HYGROMECHANICAL BEHAVIOUR OF PAINTED WOODEN PANELS FROM THE CULTURAL HERITAGE

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ABSTRACT

Provided it has been properly processed and implemented in structural applications, including protecting against biological attacks and accounting for moisture induced movements, wood is able to withstand considerable duration of loading thanks to its good resistance to fatigue and sophisticated multi-scale composite structure. For that reason, it is still present as the structural element of various types of ancient objects belonging to our cultural heritage, from buildings to painted panels or musical instruments. The requests by conservators to contribute to the maintenance of these old objects offer stimulating challenges to the wood scientists. Long-term creep predictions, essential for the design of wooden structures, would be safely validated when they manage to describe the present state of timber in an old building, while the better understanding of the ageing processes responsible for the sound quality of an old instrument could inspire novel approaches for wood drying and improvement by hygrothermal or chemical modifications.

This paper will focus on the case of wooden panels serving as the support of paintings, that usually require preventive conservation in order to tackle with microclimatic aggressions consecutive to visitors, transportation and generalization of heating and air conditioning. Moisture induced movements of the painted surface might have damaged the painting and tend to detach it for the support, while restrictions imposed by the frames to prevent these movements often provoked major cracks in the wood and the paint. One of the challenges is the explanation of the present state of the observed objects, based on the knowledge of the long term response of a wood part submitted to hypothesized boundary conditions. Another challenge is the prediction of the consequences of a restoration, considered as a modification of these boundary conditions. These questions can be formulated for specific cases, such as highly valuable objects, or in more general terms to evaluate the long term impact of conservation choices.

The wooden support of Mona Lisa, made of a single poplar plate with a pre-existing crack starting from the upper edge, has been previously modelled based on data gathered in October 2004 (fig. 1). The instantaneous response of the panel to the application of the crossbars on the back frame was rather correctly predicted, which

allowed to calculate a release energy rate low enough to guarantee against a short-term risk of propagation of the crack [1]. On the other hand, a separate simulation of the effect of hygrothermal fluctuations considerably overestimated the predicted deflections [2] compared to the measured values using a continuous monitoring of the panel [3]. Several explanations could be given to that discrepancy: partial permeability of the painted face, that would reduce the asymmetry of the moisture exchanged responsible for the curvature variations; adsorption/desorption hysteresis reducing the moisture content variations resulting from the microclimatic fluctuations; damage heterogeneity of the panel due to thickness gradients of hygromechanical loading history; dominance of longitudinal stresses induced by the frame restraint at the upper and lower edges; ageing of the material resulting in slower transfer or significantly smaller hygroexpansion ratios – or a combination of these various factors. Using additional data gathered on the same and other historical panels located in various museums or churches (fig. 2), as well as from tests on mock-up panels or clear wood specimens, some new analysis will be proposed with the objective of validating a predictive model that could be used to optimise the boundary conditions to apply to a painting and assess the risk associated with microclimatic changes for given panel configuration.
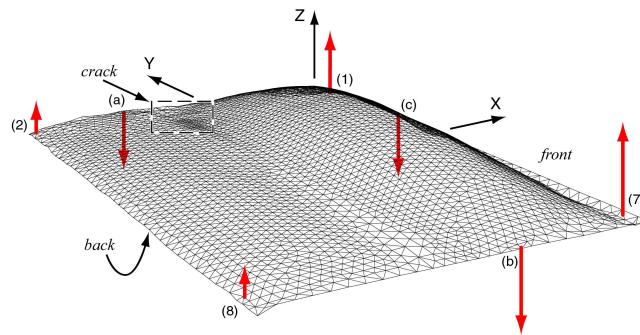

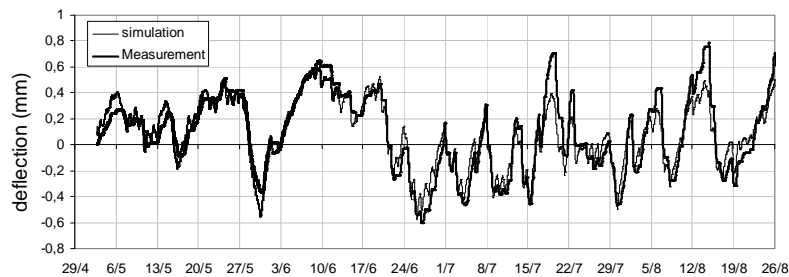Fig. 1: 2D Finite elements mesh of the Mona Lisa wooden support and applied boundary conditions

Fig 2. Comparison between in-situ measurement of a panel deflection and a simulation using TransPore 1D software developed by P. PERRÉ, Lermab, Nancy (FR).

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