NDT, SDT and their combination with destructive techniques.

Working Program

The working program of the TC includes annual committee meetings, the elaboration of joint publications and the organization of international workshops. One research and education workshop "In-situ Evaluation of Masonry and Wood Historic Structures: Challenges and Opportunities" took place in Prague, Czech Republic, in June 2005; proceedings were published containing recent state-of the-art techniques and discussing education in the above area [Kasal 2009].

A state-of-the-art report dealing with the reliability and predictive power of existing NDT and SDT methods will be published in 2010 [Kasal 2010]. The report describes the principles, applications and limitations of following methods: Stress waves; Ground penetrating radar; Radiography; Resistance drilling; Core-drilling; Shear test of glue lines; Tension micro-specimens; Screw resistance; Hardness test; Moisture measurement; Species identification; and Dendrochronology. The report reflects the current knowledge in the area of in situ assessment of the physical and mechanical properties of timber structures.

A second workshop on "In-situ Evaluation of Timber Structures" will take place in 2010. The workshop is planned for June 2010 at the University of Applied Sciences in Biel, Switzerland. An international evaluation protocol and guidelines for in-situ evaluation of timber structural members will be developed as a final product of the TC 215. A summarizing meeting and workshop, to be held in 2011, possibly in the context of the International Conference on structural health assessment of timber structures (SHATIS) in Lisbon [shatis11.lnec.pt 2010].

The expected achievements of the scientific working plan of the TC are the following:

- A comprehensive literature review on existing assessment methods. This review has been published [Kasal and Anthony 2004]; it did however not include any power-of-prediction analyses.
- Relevant publications reflecting the most recent state-of-the art developments. The state-of-the-art report dealing will be published in 2010.
- Harmonized test recommendations for the individual methods will be proposed.
- International collaboration on in-situ investigation of timber structures. The TC will create a mechanism for exchange of ideas, research data, and new collaborations.
- The TC 215AST will attempt to develop international collaborative research proposals that will be submitted to different funding agencies.
- The TC will involve young investigators and students through individual research programs.

Membership

The Rilem TC AST 215 includes leading experts in the field that encourages close collaboration, which results in joint workshops, case studies and active participation at conferences. Many members have ongoing research programs; in this regard, the TC facilitates stronger research coordination, eliminates duplication and permits faster application of newly developed and

improved NDT and SDT methods. Currently, the Rilem TC AST 215 counts members from Australia, Czech Republic, France, Germany, Hungary, Italy, Japan, Switzerland, and USA. The only active Rilem committee dealing with timber is constantly pushing to extend its membership and to increase collaboration with other research entities.

Conclusions

More research is required to both estimate individual member strengths as well as obtaining accurate quantification of deterioration. The assessment of in situ structural timber members can be improved in two ways: by gaining more accurate estimates of individual member strengths and by better locating and quantifying deterioration.

X-ray and resistance drilling techniques have proven to accurately detect areas of deterioration; these techniques can be improved by enabling to quantify and identify different stages of deterioration. Possibilities for X-ray investigation include the ability to assign different density levels to stages of decay as well as being able to accurately measure areas of reduced density, including those shadowed by sound material.

Quantitative analysis using digital imaging appears to be a promising technique. Low mass density of wood permits easy application of portable, low energy X-rays. Resistance drilling could be improved by addressing the issue of drilling path deviation associated with the flexible needle so that more accurate plots of member cross-sections can be constructed.

The examination of large timber specimens with fast neutron reveals different features, and allows an access through metal shielding, the resulting images, however, are of inferior quality compared to X-ray radiology. Two situations where the application of neutron radiology has been successfully applied are the visualization of low differences in hydrogen content as it occurs in glue-lines and the possibility to view behind a metal shielding.

After extensive research of stress wave techniques, the conclusion was drawn that the relationship between stress wave parameters and timber mechanical properties was not sufficiently developed to accurately predict in situ member strength. Research opportunities lie in finding a method of applying stress wave techniques to in situ members and arriving at reliable estimates of the member's strength.

Improvement of the tensile technique could also be addressed. Correcting equipment details as well as addressing sample size and improvements to the methodology for extracting samples along the grain could result in a more viable technique for establishing tensile strength. Bending strength estimates could then be improved using tensile strength as an estimator instead of core compressive strength.

To improve the assessment of in situ timber members, more research is required to accurately quantify MC changes; moisture induced stresses, as well as their impact on performance. Monitoring the long-term behaviour of timber bridges, damage might be recognized at an early stage and unnecessary decommissions of timber bridges can be avoided. The progress in sensing technologies, material characterization and data processing techniques have resulted in a significant interest in diagnostic tools to monitor structural integrity. These tools need to be adapted to contribute to a broader and safer use of timber for infrastructure projects. New methods are under development and some of the members of the Rilem TC are actively working on these developments. Reliability assessments of these methods or their combinations need to be done.

One goal of the Rilem TC 215 is the development of harmonized test recommendations. This will have an impact on the evaluation of historic structures and decision-making processes in their restoration. It is anticipated that the TC work will lead to better, more comparable and more comprehensive in-situ evaluation of existing structures and their components. This has a profound effect on costs of restoration and rehabilitation of historic buildings in particular. The potential economic impact of harmonized methods to assess the durability of existing structures lies in more precise and reliable evaluation of the infrastructure that will increase public safety and preserve resources through timely interventions.

Acknowledgements

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