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Code coupling for thermo-hygro-mechanical problems with application to wooden structures and painting supports of cultural heritage

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Painted wood panels of cultural heritage (furnitures, musical instruments, paintings...) are often sensitive to several loadings such as mechanical restraint, as well as humidity and temperature cycles due to the hygrothermal variations of the surrounding environment [1]. To improve preventive conservation and to guide restoration acts on wooden artworks, virtual testing via numerical simulation is necessary to assess a risk analysis, in order to predict if the object will remain safe under various scenarii.

We focus herein on a numerical strategy, belonging to the family of partitioning schemes, to solve the coupled problem of thermo-hygro-mechanical response of wood structures. Wood material is sensitive to moisture, and this dependency is itself influenced with the temperature.

An example of a rheological model (depending on moisture and temperature) is illustrated on Figure 1: it is an orthotropic Generalized Kelvin-Voith (GKV) model with several stages: elastic (e), swelling/shrinkage (rg), mechano-sorptive (ms), and two visco-elastic stages (v).

A typical numerical response of a painted panel (here *Mona Lisa* [2, 3]), when subjected to a variation in relative humidity of the environment is depicted in Figure 2, as the evolution of the central deflection of the panel.

A dedicated code is used for thermal and moisture transfer, while a structural code is used for the mechanical response. With the modularity of a partitioning scheme, the code coupling is used with minimized intrusion, when compared to monolithic codes.

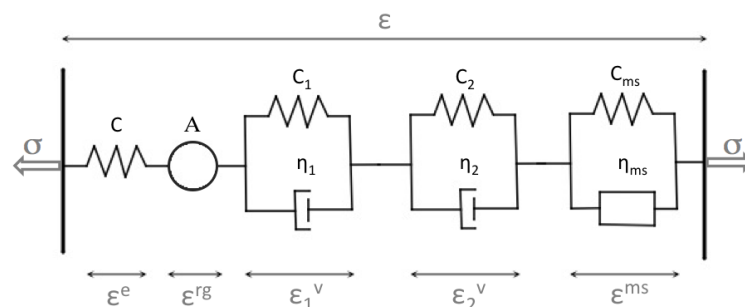


Figure 1: Example of a suited rheological model for the application of painted wood panels

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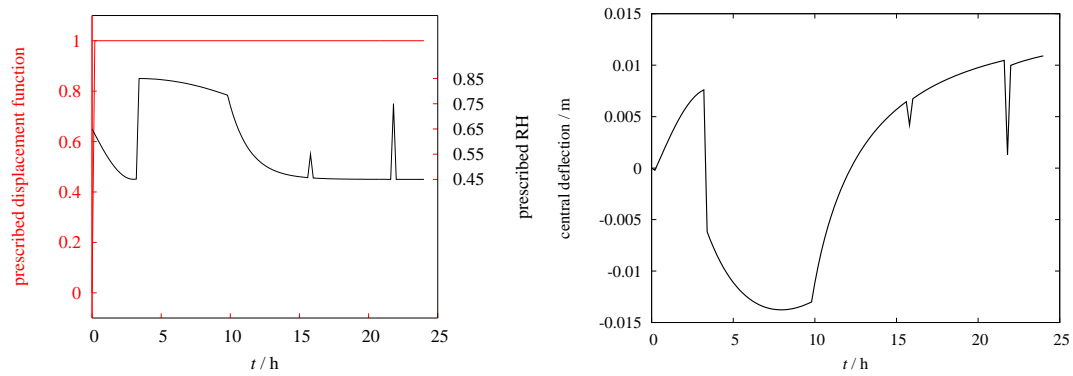


Figure 2: Loading on a painted panel (RH variations, left) and panel response (central deflection, right)

- [2] D. Dureisseix, J. Gril, and O. Arnould. Mechanical modeling of the activity of the flexible frame. In J.-P. Mohen, M. Menu, and B. Mottin, editors, *Mona Lisa, inside the painting*, chapter II.6. Abrams, New York, 2006.
- [3] B. Marcon. *Hygromécanique des panneaux en bois et conservation du patrimoine culturel*. PhD thesis, University Montpellier 2, Università degli studi di Firenze, 2009.