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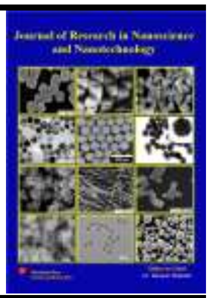

Mechanical Properties of Oil Palm Trunk Lumber Using Parallel Strand Lumber (PSL)

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ABSTRACT

This research is to study and investigates how the mechanical strength of oil palm trunk can be improved for parallel strand lumber (PSL) in the timber industry. Various methods are implemented by the wood industry for this purpose. The research uses an Instron Universal Testing Machine to perform mechanical testing on the oil palm trunk after undergoing PSL. Samples used for tensile testing adhere to the size guidelines outlined by the American Society of Testing Materials (ASTM). The results of the experiment indicate that the 1-inch strand has the highest mechanical strength compared to the 0.5 inch and 0.3-inch strand, as it has a higher fibre content that enables it to withstand applied loads or forces. However, the average sample of the 0.3-inch strand also exhibits similar mechanical strength as the 1-inch strand, due to the small size of the strand which allows for better absorption of the glue and stronger bonding with the surface.

Keywords:
Oil palm, parallel strand lumber, tensile test, mechanical testing, ASTM D143

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1. Introduction

Malaysia is among the largest producers of palm oil worldwide, with a current production of approximately 6.5 million metric tons. However, this figure pales in comparison for 11.8 million tons of oil palm production recorded in 2001. Despite the significant quantity of palm oil produced, the total biomass and crude oil capacity within the plantation is relatively small. The remaining quantity primarily comprises of lignocellulosic materials like fronds, trunks, and empty fruit bunches. [1,2]. As a result, a significant quantity of waste is generated, consisting mainly of unutilized parts from the oil palm. Additionally, oil palm trees lose their economic value once they reach 25 to 30 years of age and require replacement with new trees.

According to a 2008 report from the Malaysian Energy Centre, replanting activities generate as much as 2110 million tons of fronds and trunks. This presents a significant opportunity for manufacturers to utilize the available oil palm biomass for products such as veneer, glulam, microllam (LVL), and parallel strand lumber (PSL). The production of products using Parallel Strand Lumber and Microllam (LVL) method will result in a reduction in the proportion of biomass waste generated from oil palm. One method of producing engineered wood products involves using long thin strands of wood known as Parallel Strand Lumber [3]. Parallel strand lumber (PSL) is an engineered wood product whose structure is bonded together. This not only helps in cost savings but also results in higher density of the material by making it suitable for a variety of applications such as furniture and structural components for housing, including window and door columns. Manufacturing companies widely utilize the green construction material by using parallel strand lumber on construction and structural field which is the latest technology [4,5].

Parallel strand lumber is one of type from structural composite lumber (SCL) categories, is made up of long and narrow strands of wood, which are frequently a by-product of plywood production. These strands, when bonded together under high pressure with adhesive, produce a distinctive mesostructured in the resulting material. The bonding quality between the long narrow strands is the most critical factor that affects the performance of PSL [3,6]. PSL will be affected based on composition of adhesive penetration substrate into the wood while manufacturing process.

This study explores the use of parallel strand lumber in achieving a medium density grade of wood by applying it to both high and low-grade density wood. The mechanical properties of PSL are analysed through tensile testing. As an environmentally friendly material, parallel strand lumber has gained popularity in various applications such as cabinetry, table tops, shelving, wall and floor panels, doors, furniture, and other non-structural architectural applications, and it is now competing with materials like steel, aluminium, and concrete.

2. Methodology

The bonded between long thin strands of wood veneer will form the large beams and columns in order to perform Parallel Strand Lumber (PSL). PSL is known for its high strength and ability to distribute physical defects evenly throughout the material, making it an ideal choice for applications where high density and strength are required. The evenly distributed physical defects in PSL make it stronger than other wood products. PSL is commonly used in products that require high density. This study focuses on using oil palm trunks (OPT), which have a low density. This study aimed to increase the mechanical properties of low-density oil palm trunk (OPT) by applying the parallel strand lumber method. The veneer was cut into three different strand widths of 1 inch (25.4 mm), 0.5 inch (12.7 mm), and 0.3 inch (7.62 mm), with block sizes for each strand being the same to achieve the required density of 550 kg/m3. Figure 1 illustrates the production flow chart for parallel strand lumber on OPT and the mechanical testing to be conducted.

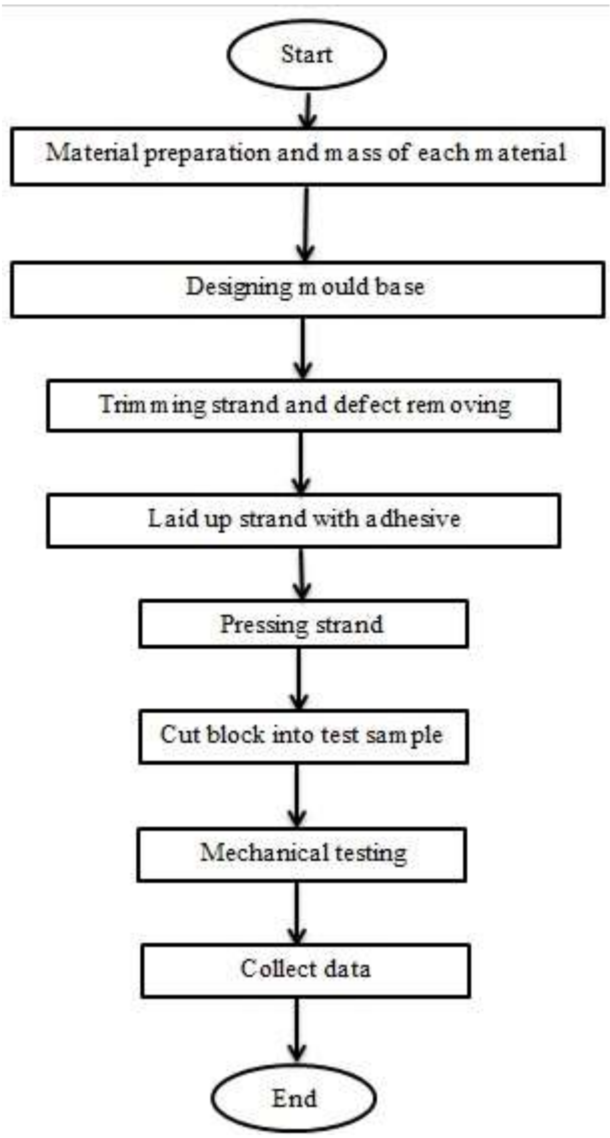


Fig. 1. Depicting of flow chart of designing PSL OPT block and mechanical testing

2.1 Dimension of Specimen for Tensile Test

The tensile test specimens were prepared according to the guidelines in ASTM D143 and cut into smaller dimensions suitable for lab-scale testing. Due to the limitations of the gripper on the Instron universal machine which can expand to the maximum 19 mm causes the specimen cannot be prepare the specimens in larger dimensions. The dimensions of the tensile test specimens are shown in Figure 2, and were cut into a non-dog bone shape.

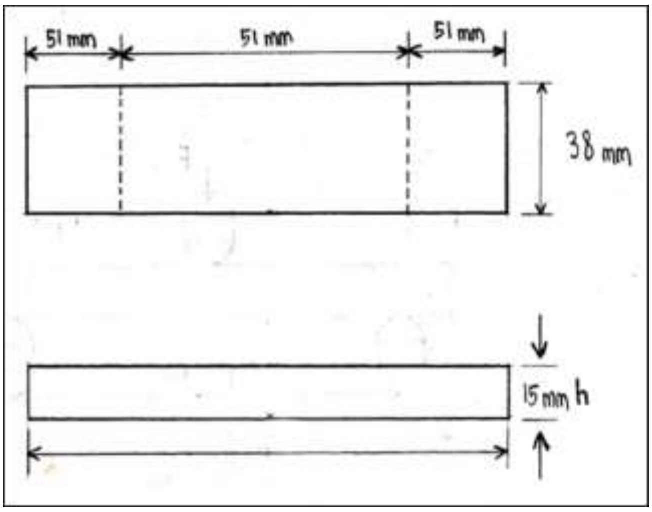


Fig. 2. Dimension of block for tensile test

The specimen used for the tensile test had to be prepared in smaller lab-scale dimensions, as per the guidelines of ASTM D143. This was because the maximum expansion of the gripper in the Instron universal machine was only 19mm. Figure 2 depicts the dimensions of the non-dog bone-shaped specimen used. The specimen had a total length of 153mm, with both ends of about 51mm reserved for the gripper. The experimental was setup for a tensile test which is a type of mechanical test that measures the strength and elasticity of a material when subjected to tension. The specimens being tested have three different sizes with dimensions specified by the ASTM D143 standard. The testing is conducted at a constant speed of 5mm/min with both ends of the specimen held in place by a gripper that measures 51mm on both sides. The Instron universal testing machine is used to perform the testing, and Figure 3 provides a visual representation of the experimental setup.

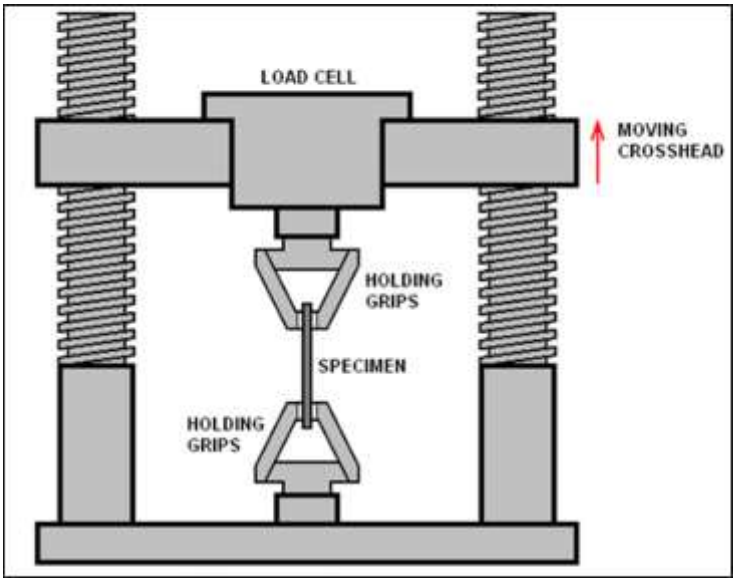
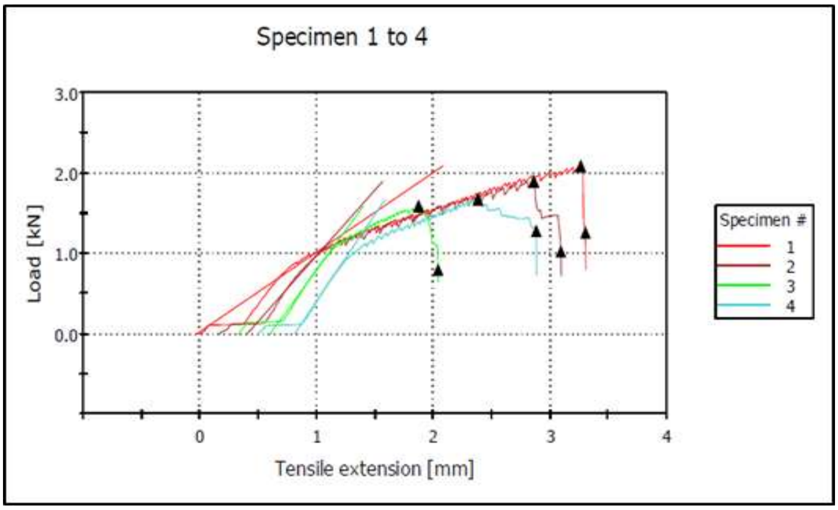


Fig. 3. Tensile test

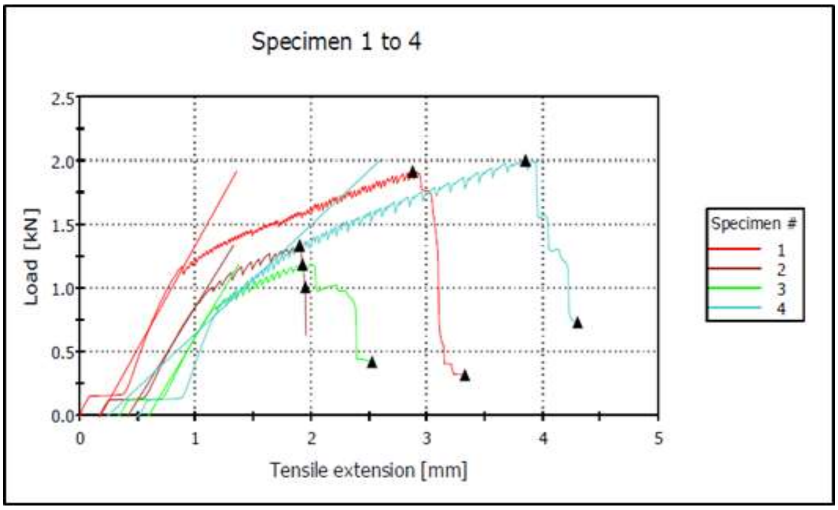
3. Results

3.1 Tensile Strength for each strand: 1 Inch, 0.5 Inch and 0.3 Inch

The study employs the tensile test to determine the elongation of the specimen. This test provides valuable data, including load applied, tensile strength, and tensile modulus, all of which are significant indicators of the mechanical strength of the material. The data obtained from the test is analysed using specialized software called Blue Hill, which is linked to the Instron universal testing machine. The results of the tensile test for each strand size, including 1 inch, 0.5 inch, and 0.3 inch, are graphed and presented in Figure 4. The graph shows the response of the material to the tensile test for each strand size, offering important insights into the behaviour of the material under different levels of stress.



a)



b)

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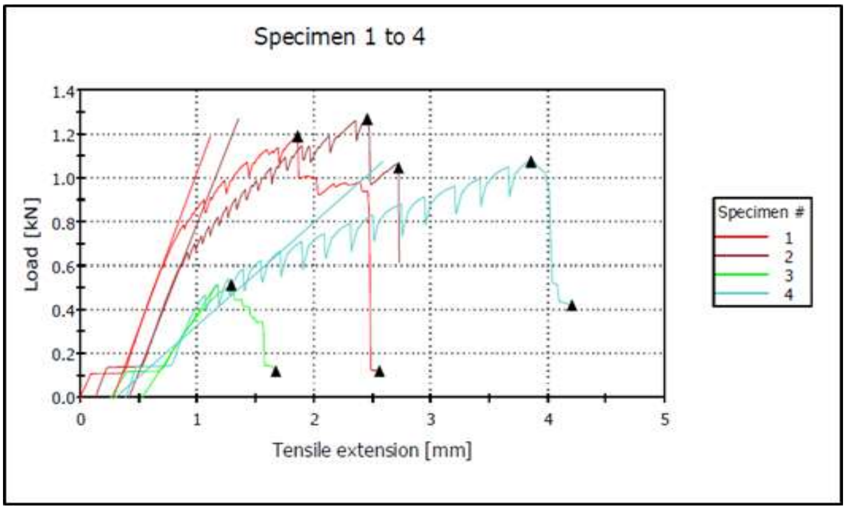
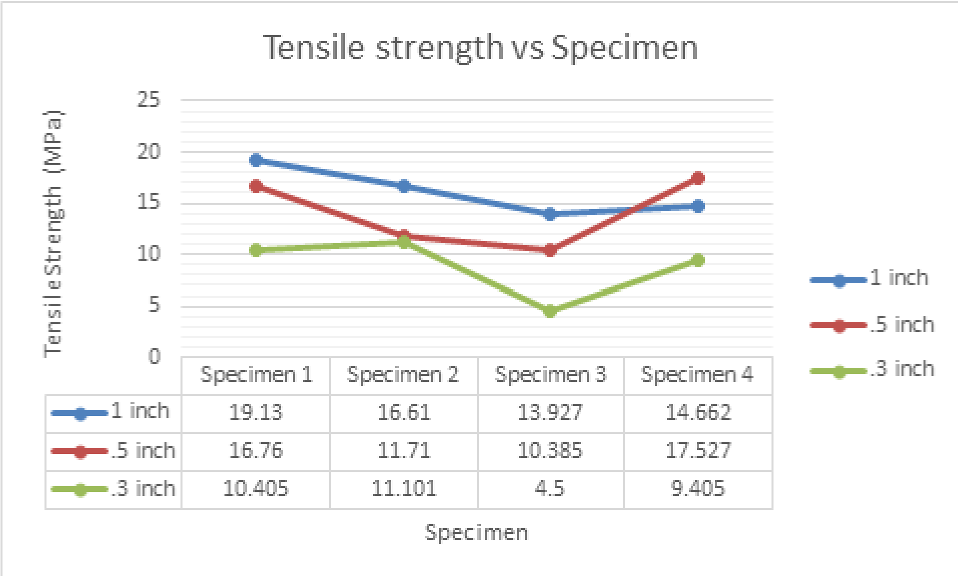


c)



d)

Fig. 4. Tensile test for each strand: a) 1 inch strand, b) 0.5-inch strand, c) 0.3-inch, d) result of tensile strength

The results of a tensile test performed on different sizes of strands show the 1-inch strand, the highest load value was 2.089 kN for specimen 1, and the lowest value was 1.593 kN for specimen 3. Similarly, for the 0.5-inch strand, the highest load value was 2.005 kN for specimen 4, and the lowest value was 1.188 kN for specimen 3. For the smallest strand, with a diameter of 0.3 inches, the highest load value was 1.270 kN for specimen 2, and the lowest value was 0.515 kN for specimen 3.

Represented in Figure 4 d) the highest tensile strength value for the 1-inch strand was 19.130 MPa for specimen 1, and the lowest value was 13.927 MPa for specimen 3. For the 0.5-inch strand, the highest tensile strength value was 17.527 MPa for specimen 4, and the lowest value was 10.385 MPa for specimen 3. For the 0.3-inch strand, the highest tensile strength value was 11.101 MPa for specimen 2, and the lowest value was 4.500 MPa for specimen 3.

Based on the pattern in the graph, it can be inferred that the 1-inch strand has the highest tensile strength (19.130 MPa) compared to the 0.5 inch and 0.3-inch strands. Furthermore, the 0.3-inch strand has the lowest tensile strength (4.500 MPa). These differences in tensile strength values can be attributed to various factors, such as the size and peripheral of the strands, which can affect their strength.

3.1.1 Load applied for each strand: 1 inch, 0.5 inch, and 0.3-inch

The load applied on each specimen in all categories as depicted in Figure 5. The graph pattern suggests that the 1-inch strand can withstand a higher load of 2.089 kN compared to the 0.5-inch and 0.3-inch strands, while the 0.3-inch strand can withstand the lowest load of 0.515 kN. These variations in load applied can be attributed to various factors, including the size and peripheral of the strands and the non-segregation of oil palm trunk strands according to their peripheral strength.

Oil palm trunk is composed of three peripheries that exhibit different strengths but the specimens were not segregated according to their peripheral strength. This lack of segregation may have contributed to the variation in load applied as the weaker strands may have been included in some specimens that leading to lower load values.

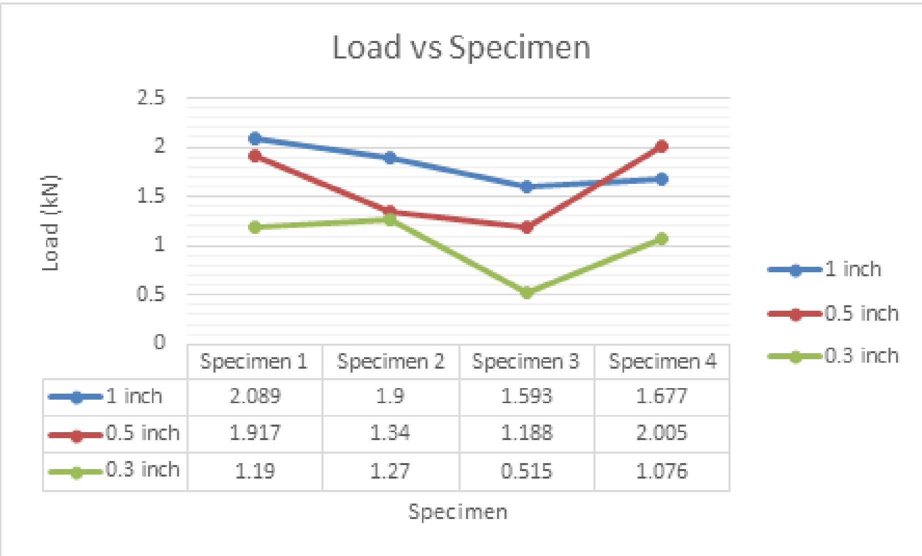


Fig. 5. Result of maximum load applied

3.1.2 Modulus for each strand: 1 inch, 0.5 inch, and 0.3-inch

Figure 6 displays the results of tensile modulus tests for each size of strand. The highest tensile modulus value for the 1-inch strand was observed in specimen 4, with a value of 4732.83 MPa, while the lowest value was recorded in specimen 1, with a value of 2275.69 MPa. For the 0.5-inch strand, specimen 1 had the highest tensile modulus value of 3562.85 MPa, and specimen 4 had the lowest value of 1866.70 MPa. In the case of the 0.3-inch strand, specimen 1 showed the highest tensile modulus value of 3132.74 MPa, while specimen 4 had the lowest value of 1027.88 MPa.

Based on the trend shown in Figure 6, the 1-inch strand demonstrated the highest tensile modulus value of 4732.83 MPa, followed by the 0.5-inch strand, and the 0.3-inch strand had the lowest tensile modulus value of 1027.88 MPa.

The experimental results suggest that the 1-inch strand exhibited higher values of load applied, tensile strength, and tensile modulus. The reason behind this is likely due to the fact that the test was conducted vertically, with the force applied in an upward direction, which required the strand to withstand the force with its own fibre strength during elongation before reaching the point of failure.

The amount of fibre present in the strand is dependent on its width, with a greater amount of fibre resulting in greater strength to withstand forces. Therefore, the wider 1-inch strand had a greater amount of fibre resulting in higher values of tensile modulus.

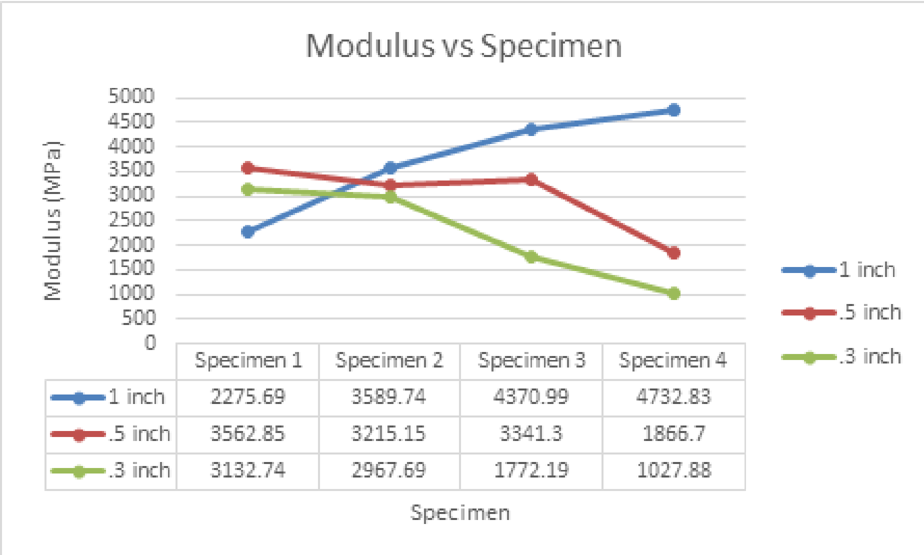


Fig. 6. Result of tensile modulus

4. Conclusions

The oil palm trunk is a composite material composed of varying properties of strength and density across its different sections, including the cortex, peripheral zone, inner zone, and central zone. Among these sections, the peripheral zone has a higher concentration of fibres and possesses greater strength. However, its lower medium density and lower density categories suggest that its strength may not be fully utilized in practical applications.

To address this issue, this study utilized a combination of strands from all sections of the oil palm trunk and applied the parallel strand lumber (PSL) method to improve the material's mechanical properties. This method arranges the strands in a parallel orientation randomly in order to eliminating any defects in the trunk and enhancing its overall strength.

The results of the mechanical testing revealed that there was no significant difference between the three strand sizes used in the study. While the 1-inch strand exhibited higher mechanical strength, the 0.5 inch and 0.3-inch strands performed equally well. This finding suggests that the PSL method can be effective in improving the mechanical properties of the oil palm trunk, regardless of the strand size used.

In conclusion, PSL method can be used to improve the mechanical properties of the oil palm trunk by arranging the strands in parallel orientation. The study found that the adhesive used in bonding the strands is also crucial in enhancing the strength and also found that the differences in mechanical strength values between the three strand sizes used were not significant suggesting that the PSL method can be effective regardless of the strand size used.

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