STUDY OF THE PHYSICAL-MECHANICAL STRENGTH AND MOISTURE CONTENT OF MAÇARANDUBA WOOD (*MANILKARA SPP*) MARKETED FOR CIVIL CONSTRUCTION IN GURUPI-TO

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ABSTRACT: As a requirement for the use of wood in civil construction, it is necessary to first understand its properties and what can modify its performance, such as its moisture content, which is inversely proportional to its mechanical strength and can become an aggravating factor for the development of pathological manifestations. This study aims to analyze whether the direct use of wood marketed in the municipality of Gurupi - TO, without prior drying, in building structures may be affected by excessive moisture. Additionally, the study seeks to examine the parallel compression strength of the wood fibers and correlate it with other strengths based on a simplified analysis of the ABNT NBR-7190 standard (1997). The species *Manilkara spp*. was used for the study, as it has good performance in structures and is locally available for purchase. Finally, it was observed that the wood is being sold within moisture classes 1 and 2, and the results of compression, tension, and embedment are equivalent to those specified in the Brazilian standard and other sources. Regarding the compression strength values, a correlation was obtained between the averages with a significance level of 5%, which was not the case for the moisture content test. Efforts were also made to understand the reasons for the reduced use of wood in structures and to encourage further research on cataloging regional wood species for structural use and the study of causes of pathological manifestations as a variation of the study.

KEYWORDS: NBR-7190, pathological manifestations, structures.

HIGHLIGHTS

- The strength and moisture content of timber in the study region was verified.
- The moisture content was compared with the respective strength of the *Manilkara Spp*. wood species.
- It highlighted the importance

of analyzing wood used in construction work.

- The possibility of using the wood sold in the study region was confirmed.

1 | INTRODUCTION

Knowing that wood has been widely used since antiquity due to its qualities of weight, resistance, thermal and acoustic insulation... knowledge about the product has had to be improved in order to improve the quality of the products generated. Wooden elements that can withstand compression, traction and bending are commonly used in building structures and, despite being a natural product, can undergo changes in their mechanical performance depending on internal and external factors such as moisture content and relative humidity. Given the market's high competitiveness with other products, such as steel and concrete, it is important to understand the application of wood in roof structures, which, depending on their layout, generate the aforementioned stresses in their parts, either separately or together, such as flexion-traction or flexion-compression.

The physical properties of wood are heterogeneity, anisotropy and hygroscopy. Its anatomy presents a heterogeneous arrangement, formed by sets of cells of different functions and ages, with their agglomerates called tissues, responsible for conducting and storing nutrients, protection, growth, and in general terms, the entire development of the plant (LISBOA, 1991). Once the wood has been felled, the material is prone to changes in humidity in relation to the environment in which it is found. Depending on atmospheric humidity, it can release or acquire the amount of water in its body (JANKOWSKY, 1990). Given the dissimilarity of dimensional variation in response to external and internal stresses, this guarantees the anisotropy of wood. According to Pfeil and Pfeil (2003) "the phenomenon of shrinkage is more important in the tangential direction, for a reduction in humidity from 30% to 0%, tangential shrinkage varies from 5% to 10% of the green dimension, depending on the species. Shrinkage in the radial direction is about half that of the tangential direction. In the longitudinal direction, shrinkage is less pronounced, amounting to only 0.1% to 0.3% of the green dimension, for drying from 30% to 0%".

By combining volume variation with hygroscopy, it is possible to obtain divergent results in terms of the piece's usability for building structures. Uneven dimensional change favours the appearance of pathological manifestations throughout the pieces, such as bowing, bulging and warping, highlighting the importance of good treatment of the wood after removal (PFEIL and PFEIL, 2003).

According to the technical standard NBR-7190 (1997) "Projeto de Estruturas de Madeira" (Design of Wooden Structures) of the Brazilian Association of Technical Standards (ABNT), which guides test methods using limit states and states of use, the equilibrium humidity for relative air humidity less than or equal to 65% is 12%, the standard reference humidity for determination tests in Brazil and the United States.

At this point, the development of tests tends to contain fewer errors due to non-conformities in the samples and more accurate results due to the greater stability of the specimens. The standard also provides tables correlating each species of wood to its respective mechanical properties. Among the dicotyledons, there is the one in the current study with the common name Maçaranduba (*Manilkara spp*), a species sold by timber companies in the city of Gurupi - TO, a city with around 76755 inhabitants and an average annual relative humidity of between 60 and 70% (IBGE,2012; INMET,2020). *Manilkara spp* occurs in the states of Pará, Amazônia, Amapá, Maranhão, Mato Grosso, Rondônia, Roraima and in non-flooded areas of the Amazon rainforest. It is moderately difficult to cut and plane and easy to turn. It is used in civil construction in external construction, in railway sleepers, bridges, crosspieces and piles, in internal construction, in scissors, beams and rafters, in floorboards, in parquet flooring, in furniture, transportation and other uses that match its qualities (EMBRAPA, 2004; JANKOWSKY, 1990; IPT, 2013).

Manilkara spp has a flexural strength of 138.5 MPa at 12% humidity, and compression parallel to the fibers of 82.9 MPa at 12% (NBR-7190, 1997). The species is difficult to air-dry, and cracks, warping and external stiffening can occur, requiring high control for kiln-drying (JANKOWSKY, 1990).

Given the importance of drying wood to achieve optimized results in terms of mechanical characteristics, the possibility of using the species for external use in beams, rafters and slats in buildings and the presence of Manilkara spp in the study region (IPT, 2013), samples of the species were researched in order to ascertain the average humidity of the pieces sold in the municipality of Gurupi - TO, correlating the strength of the samples that were not artificially dried with the genuine compressive and tensile strengths that the wood structures would be susceptible to if pieces with standard humidity were applied. The results of the average humidity, compressive and tensile strengths acquired in the laboratory were compared with other references, confirming the need to dry the pieces or ensuring their use without drying treatment after purchase.

2 | MATERIAL AND METHODS

2.1 Obtaining data

In order to obtain the data needed to make comparisons of the mechanical strength in relation to the humidity of the *Manilkara spp* species, it was necessary to sample pieces purchased from lumber yards in the region of Gurupi - TO, which had received monetary aid for research from the Federal Institute of Tocantins. The methodological development was mainly based on the NBR- 7190 (1997) “Projeto de Estruturas de Madeira” (Design of Wooden Structures) standard, as it is nationally recognized and is included in the syllabuses of Brazilian universities, along with references to works on structures, drying and handling laboratory samples of wood.

The material was purchased from two timber companies in Gurupi - TO, called Madeireira São Sebastião and Madefort, both located on Avenida Ceará in the Central Sector, and 6 pieces measuring 1 meter in length, 0.12m in height and 0.05m in width were bought from the same batch of wood of the *Manilkara spp* species known by the sellers as Maçaranduba. Given the requirements of the selection methodology, in order to avoid bias and consequent changes to the results, the goods were chosen at random (NBR-7190, 1997). Before being purchased, the beams were cut with a disc saw by the timber company for transportation and then taken to the civil construction laboratory in block 4 of the Federal Institute of Tocantins campus Gurupi - TO, which is located approximately 1.5 kilometers away, where they were stored in a ventilated and covered area.

As soon as the material arrives at the laboratory, the preparation stage begins in order to organize, identify and prepare it so as to proceed with the development of the methodological application of according to the method of simplified characterization of the strength of sawn timber for known species described in chapter 6.3 of standard NBR-7190 (1997), where, by correlation with the resistance to compression parallel to the fibers, the resistance to traction parallel to the fibers, compression normal to the fibers, embedding normal and parallel to the fibers and shear parallel to the fibers are determined.

For research purposes, no more than one sample may be taken from each specimen for the appropriate tests. As the purpose of the research is to compare the strengths of samples dried at standard humidity and untreated after purchase, 1 sample was taken from each specimen for humidity tests and 1 for the test of resistance to compression parallel to the fibers. The specimens must be free of defects and taken from areas far from the ends, excluding at least 30 centimeters or five times the smallest dimension of the cross-section (NBR-7190, 1997).

2.2 Humidity test:

The moisture content of wood is calculated from the ratio of the difference between the initial mass of the sample before and after drying, divided by the mass after drying, obtaining the percentage by multiplying the operation by 100 (NBR-7190, 1997).

As the pieces would have dimensions of 0.05x0.10x1.00 meters, they were cut using a bench circular saw with a 10-inch blade at a speed of up to 4800 revolutions per minute (Figure 1), extracting 30 centimeters from the end in the transverse direction and then worked until a sample of each specimen measuring 0.02x0.03x0.05 meters was obtained (Figure 2 and 3), where 0.05 meters runs in the direction parallel to the fibers. To help with the cut-out, templates were marked with the given measurements, where you will need a tape measure to the measurement and caliper to confirm the dimensions after cutting with an accuracy of 0.1mm.

Figure 1 - Bench saw with 10-inch blade.

Source: The author (2022).

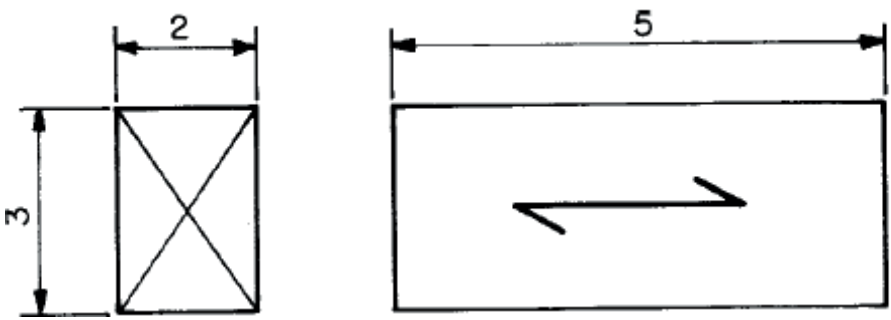


Figure 2- Dimensions of the specimen for the moisture test.

Source: The author (2022).

Figure 3 - Test specimens for moisture content testing and the respective specimens to be broken.

Source: The author (2023).

Using a scale with a precision of 0.01g, it is possible to obtain the mass of the samples, organizing the data obtained from the specimens that will be taken to the oven mentioned in figure 4 and those that will be compressed in the hydraulic press without prior drying into tables.

Figura 4 - Drying chamber.

Source: The author (2022).

After obtaining the mass of the samples, the 6 units should be taken to the drying chamber with a maximum temperature of 103°C and a variation of plus or minus 2°C. During the process, the mass of the specimens should be measured every 6 hours until there is a variation of less than 0.5% of the previously measured mass, at which point they will be considered dry. Knowing the measurements on the scales before and after drying, it is possible to calculate the moisture content of the samples using Equation 1.

2.3 Compressive strength test parallel to fibers:

In order to obtain the resistance to compression parallel to the fibers of a 12m³ batch, the maximum tension at which the specimens would resist rupture was applied. To apply the force, a hydraulic press was used with a base and top larger than the cross-sectional measurements of the sample, computing the data obtained in Mega Pascal.

The Brazilian standard shows that stiffness and strength are obtained simultaneously, with stiffness being obtained from stress and strain diagrams. Given the purpose of the research, only the destructive test will be analyzed with specimens measuring 0.05x0.05x0.15 meters, as shown in figure 5, numbered 1 to 12. As with the moisture content test, they were shaped using a 10-inch circular saw, with the aid of a measuring tape, pen and white tape

for identification and a caliper (Figure 6) to certify the dimensions with an accuracy of 0.1 millimeters. To measure the cross- sectional area of the specimen, given the inaccuracy of the pieces coming from the lumber yard, the average of the measurements of the top and bottom was taken, measuring in both directions from the top, and in both directions from the bottom, adding the sides of the top and bottom and dividing by two, thus obtaining two measurements to calculate the area.

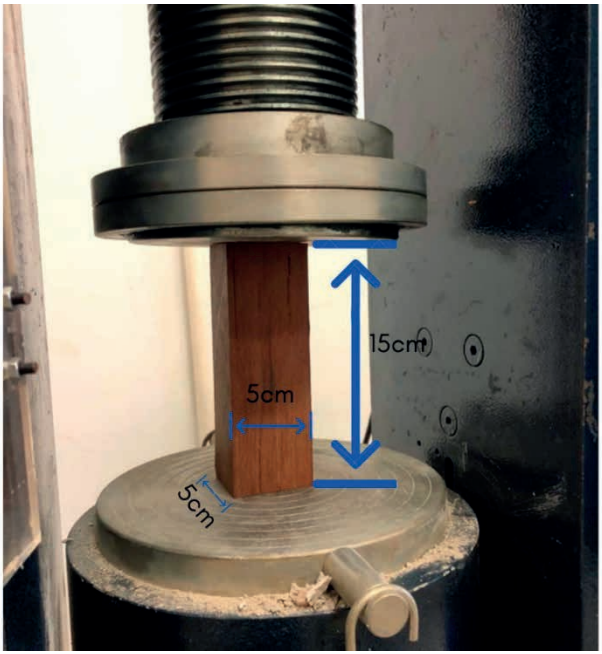


Figure 5 - Representation of a specimen with dimensions of 15x5x5cm.

Source: The author (2022).

Figure 6 - Digital pachymeter for taking measurements with a precision of 0.1 millimeters.

Source: The author (2022).

NBR-7190 recommends stipulating the strength of the specimens so that during the pressing process there is better contact and accommodation of the sample, divided into 3 compression cycles. The first cycle starts with the application reaching 50% of the estimated resistant force, after 30 seconds with stable application and then reducing to 10% of the resistant force, after another 30 seconds, the second cycle starts from 10%, repeating the process. In the third cycle, the force is applied from 10% up to the test body's resistance limit. The standard also stipulates that resistance should be obtained with loads of around 10MPa/min in all cycles. The maximum strength of each specimen will be obtained from the breaking of the specimens, and the data will be computed for calculations. For this experiment, controlled decompression will not be possible due to the availability of a manual hydraulic press.

2.4 Analysis statistics:

In order to assess the correlation between the moisture content values and the maximum compressive strength of the extracted specimens, Tukey's analysis of variance method and the ANOVA f-test will be used to compare the means of the results for each timber mill. Assuming an ANOVA significance level (α) of 5%, with the null hypothesis (H 0) representing the equality of the means of the load values at break and moisture percentage, and the difference being the alternative hypothesis (H1). In this case, the P-value (probability P) for the acceptability of the null hypothesis of equality of means must be above 5%, otherwise the means will not correlate probabilistically. For the data tabulation, 2 treatments were used: the two lumber yards where the material for the test was purchased and the only places that sold the species in the city of Gurupi - TO at the time of purchase, with 6 replicates each, since 1 test specimen was taken from each piece of Maçaranduba wood.

To carry out the tests, the programs "Microsoft Office Excel" were used for the ANOVA test and "Past" for the Tukey test and comparison with the ANOVA test results. For the ANOVA test carried out by the programs, the mean, variance, the sum of squares (SQ) of the individual results, the degree of freedom (gl), the mean square (QM), and for both the calculated F-value, P-value and critical F-value were automatically calculated for the treatments and residues. For Tukey's test, which is carried out empirically using the Excel program, data on the number of treatments and the degree of freedom of the residual from the ANOVA tables is used to enter the tabulated q value of the total amplitude, calculating the minimum significant difference and then comparing it with the contrasts of the means obtained by the results of the experiments, analyzing whether the contrasts are lower than the minimum significant difference, meaning that the null hypothesis (H0) is not rejected, or, if not, the null hypothesis (H0) is rejected.

3 | DISCUSSION

Tables 1 and Graph 1 show the humidity and maximum compressive strength values obtained from the destructive test in a hydraulic press, which have been adapted to the press.

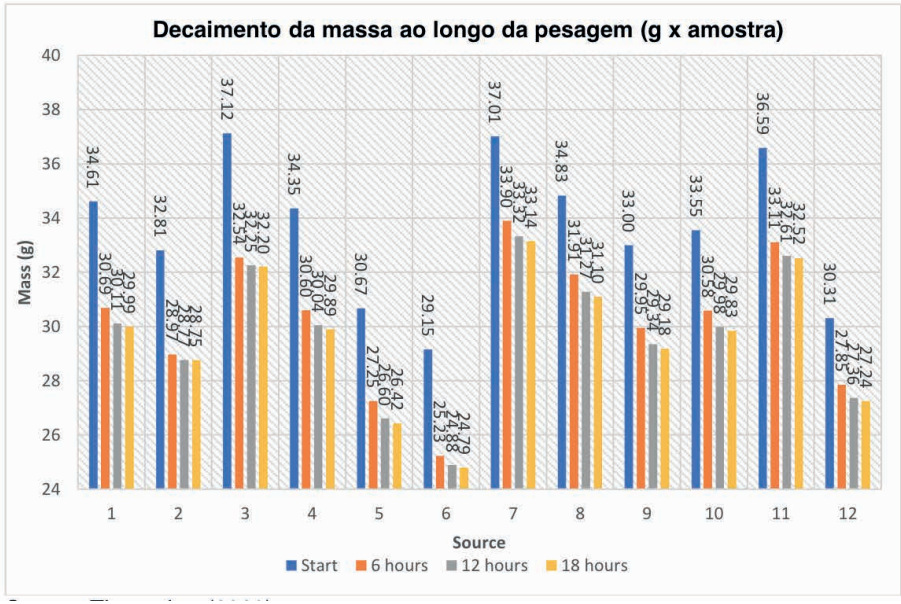
It is not possible to perform decompression at 10 MPa/minute, since decompression with a manual hydraulic press is done abruptly. Compression at 10 MPa/minute was maintained, converting to the units used by the press, approximately 2500 Kgf/minute, considering the 25cm² specimens

Loading test - compression parallel to the fibers - 10 MPa/min

	Sample	Breaking load (Kgf)	Section transverse (cm²)	Rupture pressure (MPa)
	Test	18349		
MadefortTimber (1)	**1**	15472	25,63	60,38
	2	16153	25,10	64,37
	3	13080	22,30	58,65
	4	19203	23,12	83,08
	5	19867	23,89	83,18
	6	18063	24,00	75,27
São Sebastião Timber (2)	**7**	22618	24,74	91,42
	8	19919	25,12	79,28
	9	20366	26,22	77,67
	10	17376	24,67	70,44
	11	20603	24,33	84,69
	12	27002	26,72	101,04

Table 1 - Results of loading tests with *Manilkara spp.*

Source: The author (2023).



Graph 1 - Moisture test results with *Manilkara spp.* specimens.

Source: The author (2023).

Table 2 shows the measurements taken of the specimens that were compressed. These values were used to calculate the average compressive strength, using the average of the top and bottom measurements to form the cross-section in cm².

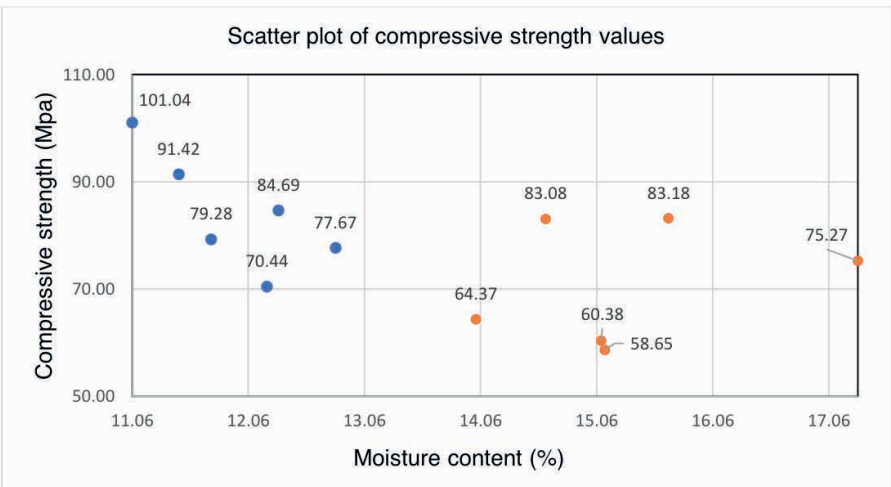
Cross-section of the specimens for the loading test

Sample	Top (cm)		Base (cm)		Average ((topX+bottomX)/2)(cm)		Average cross-section (cm²)
	A	B	A	B	A	B	A*B
1	5,01	5,13	5	5,11	5,005	5,12	25,63
2	4,95	5,1	4,94	5,05	4,945	5,075	25,10
3	5,01	4,46	4,98	4,47	4,995	4,465	22,30
4	4,95	4,57	5,1	4,63	5,025	4,6	23,12
5	4,63	5,17	4,61	5,17	4,62	5,17	23,89
6	5,14	4,65	5,16	4,67	5,15	4,66	24,00
7	4,83	5,22	4,75	5,11	4,79	5,165	24,74
8	5,16	5,08	4,81	5	4,985	5,04	25,12
9	4,98	5,22	5	5,29	4,99	5,255	26,22
10	4,7	5,03	5,06	5,08	4,88	5,055	24,67
11	4,78	5,19	4,76	5,01	4,77	5,1	24,33
12	5,22	5,14	5,27	5,05	5,245	5,095	26,72

Table 2 - Values of the cross-sectional measurements of the compressed specimens.

Source: The author (2023).

For the compression test, the average value for the Madefort timber company was 69.35 MPa, using an average cross-section of 24 cm², while for the São Sebastião timber company the result was higher, at 82.62 Mpa, with an average cross-section of 25.30 cm², correlating with average humidities of 15.31% and 11.94% respectively. For the first case, the highest compressive strength occurred in the sample with the second lowest percentage of water, while in the second case, the highest strength was the one with the lowest percentage of water, as shown in graph 2. In general, the highest strength obtained was in sample 12 together with the lowest humidity, which did not occur in relation to the lowest strength with the highest humidity, obtaining for the study the lowest strength of 60.38 MPa in sample 1 with 15.10% humidity, lower than the highest humidity in the study of 17.31% in sample 6.



Graph 2 - Graphical analysis of compressive strengths and respective humidities.

Source: The author (2023).

In comparison with the ABNT NBR 7190 (1997) standard, samples 6, 7 and 12 showed values below the standard humidity for use in characterizing species, while the other samples showed values between 12.22% and 17.31%, resulting in an average of 13.62%, making then class 1 and 2 humidity for structural calculations when using kmod2.

The strength characterization values shown in table 5 were calculated from direct relationships for species already known to the Brazilian standard, with row 3 of the table highlighting the formulations used for calculation. For fc0,k, the average of the tensile strength values corrected by equation 2 was used. The calculation showed a coefficient of variation of 16.25% and denoted strength class C60 according to table 3 of the Brazilian standard for dicotyledons.

Resistors Characteristics					
compression parallel to the fibers.	traction parallel tothe fibers.	shear parallel to the fibers.	compression normal to the fibers.	embedding parallel to the fibers.	normal embedding in the fibers.
	fc0,k/0,77	0,12*fc0,k	0,25*fc0,k	1,0*fc0,k	0,25*fc0,k
fc0,k (MPa)	**ft0,k (MPa)**	**fV0,k (MPa)**	**fc90,k(MPa)**	**fe0,k (MPa)**	**fe90,k (MPa)**
81,22	105,48	9,75	20,31	81,22	20,31

Table 5 - Results of the characteristic resistances.

Source: The author (2023).

In parallel with the ABNT NBR 7190 standard (1997) and Pfeil and Pfeil (2003), the fc0,k resistance was approximated from 82.9 MPa to 81.22 MPa in the present study. In comparison with EMBRAPA (2004), the value is between the resistances obtained for the best performing species of the *Manilkara* genus, *Manilkara huberi,* which varies between 68.3 and 101.9 MPa.

For the probabilistic evaluation between averages, the results are shown in tables 4 to 13. Firstly, table 4 summarizes the maximum compressive stress data selected for the test, where each group contains 6 results, obtaining the sum, average and variance for each of them. By analyzing the stress data instead of the resistance force, one of the variables is eliminated, which is the variation in the cross-section of the blocks, since the strength of the sample depends on its dimensions.

Group	***Counting***	***Sum***	***Average***	***Variance***	
Maderfort	6	424,91	70,82	124,31	
São Sebastião	6	504,54	84,09	118,45	
ANOVA					
Source of variation	***SQ***	***gl***	***QM***	***F***	***P-value***
Between groups	528,47	1	528,47	4,35	0,06
Within the groups	1213,81	10	121,38		
Total	1742,28	11			

Table 4 - ANOVA analysis table for the resistance to compression parallel to the fibers test,calculated using the “Excel” program.

Source: The author (2023).

In the ANOVA analysis for the strength test, the calculated F value was lower than the critical F, representing equality between the group averages (timber) for the maximum resistant compressive stress results, with a p-value greater than 5%.

Equality of means test					
	Sum of squares	**df**	**Mean square**	**F**	**P-value**
Between groups	528,146	1	528,146	4,352	0,064
Within the groups	1213,650	10	121,365		
Total:	1741,800	11	0,063		

Table 5 - Results of F and P-value calculated by the ANOVA method using the “Past” program.

Source: The author (2023).

A joint analysis of the two programs reaffirms the probabilistic fairness of averages between groups for the maximum tensile strength results.

Calculation of Tukey’s minimum significant difference				
l	n2	α	q	Δ (MPa)
2	10	0,05	3,15	24,95

Table 6 – Calculation of Tukey’s minimum significant difference.

Source: The author (2023).

Table 6 shows in Δ the amount by which the averages of the results from each logging company can vary from one another. In other words, the average of one logging company subtracted from another must, in module, be less than 24.95 (MPa).

Ranking of averages in descending order										
Sample	**1**	**2**	**3**	**4**	**5**	**6**	**Average**	**Averages in descending order**	**contrasts**	**Evaluation**
Madefort Timber	60,38	64,37	58,65	83,08	83,18	75,27	70,82	84,09	13,27	Not rejected H0
Amostra	**7**	**8**	**9**	**10**	**11**	**12**	**Average**			
São Sebastião Timber	101,04	84,69	70,44	77,67	79,28	91,42	84,09	70,82		

Table 7 – Tukey’s analysis table for calculating the contrast between means.

Source: The author (2023).

Table 7 shows the difference between the group means in the contrast column, which is 13.27 MPa, less than the maximum difference of 24.95 MPa. This means that the means are within the acceptable range for not rejecting the hypothesis of equal means. This is confirmed by the analysis carried out in the “Past” program in Table 8.

P-value for each comparison		
Timber	**Madefort**	**São Sebastião**
Madefort	-	0,06355
São Sebastião	2,95	-

Table 8- P-value table for analyzing the results of the compression test parallel to the fibers based on the Tukey test carried out in the “Past” program

Source: The author (2023).

Table 8 shows the p-values comparing the averages of the timber companies, where the empty cells are the comparisons of the average with the average itself, showing that the p-value was greater than 5%.

With reference to the moisture content test, Table 9 shows the ANOVA table calculated using the Excel program. The summary of the data shows the sum, mean and variance of the moisture content results for each group represented by the timber companies, followed by the sum of the squares, degree of freedom, mean square, F, P-value and critical F.

Group	***Count***	***Sum***	***Average***	***Variace***
Timber Madefort	6	91,85	15,31	1,27
Timber São Sebastião	6	71,61	11,94	0,40

ANOVA						
Source of variation	***SQ***	***gl***	***QM***	***F***	***P-value***	***Critical F***
Between groups	34,13	1	34,13	40,85	0,0001	4,96
Within the groups	8,35	10	0,84			
Total						
Between groups	42,48	11				

Table 9 - ANOVA analysis table for the moisture content test carried out using the Excel program.

Source: The author (2023).

For this experiment, the F-value was significantly higher than the critical F-value, and the P- value was less than 5%, indicating a probabilistic difference between the means of the timber groups. As a comparison, the ANOVA test in the “Past” program, shown in Table 10, was also carried out for the results of the moisture content test.

Test of equality of means					
	SQ	**gl**	**QM**	**F**	**P-Value**
Between groups	34,17	1	34,17	40,79	0,00008
Within the groups	8,378	10	0,84		
Total	42,55	11	0,002		

Table 10- F and P value results calculated using the “Past” program for the moisture content test values.

Source: The author (2023).

Based on the results shown in tables 9 and 10, it is statistically confirmed for both analyses that at least one of the moisture content values obtained is different from the others. To confirm this, Tukey’s test was carried out, starting with table 11, which shows the margin within which the averages can vary in order to accept or reject the hypotheses.

Calculation of Tukey’s minimum significant difference				
I	**n2**	**α**	**q**	**Δ**
2	10	0,05	3,15	4,45

Table 11- Results of Tukey’s minimum significant difference calculations for the moisture content test values.

Source: The author (2023).

For the Tukey test result calculated using the empirical form of the calculation shown in table 11, the value of the minimum significant difference was 4.45, which allows the mean of the groups to vary within this range. This must be confirmed in Table 12, in order to confirm that the hypotheses are accepted.

Classificação das médias em ordem decrescente							
Amostra	**1**	**2**	**3**	**4**	**5**	**6**	**Médias**
Madeireira Madefort	**15,10**	**14,02**	**15,13**	**14,62**	**15,68**	**17,31**	**15,31**
Madeireira São sebastião	**11,46**	**11,74**	**12,81**	**12,22**	**12,32**	**11,06**	**11,94**
Médias em ordem Descrecentes	**Contrates**	**Avaliação**					
15,31	**3,37**	**Reject H0**					
11,94		**Médias diferentes**					

Table 12 - Moisture content values for Tukey’s test.

Source: The author (2023).

The Tukey test, calculated empirically in Tables 13 and 14, shows that the null hypothesis that the means do not vary significantly is accepted. This value differed from the ANOVA method, using the “Past” program in table 13.

P-value for each mean		
	Madefort	**São Sebastião**
Madefort		0,00008
São Sebastião	9,032	

Table 13 - P-value table for analyzing the results of the moisture content test using the Tukey test in the "Past" program.

Source: The author (2023).

As shown in Table 13, when comparing means using the "Past" program, there is at least one value that is far from probabilistic agreement, indicated by the p-value of 0.00008, which cannot be identified by Tukey's empirical method because it is affirming the null hypothesis based on a significant difference.

If we look at the moisture content values for both logging companies, we can see how close they are to those of the same group and how far apart they are from the other group, which means that the trees and pieces of wood were chosen, treated and stored differently from the moment they were harvested, split and stored. As mentioned by Silva (2017), the extraction region for the Cupiúba wood species (*Goupia Grabla Aubl.*) can have a 50% chance of the physical properties not being equivalent in analyses carried out in three regions in the states of Mato Grosso and Roraima, in which even with the simulation technique the result was 44% of the physical properties not being equivalent. For the study in question, the origin of the Maçaranduba wood used was not obtained, as the aim of the research was to analyze what the moisture content would be, depending only on the species analyzed.

In order to compare individual cases, eliminating the humidity and specimen session variables, a comparative analysis was made of the compressive strength results corrected for 12% humidity using equation 2, shown in table 14.

Loading test - compression parallel to the fibers - 10 Mpa/min - 12% moisture content						
	Sample	**Breaking load (Kf)**	**Cross-section (cm^2)**	**Tensile strength (MPa)**	**Moisture content (%)**	**Breaking stress at 12% (MPa)**
Timber Madefort	**1**	15472	25,63	60,38	15,10	65,99
	2	16153	25,10	64,37	14,02	68,27
	3	13080	22,30	58,65	15,13	64,15
	4	19203	23,12	83,08	14,62	89,61
	5	19867	23,89	83,18	15,68	92,35
	6	18063	24,00	75,27	17,31	87,25
Timber São Sebastião	**7**	22618	24,74	91,42	11,46	89,93
	8	19919	25,12	79,28	11,74	78,67
	9	20366	26,22	77,67	12,81	79,56
	10	17376	24,67	70,44	12,22	70,90
	11	20603	24,33	84,69	12,32	85,51
	12	27002	26,72	101,04	11,06	98,21

Table 14 – Loading test results at 12% moisture content.

Source: The author (2023).

When the tensile strength values were corrected, the overall average was reduced to 80.87 MPa due to the presence of specimens with less than 12% humidity, which means that when the correction is made, the strength is lower. However, from the ANOVA test carried out using the Excel data analysis program shown in Table 15, a higher correlation of values was obtained.

Group	***Counting***	***Sum***	***Average***	***Variance***
Maderfort	6	467,6139	77,93564	171,3602
São Sebastião	6	502,7723	83,79538	91,78742

ANOVA

Source of variation	***SQ***	***gl***	***MQ***	***F***	***P-value***	***Critical F***
Between groups	103,0097	1	103,0097	0,782904	0,397031	4,964603
Within the groups	1315,738	10	131,5738			
Total	1418,748	11				

Tabela 15– ANOVA test using the Excel program for the results of the loading test at 12% moisture content..

Source: The author (2023).

For this test, the variance for group 1 (Madeireira Madefort) was higher and for group 2 (Madeireira São Sebastião) was lower compared to the ANOVA test in tables 6 and 7, the P-value shown in table 15 was higher than the P-value for the tension values for resistance

to compression parallel to the fibers considering only the section of the specimens, being approximately 0.40 compared to 0.06. This shows greater probabilistic equality between the data that eliminates the humidity variable which, according to the other sources cited, directly affects the mechanical performance of wood.

4 I CONCLUSION

In view of the above, the Maçaranduba timber decks sold without prior drying in the municipality of Gurupi - TO showed high performance in strength class C60 with an average of 81.22 MPa and adequate hygroscopic equilibrium for $_{kmod2}$ (1) and (2) with an average of 13.62%, in confirmation of other sources which had already been investigated and representing a value close to the estimate of the Brazilian standard for timber structures for equilibrium humidity for locations with relative humidity of less than 65%. Based on the probabilistic analysis, the correlation of the data for resistance to compression parallel to the fibers was observed, accepting the null hypothesis of probabilistic equality; for the moisture content results, the hypothesis of non-equality of means was accepted, stating that some external or internal factor influenced the disparity in the results. Since it is hardwood, mechanical characteristics with high values were expected when the experiment was successfully carried out. Knowing this, there is a need to develop studies to characterize regional species and subspecies for use in construction, in order to provide a basis for structural calculations and determine possible uses and limit stresses for use in buildings. The problem of the research was to analyze the possibility that the humidity of regionally marketed wood is modifying its physical and mechanical performance, and could cause it to develop irreversible pathological manifestations. Laboratory tests proved that the hypothesis was negative, which leads us to think of other possibilities for causing pathologies in works with wooden structures, such as periodic maintenance and prior treatment, subjects that could become the subject of further research in the field of wooden structures. The compressive strength values found confirm the quality of the wood, which can be used for elements that can withstand compression and traction, as well as being well suited to nails and screws for fixing. Based on this work, it is possible to reference the values for structural calculation of regional works, using $_{kmod2}$ and the strength values analyzed.

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