

PROCEEDINGS IRF2013

4th International Conference
INTEGRITY-RELIABILITY-FAILURE

U PORTO - U TORONTO - U MADEIRA
Funchal, 23-27 June 2013

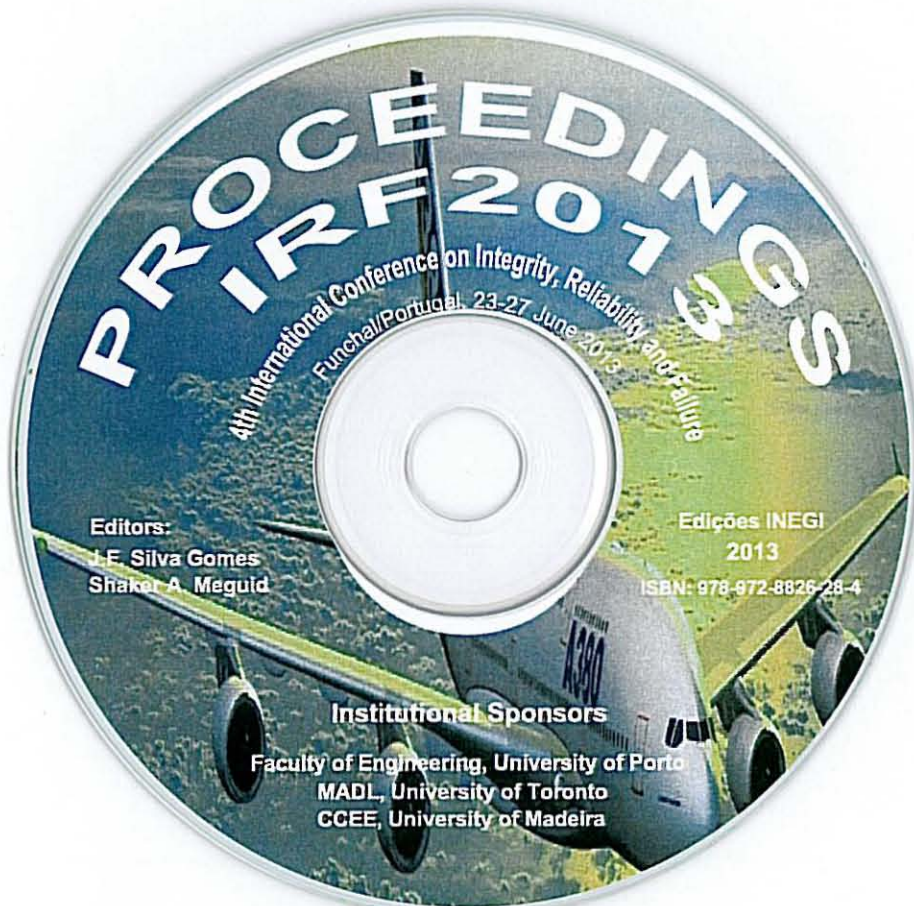
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Edições INEGI
2013

(ISBN 978-972-8826-28-4)

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PAPER REF: 4524

DIMENSIONAL STABILITY OF WOOD IN PRESENCE OF WATER

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ABSTRACT

An experimental program was defined aiming to evaluate the dimensional stability of hardwood and softwood species. The maritime pine softwood (*Pinus pinaster*) and the ash hardwood of the North-east region of Portugal are analysed. A group of thirty specimens were made for each species of wood. The experimental procedure has been conducted according to NP EN 614 and NP EN 615. For each wood species, one half of the specimens were previously dried while the other one half was prior saturated. Two main variables were studied in normal environmental conditions: mass and dimensional variation. Tests were conducted at 20°C environment temperature and 60% of relative humidity. Measurements were taken allowing to quantify the dimensional variation suffered during the dry/saturation process for both species. The properties that define the behaviour of wood against temperature and moisture actions are assessed in this work. Hygroscopicity and shrinkage are given special attention.

Keywords: hygroscopic, shrinkage, experimental evaluation, dimensional changes.

INTRODUCTION

Wood is the most significant raw material. It is important not only because it is used for literally hundreds of products, but also because it is a renewable natural resource. Through a careful and planned use, forests could provide a perpetual supply of wood. All wood in growing trees contains a considerable amount of water due to both photosynthesis and growing processes. This water is commonly called sap. In the wood's drying process after harvest, the removal of free-water occurs first, with no change either in dimension or in physical and mechanical properties. At the state where no free-water is presented in the cell cavity and the cell wall is fully saturated with bounded water, the cell reaches the fibre-saturation point (MCfs). For practical purposes, this level of moisture content is generally considered around 25-30%, but it may be significantly different among wood species, (Simpson et. al., 1999). Wood is dimensionally stable when moisture content is greater than the fibre saturation point. Below MCfs, wood dimensions changes and it gains moisture (swells) or loses moisture (shrinks) in the form of bounded water. The level of MCfs depends on the relative humidity and temperature of the surrounding air. Shrinkage and swelling are the cause of many of the problems that can occur in wood both during drying and in use; therefore, a deep knowledge will help to minimize such problems. Splitting, warping, and open joints are examples of problems that can occur due to uneven shrinkage.

Moisture is one of the most important causes in the building pathology. The material degradation can be affected by the presence of water, both in vapour and liquid phase. Wood has a strong hygroscopic behaviour, with large rise and fall of moisture content and

dimension stability caused by variation of the relative humidity of the surrounding air. The moisture content relationship has an important influence on wood properties and performance (White et. al., 1999).

The main goal of this work is to study the water movement in wood: first of all, the drying process, which occurs before the manufacture and use as finished wood products, and secondly the gain and the loss of water in response to the changes in environmental conditions that surround the wood.

EXPERIMENTAL SETUP

A total of 60 specimens were tested in order to assess shrinkage and swelling behaviours of the two woods species. The assumed geometry for the specimens is 40x40x10 mm (Fig.1), based on NP EN 614 recommendations. Before running the tests, one half of the specimens of each species were dried in an oven at 103°C +/- 2°C (Fig. 2), while the other one half was saturated in a water tank (Fig. 3) until a constant mass is attained. Mass is considered constant when the difference between two consecutive weight measurements, delayed 2 hours, is less than 0.5%. Table 1 resumes the specimens distribution and its denomination.



Fig. 1 – Specimens wood sections



Fig. 2 - Dried specimens



Fig. 3 – Saturated specimens

Table 1 - Specimens distribution and its denomination.

Wood species	N. of Specimen	Dried	Denomination	Saturate	Denomination
Softwood specie					
Maritime Pine	30	15	DP	15	SP
Hardwood specie					
Ash	30	15	DA	15	SA

Note: DP – Dried Pine; DA – Dried Ash; SP – Saturated Pine; SA – Saturated Ash

The tests were carried out in a climatic chamber with a constant internal environment of 20°C and 60% (RH), during a period time equal to 24 hours or more, until stabilization of dried and saturated specimens. It is considered that stabilization process was completed when dimensional variation between two successive measurements of specimens is less than 0.5%. Afterwards, the whole process is repeated until complete four cycles. The last cycle ends with the previously saturated specimens placed in the oven to be dried while the other half was saturated. The wood species had different speeds of stabilization, however the specimens remained inside the climatic chamber until the stabilization of both wood species. In addition to the registration of dimensions, during the stabilization process, moisture and weight data

were also collected. The weights were performed using a balance with less than 5 mg error and moisture content readings were made using a hygrometer.

For all measurements, a calibrated dial gauge coupled to a steel base with a precision equal to 0,001 mm was used.

TEST RESULTS AND DISCUSSION

Fig. 4 illustrates the average dimensions variation values of shrinkage/swelling for saturated and dried specimens in radial and tangential directions (Δr and Δt , respectively) obtained in the experimental program. The variation values were calculated from the equation 1, where d_1 is the dried or saturated specimen dimension in radial or tangential direction at reading time, and d_0 is the radial or tangential dimension at the beginning of the test cycle.

$$\Delta_{D,S} = \frac{d_1 - d_0}{d_0} \tag{1}$$

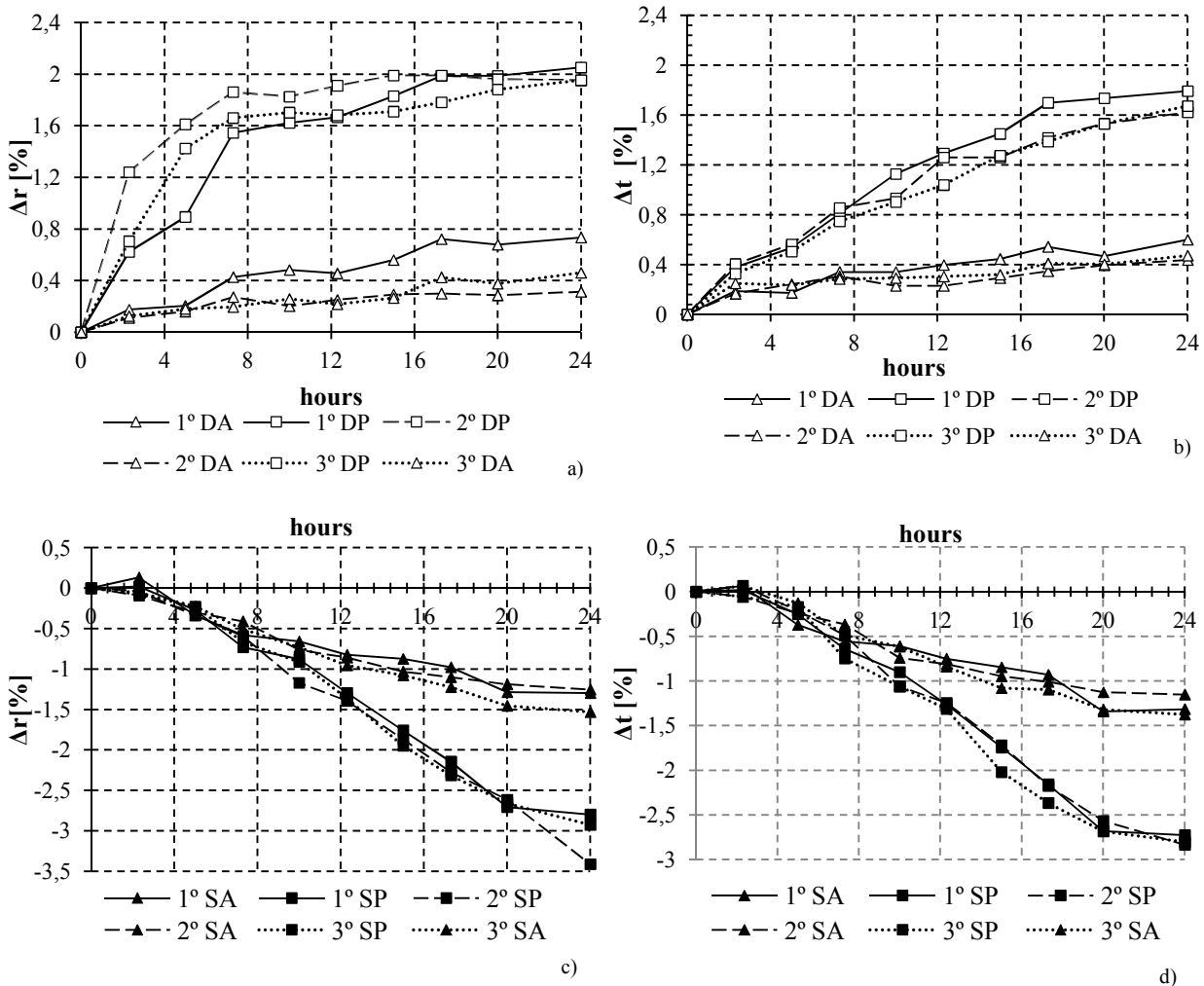


Fig. 4 - Dimensional variation in time in radial and tangential directions: a) dried specimens in radial direction; b) dried specimens in tangential direction; c) saturated specimens in radial direction; d) saturated specimens in tangential direction.

From the analysis of the graphics represented in Fig. 4 the swelling becoming stable after 24h for the two wood species, both in radial and tangential directions. Despite the difference between the tangential and radial shrinkage, the results obtained for both measured directions

show the same trend of being stable after the first 24 hours. Fig. 4 also shows that Maritime Pine demonstrates an oscillation at the end of stabilization period.

Also, for dried specimens, the ash wood presents a most stable behaviour (0,4%) when compared to pine wood specimens (about 2,0%), both in radial and tangential directions. Same conclusions can be drawn for saturated specimens. As shown, is identified a most stable behaviour for ash wood, which stabilizes at 1% while pine becomes stable at about 3%.

Therefore, it is possible to assess the weight loss of each specimen for the two wood species. Fig. 5 shows the average weight variation (ΔW) of saturated and dried specimens obtained in current experimental program. The variation values were calculated from the equation 2, where W_1 is the dried or saturated specimen weight at reading time and W_0 is the weight at the beginning of the test cycle.

$$\Delta W_{D,S} = \frac{W_1 - W_0}{W_0} \quad (2)$$

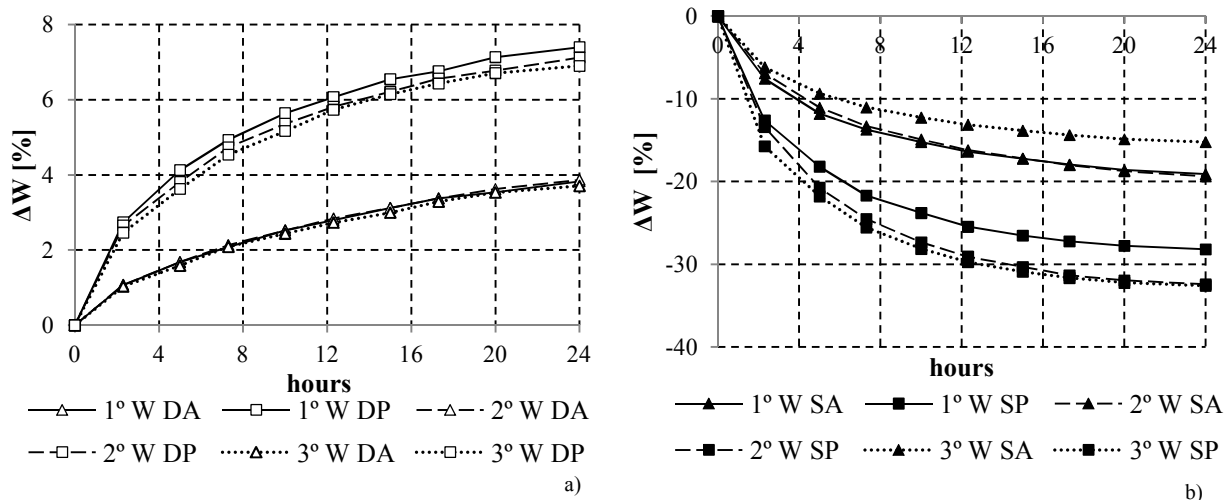


Fig. 5 - Weight variation: a) dried specimens; b) saturated specimens.

From the analysis of Fig. 5 one can observe that for both dried species the mass has a linear behaviour, in the three cycles. The ash wood shows a most stable behaviour (4%) when compared to pine wood specimens (about 7,0%) and the mass stabilized after 20 hours. Similar conclusions can be drawn for saturated specimens, since ash wood exhibits a most stable behaviour (20%) when compared with pine (30%).

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