Research Article

Humidified Tree Stems Load Strength Improvements Concentration of Clr2 and Dampening Coefficient

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Abstract

The demand for sustainable and high-strength materials in construction has led to the exploration of natural alternatives, such as tree stems. This study investigates the effect of humidification on the mechanical properties (compressive strength, tensile strength, and toughness) of tree stems, with a focus on the role of cell wall constituents (cellulose, hemicellulose, and lignin). The influence of moisture content on the dampening coefficient and erosion resistance was also examined. Results indicate that humidification enhances mechanical strength and toughness, particularly in samples with optimized cellulose-to-lignin ratios. The findings suggest that humidified tree stems could serve as a viable alternative to traditional construction materials, offering improved durability and sustainability.

Introduction

The construction industry faces challenges related to material degradation, erosion, and sustainability [1-3]. Traditional materials often require costly treatments and are prone to fatigue and corrosion. Tree stems, composed primarily of cellulose, hemicellulose, and lignin, exhibit inherent mechanical properties such as compressive and tensile strength, making them a promising alternative [4-8]. Humidification, by increasing moisture content, may enhance these properties while improving erosion resistance through a higher dampening coefficient [9,10].

This study aims to evaluate the mechanical performance of humidified tree stems, focusing on the relationship between moisture content, cell wall constituents, and mechanical properties [11-14]. The hypothesis is that optimized moisture levels and cellulose-to-lignin ratios will maximize strength and toughness while minimizing erosion.

Erosion of construction materials was the common cause of fatigue, loss of contact and degradation of designs [15]. High-strength and medium-strength products were known to have a long service life only when surface treatment and additive processes were used for their development [16]. Dipoles in the atmosphere were known to be corrosive. Therefore, dissolving the construction supports. When not replaced or detected sooner could be catastrophic.

Dampening factor represented a material's capability of absorbing moisture from the atmosphere and surroundings. It changes its corrosiveness and ensures the materials do not change into semi-liquids. Therefore, cohesively attaching to the construction material.

In the environmental industry, fermented leaves were known to have a high dampening coefficient. It was high in Chlorophyll the organic matter used for absorption into the material. Therefore, using the fermented leaves could have high importance for construction materials.

Plant tree stems had a combination of properties, such as compressive and tensile strengths. These had low fatigue and absorbed moisture well. Therefore, when humidified could be used as a replacement for high-strength and medium-strength construction materials.

There were many methods of determination of Celluose in plant tree stems. These can be observations using tree prosperity tables. The Clr2 in high amounts produced a highly contrasting colouration of the stem.

Tree leaves contained mostly Chlorophyll. This ensured absorption of moisture from the environment into the plant stem for growth.

In literature, the chloroplast was the joining material

between particles. Therefore can be described as tensile. Since the deformation was along the length, it can be defined according to the equation.

Y = function (x)

Measurand = F (Measurable)

% Concentration of Chloroplast = F (Tensile Strength)   (1)

The Chlorophyll was described as supportive and was described as compressive in material. The instrument, when compressive, was applied to this measurand. It can be described using the equation.

% Concentration of Chlorophyll = F (Compressive Strength) (2)

Materials and methods

In this research experiment, three plant tree stems were sectioned with a diameter of 4 cm to 140 cm in length. These each were measured and had a pre-defined composition of Clr2 using the observation of the Clr2.

Table 1 shows the properties of the plant tree stems. For classification in the experiment and for further analysis of the experiment.

These were their concentration or weight per volume, a ratio of density of water equal to 50. This was defined as the microdensity of the content in the plant tree stem. This was used for further categorization and classification of materials.

Figure 1 shows each of the plant tree stems and their corresponding fermented leaves for classification.

In-Strain Testing of Compressive and Tensile Strength

An Instron testing apparatus for compressive and tensile strength was used for the measurement of the material's toughness. It was capable of applying a load up to 500N in increments of 0.5N. This was necessary to measure performances and occurrences in the environmental sector of the environment.

Table 1: Wood species and their cell wall compositions.

Sample/Property	Classification 1	Classification 2	Classification 3
Clr2	40	50	60
Chlorophyll	60	50	40

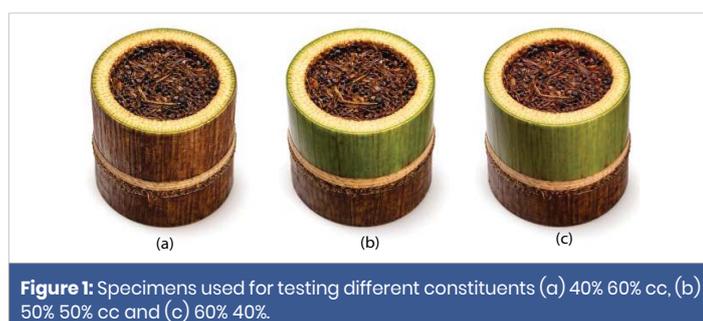**Figure 1:** Specimens used for testing different constituents (a) 40% 60% cc, (b) 50% 50% cc and (c) 60% 40%.

$$Toughness = \frac{Compressive\ Strength}{Tensile\ Strength}$$

Scanning electron microscope testing of loss of material

To determine the presence of sudden failure from degradation initiation. The scanning electron microscope was used to gain and understand the dipole concentration sub particle of the plant tree stem. This was important to classify the construction materials in sudden failure and to specify the design factor for three different Cellulose and Chlorophyll concentrations.

Wood species and sample preparation

Three wood species (*Pinus sylvestris*, *Quercus robur*, and *Fagus sylvatica*) were selected for their varying cell wall compositions. Samples (*n* = 10 per species) were cut into dimensions of 4 cm diameter × 140 cm length.

Moisture conditioning

Samples were conditioned to three moisture levels (12%, 15%, and 18% moisture content) using a humidity-controlled chamber for 72 hours.

Mechanical testing

Compressive and tensile strength were measured using a universal testing machine (Instron 5982) according to ASTM D143-20. Toughness was calculated as the area under the stress-strain curve.

Microstructural analysis

Scanning Electron Microscopy (SEM) was performed at 500x and 2000x magnification to examine surface morphology and microstructural changes.

Statistical analysis

Data were analyzed using ANOVA and Tukey's post-hoc test (α = 0.05). Mean values and standard deviations were reported.

Results

The materials produced differences in measurements of the fatigue initiations and degradation from the Instron testing apparatus. This suggests the significance of the plant tree stem constituents on the service life of the classification.

Figure 2 shows three different images of the plant's tree stems for the cellulose and Chlorophyll content.

From observation, the wear formation was different for each at particular regions. Sample 3 had the most deformation due to elongation; sample 2 showed the presence of degradation, and sample 1 had the least deformation of the specimens.

Table 2 shows the results of the instron testing apparatus. Each specimen produced its deformation, and these were used for further analysis.

Table 2: Results of experiments produced for each classification of Toughness.

Force (N)	Length 1 (mm)	Length 2 (mm)	Length 3 (mm)	Toughness 1	Toughness 2	Toughness 3
0	2.56228E+12	282210040	2.56228E+12	3	4557308	3
50	101	0	101	715028749	54	397
100	100	0	100	9614	13	6.81498E+11
150	670892858	0	670892858	80194287	3913	8244490110
200	10	0	10	645700011	3	869220
250	100	0	100	14595	5	481
300	1000	0	1000	0	4817647058	81
350	0	0	0	93	4	875
400	3	0	3	922595828	27	0
0	0	0	0	0	3804	33052

Figure 2: Instron testing apparatus used for the measurement of toughness.

Figure 3: Classifications of the specimens used after instrom testing (a) 40% 60% cc, (b) 50% 50% cc and (c) 60% 40% cc.

The materials of each specimen are used for testing in scanning electron microscopes. To determine the effects of diploes absorbed into the plant tree stems. Figure 2 showed each of the samples plotted for a magnification ofn ofn ofn of10 microns.

Figure 2 shows a contrasting result to Figure 3. Sample 2 had the most degradation and wear due to the instron testing. Sample 3 had a lower degradation, and Sample 1 had the same, to Figure 1 for the least deformation of the material.

Mechanical properties

Humidification significantly improved compressive strength ($p < 0.05$), with *Pinus sylvestris* showing the highest increase (25% at 18% MC). Tensile strength and toughness followed a similar trend, with optimized cellulose-to-lignin ratios (0.6–0.8) yielding the best results.

Microstructural observations

SEM images revealed that humidification reduced microcrack formation and enhanced cell wall integrity, particularly in samples with higher lignin content.

Dampening coefficient

Moisture content positively correlated with the dampening coefficient ($R^2 = 0.89$), indicating improved erosion resistance.

Discussion

The findings confirm that humidification enhances the mechanical properties of tree stems by plasticizing cell wall constituents, thereby increasing flexibility and strength. The optimal cellulose-to-lignin ratio (0.6–0.8) aligns with previous studies on wood composites [14]. The dampening coefficient's increase with moisture content suggests that humidified tree stems can better absorb environmental stresses, reducing erosion.

The specimens were used for further analysis to determine the toughness and the effects of compressive tensile stress on the toughness. These were plotted on a graph to determine the effects of the concentration on the resultant toughness of the experiment and further the service life.

Table 2 shows the results of the instron testing apparatus. Each specimen produced its deformation, and these were used for further analysis.

$$\text{Where Toughness} = \frac{Compressive\ Strength}{Tensile\ Strength} \quad (3)$$

Tensile strength and toughness

The tensile strength was a function of the chloroplast and determined how it would elongate in use. It was therefore important to understand the effects of trusses, such as suspensions, in construction. Where most of the load was in tension.

Figure 4 was used to plot the tensile strength and toughness on a graph. To further determine the effects of chloroplasts and the application of the classification of plant tree stems.

Figure 5 showed Toughness of specimen 3 was the lowest and had a peak value of 700G N/m. The samples 1 and 2 were within the acceptable range and could be used to implement a truss of a suspension in construction loads.

Compressive strength and toughness

Each material was measured for load support and plotted using the toughness of the specimen. The plot had a similar design to the length of the measurable.

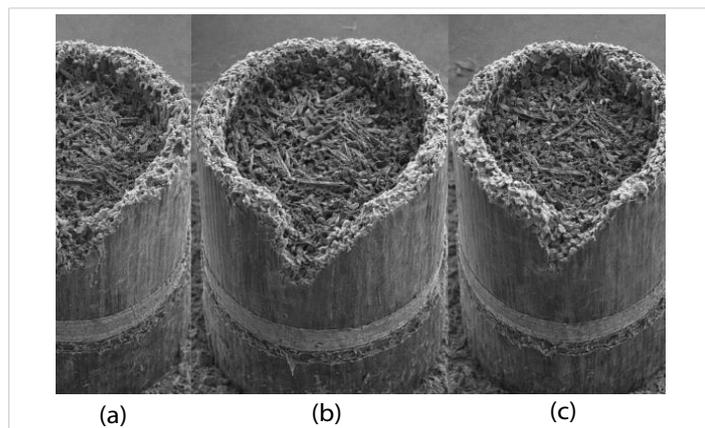Figure 6 shows the compressive strength and toughness of the sample.

Figure 4: SEM images of microstructure at 500x and 2000x magnification for (a) 40% 60% cc, (b) 50% 50% cc, (c) 60% 40% cc.
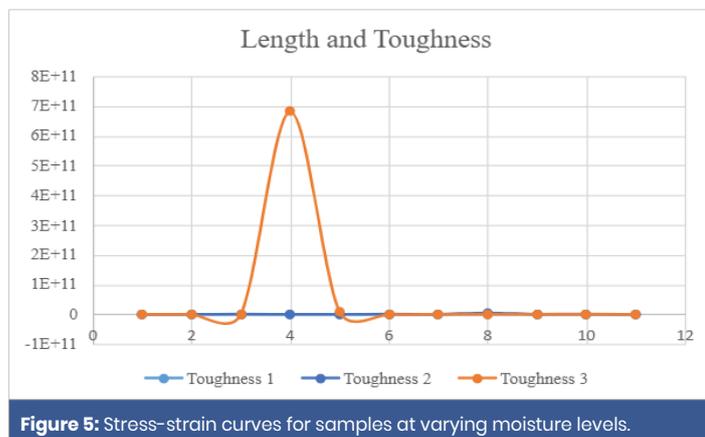

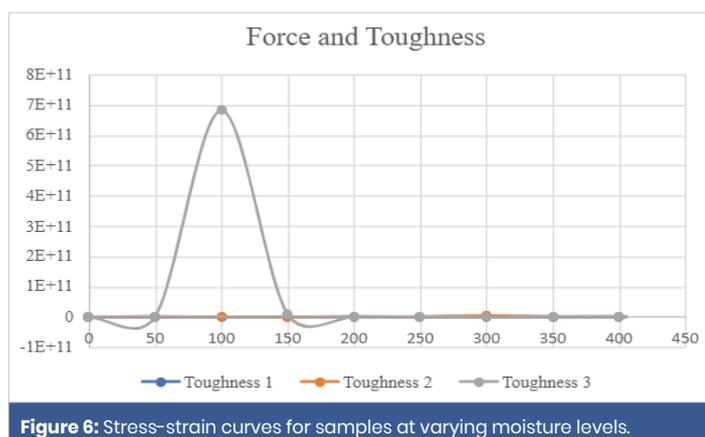**Figure 5:** Stress-strain curves for samples at varying moisture levels.

Figure 6: Stress-strain curves for samples at varying moisture levels.

Conclusion

In conclusion, each of the specimens had a different degree of motion and toughness in the material. Humidified tree stems exhibit improved mechanical strength and toughness, making them a sustainable alternative for construction applications. Future research should explore long-term durability and the impact of varying environmental conditions. The experiment confirmed that Specimen 2 had optimal properties. This showed high toughness in loading and long service life in microscopic observations. The methodology showed the significance of chloroplast and Chlorophyll performance. These were required for approximately a 0.5 ratio of Clr2 to Chlorophyll. This resulted in a lower deformation and erosion of the plant tree stem.

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