

# Modelling the time-dependent behaviour of wood

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*This presentation will be dedicated to the memory of David Hunt (1930-2016), who made very significant contributions to the understanding of time-dependent phenomena in wood.*

As a hygroscopic polymer wood displays a viscoelastic behaviour strongly influenced by temperature and humidity. The time-dependency of its response to a mechanical loading results from the delayed movements of molecular components under stress, as much as from the kinetics of the sorption process or any other chemical reaction modifying the molecular structure. Mechanosorption is a typical example of such complex interaction. It refers to the phenomena observed when wood is subjected simultaneously to mechanical loading and sorption resulting from changing hygrothermal conditions. The difference between the observed response and that expected from viscoelastic data at constant moisture content (m.c.) (e.g., creep or relaxation) is defined as the mechanosorptive response – although the evaluation of that “expected” response is not straightforward\*. Mechanosorption has been commonly modelled as a time-independent process, only governed by variations of the moisture content. This hypothesis is not easily verified due to the time-dependency of the sorption process, and it seems to be in contradiction with observations that it triggers viscoelastic processes. The large dominance of mechanosorptive over constant-humidity creep is another belief that needs to be put in perspective: it depends on the reference being the dry or wet state [1].

Based on the work of Ranta-Maunus in the 70ties m.s. was initially modelled using viscous-like elements where time is replaced by m.c., distinguishing desorption (-), adsorption (+) and ‘adsorption above highest level reached since loading’ (++)). Hunt in the 80ties introduced the m.s. ‘trajectories’ where the creep compliance is plotted against m.c., and the concept of ‘creep limit’ reached after repeated humidity cycles under load (Fig. 1a-d). He proposed that the creep limit is approached both in sorption and desorption, and explained the apparent recovery during adsorption as moisture expansion modified by strain [2]. This led to rheological models based on combinations of “m.s. dashpots” and springs, commonly used in numerical developments, with viscoelastic components modelled separately. It was also assumed by Matar [3], as a conservative hypothesis, when he derived equations of the long-term creep of softwood as a function of wood quality, in view of improved evaluation of Kdef factor in Eurocode5 (Fig. 1e).

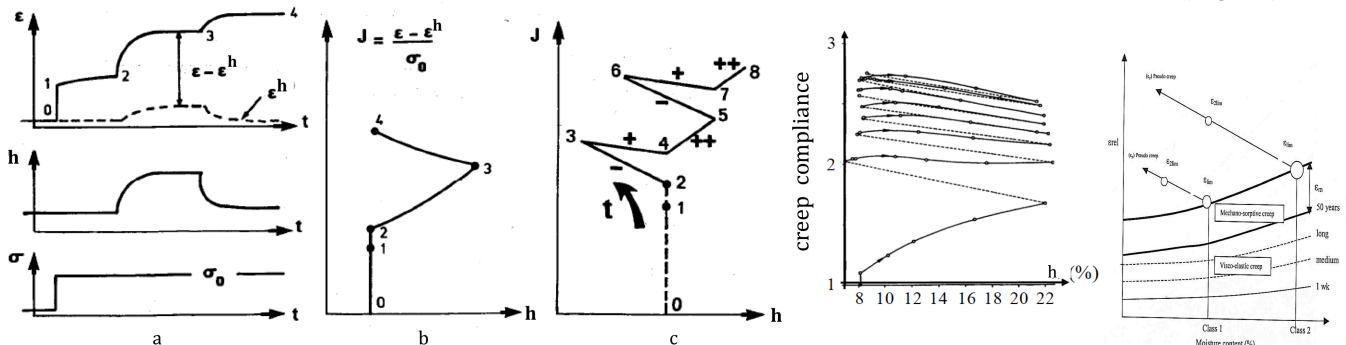


Fig. 1: Construction of mechano-sorptive trajectories: (a) Humidity cycle under constant load; (b) Corresponding trajectory; (c) Representation of Ranta-Maunus model; (d) effect of repeated cycles under load according to Hunt (1992), showing the apparent creep/recovery at the creep limit explained by a modified hygroscopic expansion; (e) Creep prediction combining creep at given m.c., m.s. creep and pseudo-creep/recovery according to Matar (2003).

\* “Hygro-locks” is a convenient way to evaluate the “expected viscoelastic response” needed to define, by difference, the m.s. contribution. A hygrolock spring extends when loaded under wetting and does not under drying, and can be combined with dashpots to fit any viscoelastic spectra obtained at different m.c. levels [4]. An equivalent formulation was proposed by Colmars [5] to avoid excessive memory storage in long-term simulations.

## References

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