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MATERIAL TESTING OF CASUARINA GLAUCA WOOD FOR USAGE WITHIN A TRUSS

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Abstract: The structural use of wood is prominent in countries around the world as wood has many advantages compared to other materials used. These advantages include having a low cost, light weight and low environmental impact. The use of wood in structures, though common in many countries, is not common in Egypt. Glauca is a local tree that is under the family of Casuarina trees; it originated in Australia and is also available in Egypt in abundance. It has several advantages such as it can be irrigated using wastewater and could tolerate elevated temperatures and arid conditions which facilitates its plantation. Unfortunately, such tree is not taken advantage of in the construction field neither in Egypt, nor abroad as there are no published researches regarding its utilization in any structural element. This study aims to verify the ability of the local Glauca to be used as a structural element through conducting material and resistance tests to determine its properties and durability. Glauca has proved to be very promising and is capable of providing a cheaper alternative to the commonly used materials both locally and internationally.

1 INTRODUCTION

Wood compared to other materials has low embodied energy and low carbon impact. One of the major things considered when comparing wood to other materials is that wood emits less carbon in its production as compared to concrete and steel [1]. Egypt's use of wood is limited formwork, carpentry tools and furniture but not in structures. This is due to the absence of a design code of practice, lack of information on the mechanical properties of the local wood and the high cost of its imported types. Casuarina wood is commonly known as she-oak or Australian pine and is one of the most growing trees in dry areas. It originated in South east Asia and Australia by the late 1852's and was introduced to Egypt in the early 90's [1]. Casuarina consists of 17 types, however, the common planted types in Egypt are Casuarina Equistifolia, Casuarina Cunninghamiana, Casuarina Glauca and a hybrid between the last two [2]. This study focuses in the properties of Casuarina Glauca which has 20 cm thick branches and its average height varies from 2 to 4 meters in Egypt with life span of 12 years [3]. Among the advantages of Casuarina species is that it can grow in poor sandy soil that lack nutrients and can grow on waste water irrigation that is contaminated with deadly poisons such as arsenic and cyanide [1]. As the wood will be exposed to various climate conditions, the need to conduct different tests is essential to assess its durability and the effect of severe weather conditions on its structural behavior. This study investigates the behavior of wood and its resistance under humidity, elevated heat, moisture, its grade and specific gravity. The findings will be used to assess the durability of this wood when used in trusses of inaccessible roofs.

2 Methodology

In order to have a functional truss product, its durability and ability to withstand different weather conditions and maintain its quality on the long run is as important as its safety. Therefore, this research opted to conduct material tests on the wood. This included grading the wood, obtaining its specific gravity, evaluating the effects of humidity, elevated temperature and moisture. Samples were coated using wood shield as shown in Figure 1 to simulate the coated end product and asses the wood's performance. This coating protects against cracking, peeling, and erosion. The coating used is JOTUN wood shield and was applied left to dry for 24 hours.

Figure 1: Wood coating used in the experiments.

Due to constraints in time and equipment availability, there were some minor deviations to the standards while performing the tests. The other deviation was in the size of the specimens through which we were confined with the cross sections received from the supplier. The first test performed was the grading of the wood according to European standards. The second test was the specific gravity which was performed according to the ASTM standards. Non-standardized test was then conducted to evaluate the wood’s resistance to humidity, elevated temperature and moisture.

2.1 Grading

Grading of the wood was conducted according the European standards EN 975-1 [8] to evaluate where it stands in terms of quality as compared to other oak trees. The grading system consists of three letters; the first is Q which is standard for all oak trees, the second depends of the shape of wood being inspected and the third represents the grade, letter A indicating an exceptional grade. Lower grades are assigned numbers from 1 to 3, 1 being the second highest quality after A. Since the members inspected were beams, the first two letters of the grade are Q-P. 53 beam samples with cross sections of 4X4 cm and 94 cm length were inspected for sound and unsound knots, wanes, all types of splits, rots, holes and curly grains. The inspection included the number of defects per meter and the diameter of defects as a percentage of the width of the member being inspected.

2.2 Specific gravity

The first test conducted was the Specific gravity test, samples as shown in Figure 2. The test was performed following the procedures of ASTM D2395 [4]. The aim of performing the test is to obtain the density which was used in calculating the weight of the truss in order to be able to perform structural analysis.

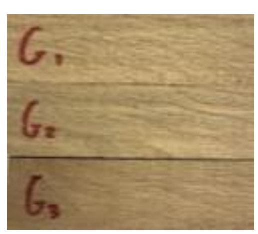

Figure 2: Specific gravity sample

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2.3 Moisture test

The second test conducted was the resistance to moisture effects following procedures of ASTM D870-15 [5]. Four coated and four uncoated samples were immersed in water to assess its effect on the wood. Visual inspection was done to evaluate the degree of deterioration of the wood due to its immersion in water. This test would resemble the use of the truss in areas with heavy rain conditions such as Alexandria, Egypt.

2.4 Elevated temperature test

The resistance of the wood to elevated temperature was examined by performing the ASTM D5664-17 [6]. Samples were left in the oven to dry as shown in Figure 3, with deviations due to the time limitations. Compression tests, following ASTM D5664 – 17 [6], were performed on both coated and uncoated samples, and stress Vs. strain curves were obtained to evaluate the effect of elevated temperature on the wood's compressive strength. The test was conducted on three temperatures, two samples in room temperature, four samples in 36° C and eight samples in 66° C. Each sample was divided into two, coated and uncoated. An average of the results of the compression test were then obtained.

Figure 3: Elevated Temperature Resistance samples

2.5 Humidity Test

Non-standardized test that was conducted to observe the behavior of the coated and uncoated wood when exposed to humidity for one and four. The test aims to inspect the variations in the wood's compressive strength due to water absorption. The procedures include having 4x4x16 cm samples as shown in Figure 4, divided into a control sample that is not exposed to humidity, two coated and one uncoated sample that were constantly exposed to humidity by placing them in a curing room for the aforementioned durations. After removing the samples from the curing room, they were left out to dry for two hours. Compressive tests using the MTS machine and stress Vs. strain curves were obtained.

Figure 4: Humidity Resistance samples

3 RESULTS AND ANALYSIS

3.1 GRADING

In this test, 55 beams were inspected and the results showed that on average 10% of the beams that were used in the assembly of the truss were of grade Q-P-A, 25% of grade Q-P-1, 25% grade Q-P-2 and 40% were of lower grade as shown in Figure 5. Since the wood is of high variability in terms of strength and properties, it is recommended that Glauca wood beams used in any construction should be of the same grade to ensure quality and to be able to predict a pattern for the behavior of the structural element.

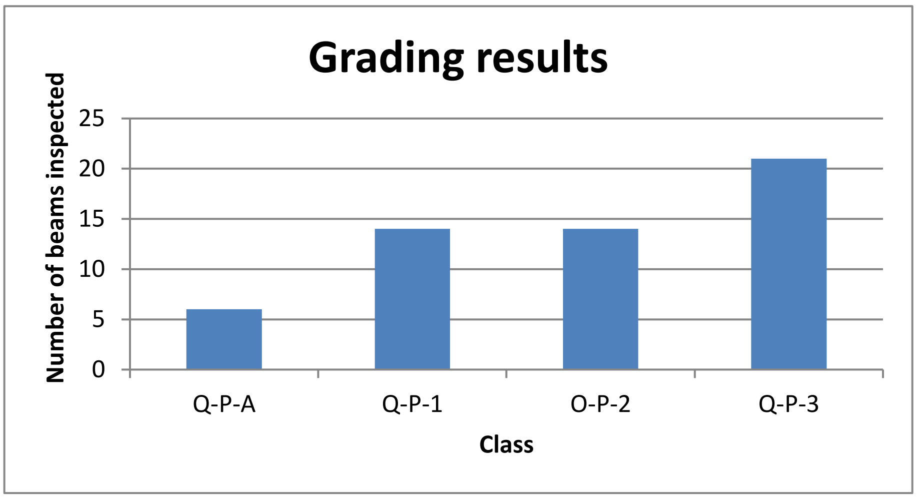

Figure 5: Grading results

3.2 SPECIFIC GRAVITY

The experiment resulted in a specific gravity that ranges between 0.7 to 0.8. This range follows the universal trend of wood specific gravity, especially for the oak wood.

3.3 MOISTURE TEST

After the samples were soaked for two weeks in water, physical changes started appearing on the wood as shown in Figure 6. Coated samples showed color change as the coating started to come off the wood and formed a gel layer on the wood sample. The sample absorbed water moderately as compared to the uncoated samples. Which shows that the coating protected the wood and it preserved its structure. As for the uncoated samples, they experienced very high-water absorption and they softened and twisted.

Figure 6: Moisture Resistance samples

3.4 ELEVATED TEMPERATURE TEST

3.4.1 ROOM TEMPERATURE TEST

Samples at room temperature acted as a control sample to obtain the compressive strength of the samples without exposure to elevated temperature. Two samples were divided into coated and uncoated samples. The results show that the strength of the samples was not affected by the coating layer as shown in Figure 7. This was beneficial as it confirms that any conclusions drawn from the 36° C and the 66° C will be solely due to elevated temperature.

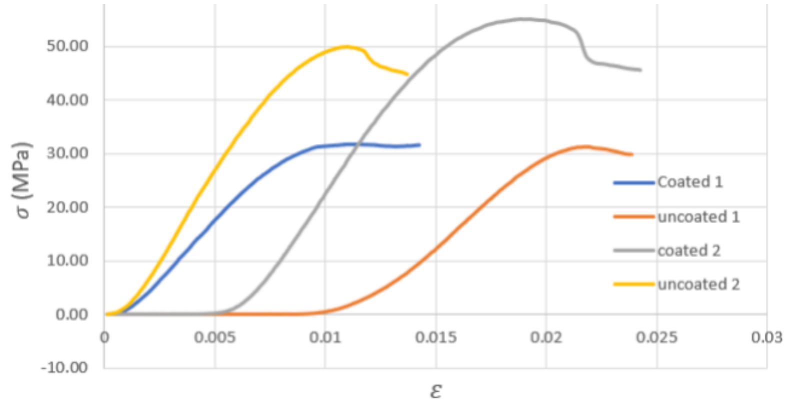

Figure 7: Room temperature Compression test

3.4.2 36°C TEMPERATURE TEST

Two samples were divided into coated and uncoated samples. The results show negligible change in strength between the coated and the uncoated samples as can be seen from Figure 8. The general observation of these results suggests that the 36°C is not the temperature that affects the wood in terms of its strength. Moreover, it did not affect the coating as the coated samples did not experience any change. It is expected that this is due to the natural environment in which the Glauca tree grows in, which is almost above 40° C all year long.

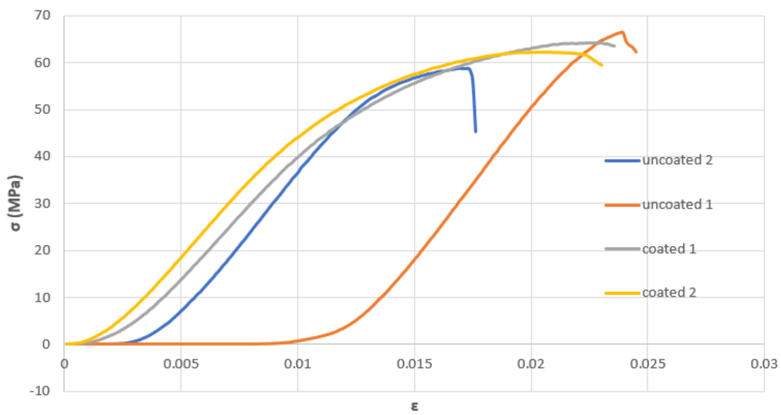

Figure 8: 36°C Compression test

3.4.3 66°C TEMPERATURE TEST

Four samples were divided into coated and uncoated. The general pattern observed from Figure 9 is that the strength of the coated samples was lower than the strength of uncoated samples when they were exposed to high temperature. This observation suggests that the coated samples had a lower strength due to their high moisture content. In the uncoated sample, the high temperature caused the water to escape making the fibers tougher and increasing its strength. Since the coating of the coated samples acted as a barrier that prevented the water from escaping even at high temperature, the uncoated sample had a lower moisture content which in return yielded higher strength. This test concludes that the moisture content has a huge effect on the strength of the Glauca wood. It was apparent that as the moisture content increased, the strength of the wood in the coated samples decreased. Thus, the coating was not needed in the low temperature of 36° C, while it was ineffective in high temperatures. It is therefore, recommended that another coating should be opted if the truss is to be used in environment with high temperatures. It was also observed that though the strength was increased, the ductility of the wood decreased, and it became more brittle with the exposure to elevated temperature as seen in Figure 13.

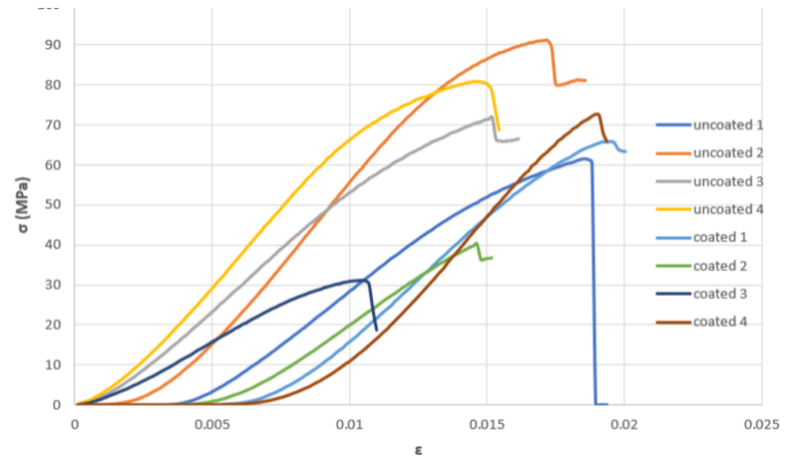

Figure 9: 66°C Compression test

Figure 10: Failure of sample at elevated temperature

3.5 HUMIDITY TEST

Two one-meter beams with a 40x40mm cross section were divided into four samples. The results observed validate the results obtained from the elevated temperature test. As observed in Figure 11 and 12, both the coated and uncoated samples had lower strength than the original strength of the control sample when exposed to humidity for one and four days. This further indicated that the strength is affected by the increase in the moisture content. It is apparent that as the time of exposure to humidity increases, more water is absorbed by the wood and the more the strength is affected. However, the coated samples showed a less reduction in the strength than the uncoated samples in both durations. This is because it prevented the wood from absorbing water as compared to the uncoated samples. This prevented the weakening of its fibers and consequently prevented the weakening of its compressive strength.

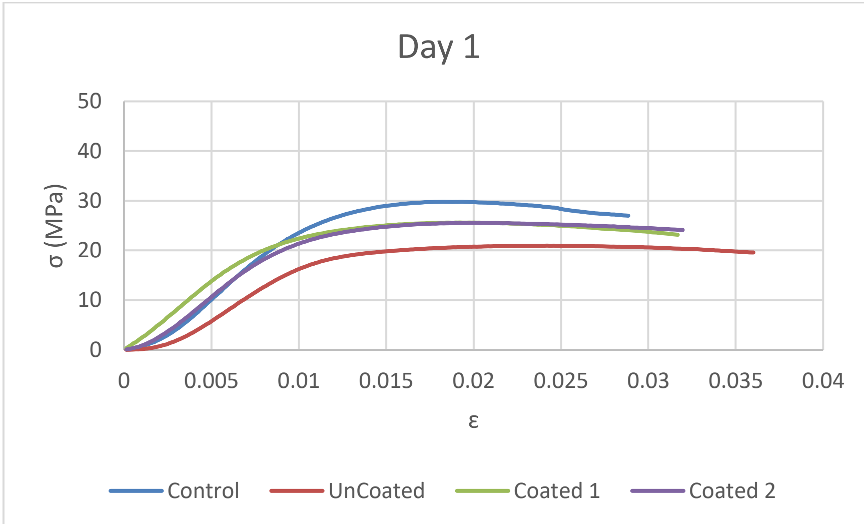

Figure 11: Humidity day one compression test

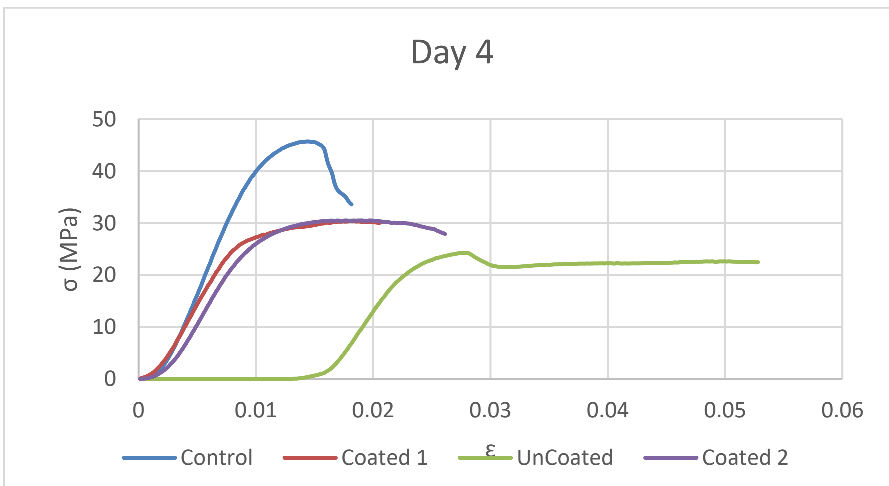

Figure 12: Humidity day four compression test

The general conclusion of these tests is that the strength of the wood decreases with the increase in its moisture content. The coating proved to be ineffective in elevated temperatures, but effective in relatively low temperatures. The coating showed to be somehow effective in preserving the wood from humidity levels; However, it is recommended that further research be done on the type of coating to be used in case the truss is to be used in areas with very high humidity levels that lasts for long periods.

4 CONCLUSION

The major finding of this study is that Casuarina Glauca is a promising type of wood that can be used in structural applications. However, it has very high variability by its nature which suggests that there has to be high-quality control while using it in structural applications. Moreover, it was found that the dryer the wood, the more strength it attains and the more brittle it is. On the other hand, Glauca wood loses strength with increasing moisture content inside the wood. Finally, based on this research and its promising outcomes, Glauca wood was utilised in the design and testing of a 12m truss that can be used as an inaccessible roof located in Egypt. The findings of this research recommended that the truss should be used in hot dry areas to maintain its durability.

5 RECOMMENDATIONS

Referring to the results of the elevated temperature and humidity tests, it is recommended to use Casuarina Glauca wood in hot and dry areas. However, it is apparent that evaluating the effect of climate conditions on the wood behavior is not fully displayed by testing for compression only; therefore, other tests for the behavior of the wood should be conducted. Among these tests, the Standard Test Method for Laboratory Evaluation of Solid Wood for Resistance of termites ASTM D3345-17 [7] should be conducted on the Casuarina Glauca wood to evaluate its resistance to subterranean termites. The test is divided into two experiments. The first experiment is the First-choice test data where Casuarina wood will be tested with the existence of southern yellow pine, an alternative material that termites can feed on. The second experiment is the no choice data, where the wood will be the only option for the termites to feed on and morality data of the termites is to be observed. Conducting such test is of vital importance in order to know to what extent the existence of such termites can be a source of damage on the wood and any structural element.

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