Wood dimensional changes as consequence of its hygroscopic behavior

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Key words: hygroscopic, wood, experimental evaluation, dimensional changes

ABSTRACT

Wood has a strong hygroscopic behavior, with a huge variation of moisture content and dimension stability caused by modifications of the relative humidity and temperature of the surrounding air. This moisture relationship has an important influence on wood properties and performance. Many of the challenges of using wood as an engineering material arise from changes in moisture content or an abundance of moisture within the wood. Wood is dimensionally stable when moisture content is greater than the fiber saturation point (MC_{fs}). Below MC_{fs} wood changes dimension as it gains moisture (swells) or loses moisture (shrinks), because volume of the cell wall depends on the amount of bound water [1]. With respect to dimensional stability, wood is an anisotropic material. It shrinks (or swells) most in the direction of the annual growth rings (tangentially), about half as much across the rings (radially), and only slightly along the grain (longitudinally).

In this work, an experimental program was defined with the aim to evaluate the dimensional stability of three coniferous wood species: maritime pine (*Pinus pinaster*), scots pine (*Pinus sylvestris*) and spruce (*Picea abies*). A group of sixty specimens were made of spruce and eighty specimens were considered for the maritime pine and scots pine groups, individually. The experimental procedure consists in the division of each group of specimens into two subgroups, being the specimens of one subgroup saturated and the ones of the second, dried. Then, the specimens of each subgroup were all placed in a climatic chamber with the references conditions of RH = 60% and T=20ºC. As the moisture content of the specimens changed until achieving the hygroscopic equilibrium of the environment, measurements of their dimensions were taken being possible to quantify the dimensional variation suffered during this process. Figure 1 presents the geometry assumed for the specimens based on the [2] recommendations. For the measurements, a dial gauge with a precision of 0.001 mm coupled to a steel base was used (Figure 1).

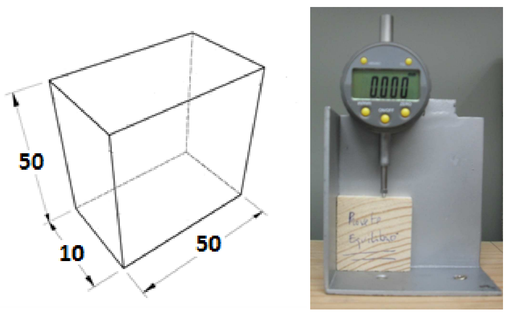

Figure 1: Specimen geometry and test setup used to measure the wood dimensional changes

In each measurement, the moisture content of the wood specimens was measured trough two distinct methods: with a thermo hygrograph and using the oven dry method suggested by [3]. Therefore, it was possible to assess the weight loss of each specimen for the three wood species, Figure 2a, and also to study the reliability of the values of the moisture content measured by the thermo hygrograph. Moreover, it was possible to quantify the equilibrium moisture content (EMC) of each wood species in both situations: desorption and adsorption, Figure 2b.

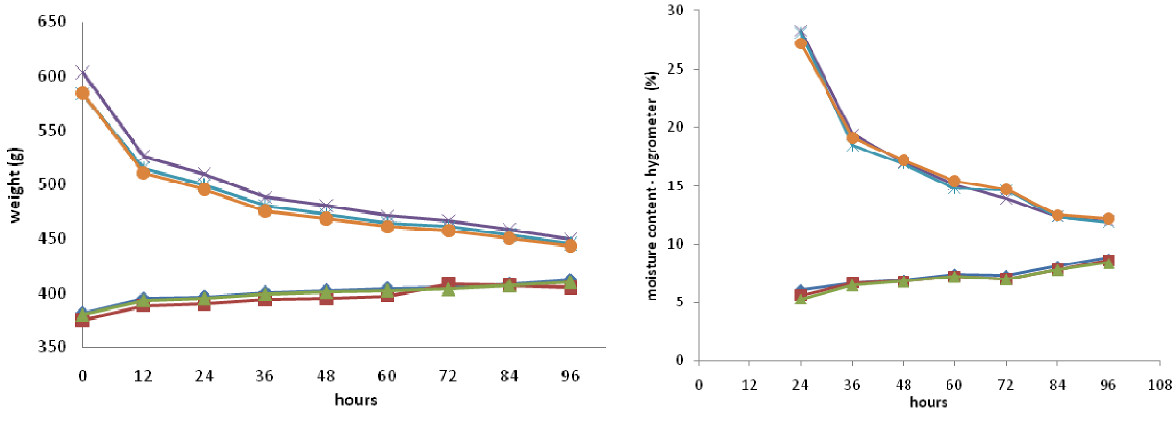

Figure 2: Weight loss (a) and moisture content variation (b) as function of the hours in the climatic chamber

Comparing the wood species, it is the Spruce (A) that presents higher dimensional changes, while it is the Maritime pine (P) that is more stable under moisture content variation. Figure 3 presents the summary of the tests results in terms of percentage of dimensional variation through hours and as function of the moisture content variation. It is important to note that expansion is considered positive. Tests results allow to conclude that the most important dimensional variation occurs in the first 24 hours.

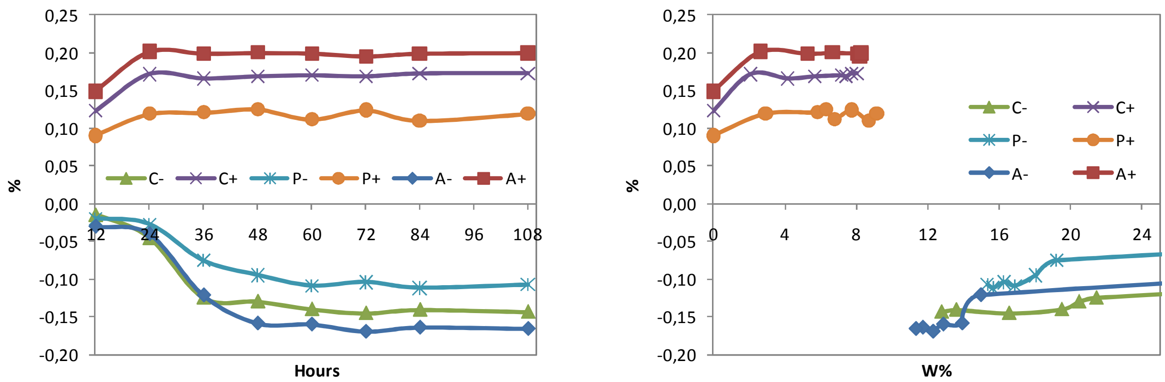

Figure 3: Dimensional changes of the three wood species in function of the time (a) and moisture content (b)

References

[1] Forest Products Laboratory. Wood handbook - Wood as an engineering material. *General Technical Report FPL-GTR-190*. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory: 508 p. 2010.

[2] NP-615:1973. Madeiras — Determinação da retracção.

[3] NP-614:1973. Madeiras — Determinação do teor em água.