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Correlation between density and porosity from ten species of tropical wood

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ABSTRACT
Wood, like several materials, initially has to be characterized to assess its potential use. Among the main properties, the apparent density is one of the most important properties, since it constitutes a reliable estimator of the other mechanical properties for the development of projects. In addition, to make the density estimate and thus the mechanical properties of the wood more expeditious, in this work the objective was to confirm the existence of a correlation between the density of the wood and its porosimetry, determined by the mercury intrusion technique. It was possible to find a correlation from the elaboration of a curve of the density and porosity results of ten species of tropical wood.

Keywords - Apparent density, porosity, tropical wood

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I. INTRODUCTION

Characterizing the materials is an initial procedure to assess their potential for use in the most different applications [1].

Different tests are usually adopted to proceed with the referred characterization, some simpler, others more elaborated, always seeking to achieve the reliable and most representative results [2].

Ceramic products have been widely used in several applications that impact human daily life, from buildings to industrial uses [3].

Tests using mercury intrusion technique, among the best known alternatives, are fundamental for estimating ceramic products behavior, especially their porosimetry, considering the ease of their performance, as attested by several authors [4]; [5].

In recent years, mercury intrusion technique has also come to be used in several studies involving wood, wood based products as well as other lignocellulosic composites [6]; [7]; [8], [9]; [10]; [11].

In the case of structural applications of wood, apparent density is one of the most important properties, since it constitutes a reliable estimator of other mechanical properties for development timber designs [12]; [13]; [14].

In order to make the density evaluation and, thus, the wood mechanical properties more expeditious, the aim of these work is to confirm the existence of a correlation between wood density and its porosimetry, determined by mercury intrusion technique.

Such verification proves to be timely and indispensable since wood anatomical aspects, including those related to pore permeability [15], which may or may not present obstruction, could interfere with porosimetry results, compromising the use of mercury intrusion technique for wood-related studies.

II. MATERIAL AND METHODS

To achieve the proposed objective, ten tropical wood species, grown and available in Brazil, were chosen, covering a wide spectrum of densities, between 0.4 and 1.1 g/cm3. Are they: Tatajuba (*Bagassa guianensis*); Roxinho (*Peltogyne recifencis*); Cambará (*Erisma uncinatum*); Cedroarana (*Cedrelinga catenaeformis*); Cumaru (*Dipteryx odorata*); Cupiúba (*Goupia glabra*); Caixeta (*Simarouba versicolor*); Cedro (*Cedrela fissilis*); Sucupira (*Bowdichia nítida*); Cajueiro (*Anacardium sp*.).

Apparent density determination was carried out following the recommendations contained in

ABNT NBR 7190 [16], in its Annex B: "Determination of the properties of wood for structural design".

Twelve density determinations were made for each species and, in results analysis, the respective means were considered. These tests were carried out in Wood and Timber Laboratory, São Carlos Engineering School, University of São Paulo, Brazil.

Wood porosity was determined using the Micromeritics Poresizer Equipment - 9320 equipment (Fig. 1), available in São Carlos Physic Institute, São Paulo University, Brazil.

Figure 1 - Micromeritics Poresizer Equipment - 9320.

For each species, three porosity determinations were made and, in results analysis, the respective means were considered.

Several regression models were tested in results analysis. The one considered most convenient was the linear, presented in the following item.

III. RESULTS AND DISCUSSION

Mean values of wood density are presented in Table 1.

Table 1. Apparent density (AD) of ten tropical Brazilian wood species. Mean values.

Specie	Apparent density (g/cm^3)
Tatajuba	0,95
Roxinho	0,94
Cambará	0,70
Cedroarana	0,57
Cupiuba	0,86
Cumaru	1,09
Caixeta	0,41
Cedro	0,50
Sucupira	0,79
Cajueiro	0,55

Mean values of porosity are presented in table 2.

Table 2. Porosity (P) of ten tropical Brazilian wood species. Mean values

Specie	Porosity (dimensionless)
Tatajuba	0,3160
Roxinho	0,2962
Cambará	0,4610
Cedroarana	0,7204
Cupiuba	0,4036
Cumaru	0,3663
Caixeta	0,7325
Cedro	0,7329
Sucupira	0,4466
Cajueiro	0,6595

From Tables 1 and 2, a expression is obtained, relating AD and P, (i.e, (1)).

$$AD = -1{,}18P + 1{,}34 \quad (1)$$

R^2 is equal to 0.88, value that permit to consider porosity a very good estimator to apparent density, using the same approach indicated in [17]; [18].

IV. CONCLUSION

Results showed that it's really possible to evaluate wood apparent density by the porosity determined by mercury intrusion, although eventual pore obstruction in some wood species, point that initially could bring uncertainties in validity of the cited hypothesis.

It's suggested that, in future researches, another wood species be evaluated in order to expand the number of information and, so, the estimator presented in equation 1 can be optimized.

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