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PERFORMANCE OF FINGER JOINTED TIMBER BOARDS WITH DIFFERENT JOINT CONFIGURATIONS

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Abstract: Timber is one of the construction materials commonly used in Sri Lanka. When using timber for construction purpose waste timber is also produced. This is being used in a useful manner with finger jointed system. But in Sri Lanka still there is a lack of knowledge in using finger joint in an efficient way. Main objective of this study is to find the most suitable finger joint length and type of adhesive through experimental results to have better efficient structural performance. Tests such as bending, compression (grain parallel and perpendicular), tension (parallel to grain) and shear perpendicular to grain were conducted. For these tests BS 373:1957 and EURO CODE 5 were used as standards for tests. In Sri Lanka Hardwood class timber waste is generated in more than other classes. Therefore, Hardwood class timber Teak has been used for all test carried out. Ultimate limit compressive stress grain parallel Finger jointed timber variation was obtained between 24.17 MPa - 36.09 MPa. At the same time the serviceability limit compressive stress grain perpendicular value variation was between 22.02 MPa - 26.15 MPa. Here the highest value was obtained for the finger length of value 14mm.Similarly, the Ultimate limit compressive stress of Grain perpendicular varies between 5.69MPa - 9.6MPa and the serviceability limit compressive stress of grin perpendicular varies in between 1.91Mpa-5.59 MPa. Here highest value was obtained for the finger length of 25mm. Also the shear stress values showed the variation between 2.5 MPa -3.14 MPa. The Modulus of elasticity varies between 1.249GPa - 2.889Gpa. Here the highest value was attained when the finger length was at 14mm. And also the Ultimate modulus of Rupture differs within the range of 12.44MPa - 27.37Mpa where the highest value was gained for the finger length of 25mm. Ultimate limit of tensile stress varies between 12.54 MPa -18.5 MPa here highest value attained when the finger length was at 25mm also Favicol SWR adhesive shows high Tensile stress value 18Mpa finally The Strength properties show a non-linear variation with the finger length. Therefore, based on structural strength requirement finger length should be decided.

Keywords: Structural performance; Finger joint, Teak; Joint configuration; Adhesive type

1. Introduction

Off-cut wood is the main waste emitted from the sawn mills. Off-cut wood gained as wastage from this manner is already being used as fuel in kiln fired boilers. But this method of using as fuel is not economically efficient. Because of this the finger jointed timber system was introduced in timber inefficiency is the unavailability of the proper knowledge about finger jointed system. Figure 1 shows finger jointed timber board. In this study the structural performance of the finger jointed timber is going to be investigated through experimental results. In Sri Lanka the Hard Wood class timber is commonly used, therefore this type of Hard Wood class timber has been selected for the experiments. There are three main advantages in the finger jointed timber system namely increase in usage of long part, re-usage of short pieces of waste material and clear wood form low grade lumber.

The strength of the finger jointed timber can be varied with the variation of the factors such as species, density of wood, natural defects configuration of finger and glue type. The strength of the finger jointed timber will also vary with the adhesive type used for the finger jointed system. This factor is also going to be analyzed under this study. All the test samples for compression, tension, shear and flexural experiments were taken with the moisture content around 12% to 20% Moisture content measured by moister meter. Current study is investigated structural performance of finger jointed Teak timber boards with different joint configurations

2. Methodology

The following methodology was developed to observe the variation of Load bearing capacity of the Finger jointed timber with its joint configuration. Figure 2 clearly shows how the joint configuration of Finger jointed timber is commonly named. Considering the Load bearing capacity of Finger jointed timber, it is expected to be changed with the variation of Finger length(L), Pitch width(P), Tip width(T) and Tip gap (T.G). As the Finger length is expected to have a significant impact in Load bearing capacity, it was decided to observe the variation through experiment. In the experiments the following strength parameters were observed with change of the finger length. Such strength parameters are;

1. Compressive stress
    a. Grain parallel
    b. Grain perpendicular
2. Tensile stress
3. Flexural stress
    a. Modulus of Rupture
    b. Modulus of Elasticity
4. Shear stress

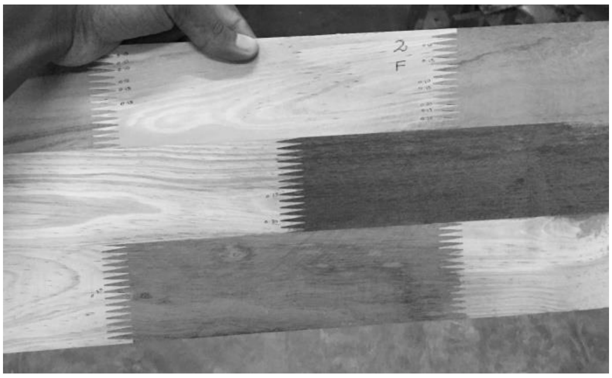

Figure 1: Finger jointed timber board

These strength parameter variations were observed with the change of Finger lengths 14mm, 19mm and 25mm for the experiments.

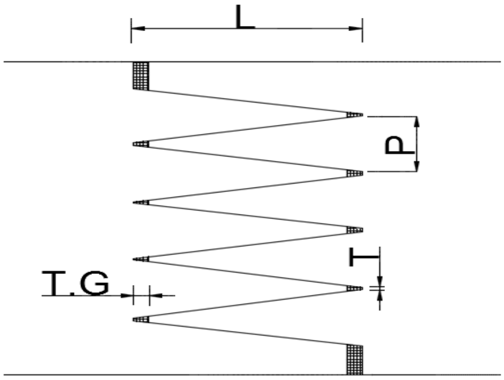

Figure 2: Configuration of Finger jointed timber

It was observed that Load bearing of the Finger Jointed timber was changing with the Adhesive type used for the Jointing work. In order to explain it through the experiments, the tensile stress variation was observed for several Adhesive types used for timber work. Tensile stress is only considered in these experiments because adhesive get failure mainly due to tensile load. Different adhesive types used for these experiments are given below

1. Favicol SWR (Synthetic Resin Adhesive)
2. Epifix (Epoxy Adhesive)
3. Favicol PUR (Polyurethane Adhesive)

Addition to this it was also observed how the position of the finger joint influence in the timber flange in these experiments. Flexural stress was considered as the main factor in these experiments.

In order to observe the variation of load bearing capacity of finger jointed timber with finger length, all other parameters such as timber class, width, height and adhesive type were kept constant while finger length was changed and the variation of load bearing capacity was observed.

To investigate the variation of load bearing capacity of finger jointed timber with adhesive, the adhesive type was changed while all other parameters were kept unchanged and the load bearing capacity was tested. Then the finger jointed timber was compared with the normal timber and the applications of finger jointed timber were also discussed. This research was conducted according standard codes such as BS 373:1957 and EURO CODE 5.

2.1 Compression Test

Compression test was conducted parallel to grain and perpendicular to grain. Axial compression was given at the rate of 2mm per minute up to ultimate failure by using Universal Testing Machine. (BS373, 1957 [1])

$$P = F/A \qquad \text{Eq.1}$$

P - Compressive stress
F - Load applied on the Specimen
A - Cross sectional area

2.1.1 Compression parallel to Grains

Compression capacity parallel to grain test was conducted by using 50mm×50mm×400mm timber specimen. Figure 3 shows test set-up for compression load applied parallel to grain.

2.1.2 Compression perpendicular to Grains

Compression test perpendicular to the grains was conduct by using 50mm×50mm×50mm timber cubes. Same procedure was conducted as compression grains parallel. Figure 4 shows applied test set-up for compression load applied perpendicular to grain.

Figure 3: Test set-up for compression grain parallel

Figure 4: Test set-up compression grain perpendicular

2.2 Flexural Test

Specimens were subjected center point loading bending test. Applied central loading and the mid-span deflection were measured. Size of 50mm×50mm×750mm timber specimens were used for the test. Load was given at the rate of 2mm per minute up to ultimate failure by using Universal Testing Machine with simply supported condition at the ends as shown in Figure 5. Test results were used to calculate modulus of elasticity (MOE) and modulus of rupture (MOR) as expressed equation (2) and (3).

$$MOR = MY/I \qquad \text{Eq. 2}$$

M - Maximum Bending moment

Y - Maximum distance from neutral axis to edge of the section

I - Second moment of area

$$MOE = WL^3/48\delta I \qquad \text{Eq. 3}$$

L -Length of timber specimen

W - Maximum load applied at the center of specimen

δ -Maximum deflection of timber beam

I - Modulus of elasticity

Figure 5: Test set-up for flexural

2.3 Tension Test

Tensile test was conducted by using size of 50mm×50mm×300mm timber specimen as shown in Figure 6. Load was applied to grains parallel of the samples by using Universal Testing Machines with 2mm per minute loading rate. (BS373, 1957 [1]). Tension capacities of specimens were calculated using maximum load and average area of the specimens as expressed in equation (4)

$$T = F/A \qquad \text{Eq. 4}$$

T -Tensile Stress

F - Load act in Specimen

A- Cross sectional area

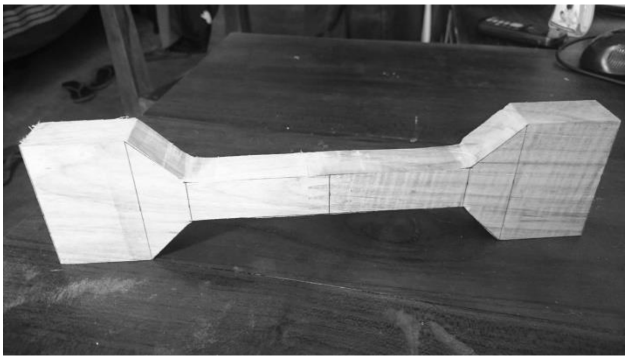

Figure 6: Specimen of tension capacity test

2.4 Shear Test

Shear test was conducted by using size of 50mm×50mm with thick 25mm 'L' shape specimen. Load was applied to grain perpendicular to the samples by using Universal Testing Machine as shown in Figure 7 with a loading rate of 0.5mm per minute up to failure Shear capacity was calculated by using maximum load and average shear area.

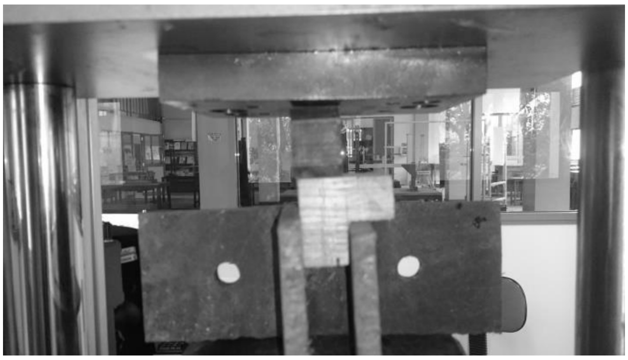

Figure 7: Test set-up for shear

3. Results and Discussion

The experiment was done to examine the load bearing of the finger jointed timber. Figure 8 shows load vs extension variation for timber specimen. The serviceability load and the ultimate load values can be calculated from the graph as shown in figure 8.

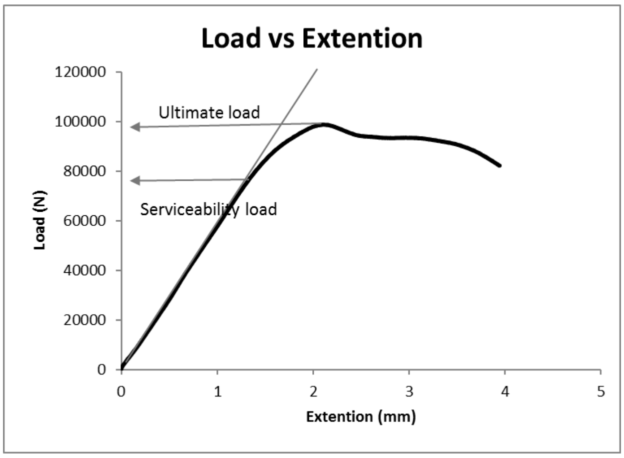

Figure 8: Applied load vs Extention curve

3.1 Flexural stress variation with Finger length

Flexural strength capacities were calculated with the experimental data. From the results gained the maximum Modulus of Rupture was achieved for the finger length value of 25mm (Figure 9). The Modulus of elasticity of Finger jointed timber showed variation of decrement with the increment of the finger length. This variation is clearly shown in the Figure 10. Failure mode of flexural specimen is shown in the Figure 11.

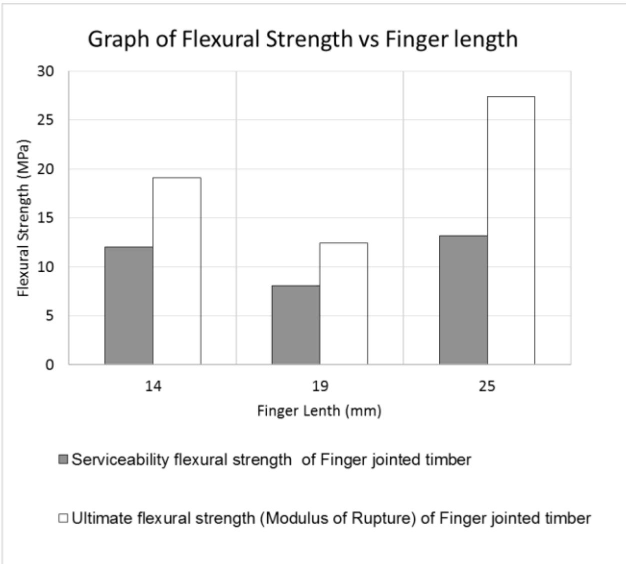

Figure 9: Graph of Flexural Strength vs Finger length

3.2 Compressive stress variation with Finger length

Compressive strength capacities were calculated with the experimental data. Here the compressive stress of Grain parallel was increasing with the increase of finger length.

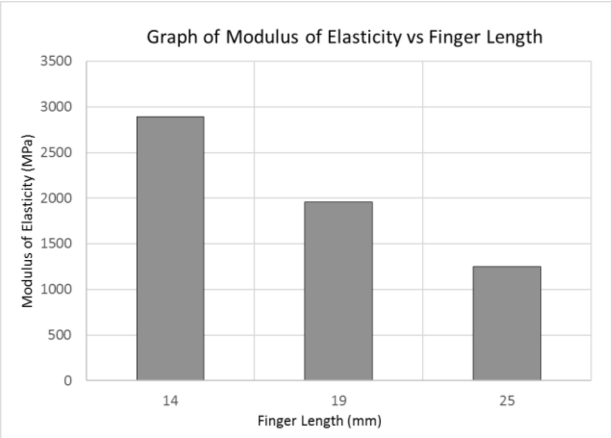

Figure 10: Graph of Modulus of Elasticity vs Finger length

At the same time compressive strength of grain perpendicular shows the highest serviceability capacity of 5.59 MPa and the highest ultimate capacity of 9.6 MPa for finger length of 25mm.Figures 12 and 13 clearly shows the variation of Compressive capacity vs Finger length. Failure mode of the compression grain parallel specimen is shown in the Figures 14.

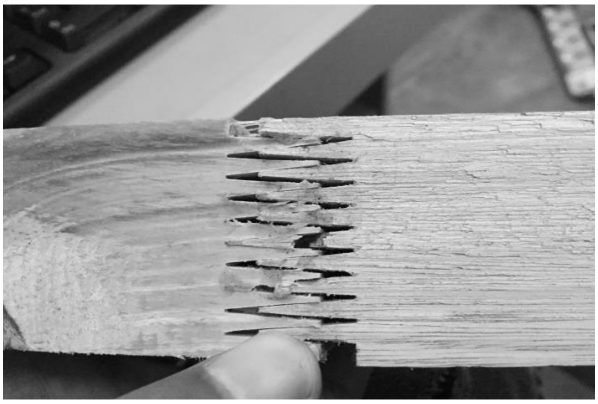

Figure 11: Failure mode of flexural specimen

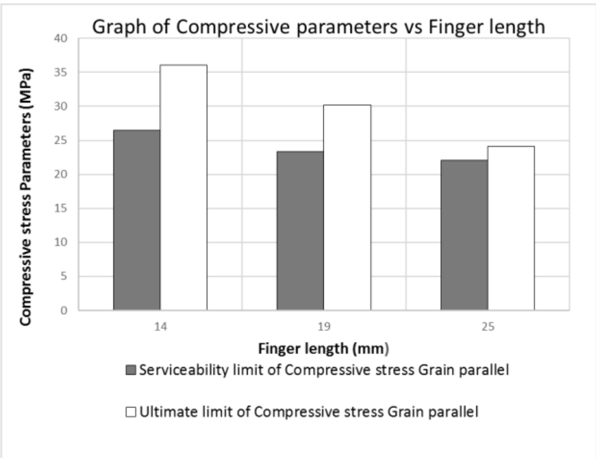

Figure 12: Graph of Compressive Stress grain parallel Vs Finger length

3.3 Shear stress variation with Finger length

Shear stress values were calculated from the experimental data. These values increase with the increase of finger length. Figure 15 clearly illustrate the variation of shear stress vs Finger length.

3.4 Tensile stress variation with Finger length

Tensile stress capacities were calculated using experimental data. The Tensile stress was increasing with the increase of finger length. At the same time Tensile strength of Grain Parallel shows the highest ultimate capacity of 18.50 MPa for Finger length of 25mm.Figure 16 shows the variation. Failure types of the Tensile specimen shown in Figures 17.

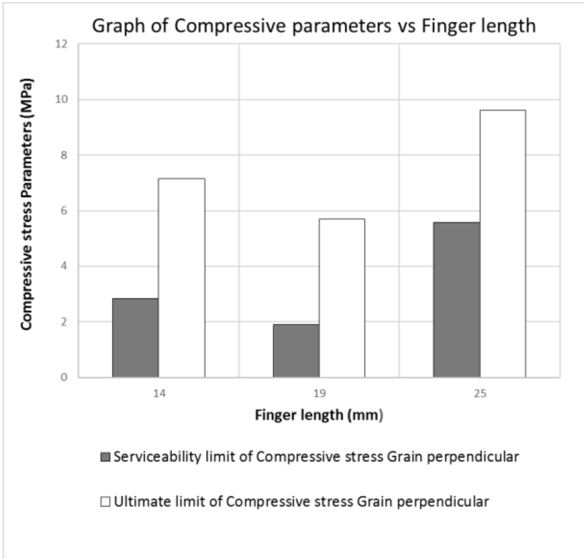

Figure 13: Graph of Compressive Stress grain perpendicular Vs Finger length

Figure 14: Failure mode of compression grain parallel specimen

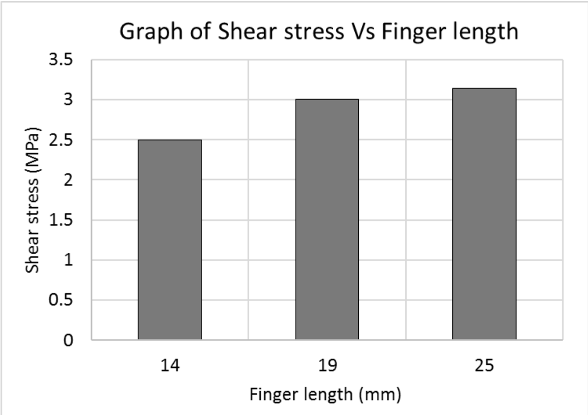

Figure 15: Graph of Shear Stress Vs Finger length

3.5 Tensile stress variation with Adhesive type

Tensile stress capacities were calculated with the variation of adhesive type in order to find out load bearing capacity of finger jointed timber with different type adhesives. Here, Favicol SWR adhesive was showed highest Tensile capacity of 13.59 MPa The Following Figure 18 shows the variation of tensile capacity for different adhesive type.

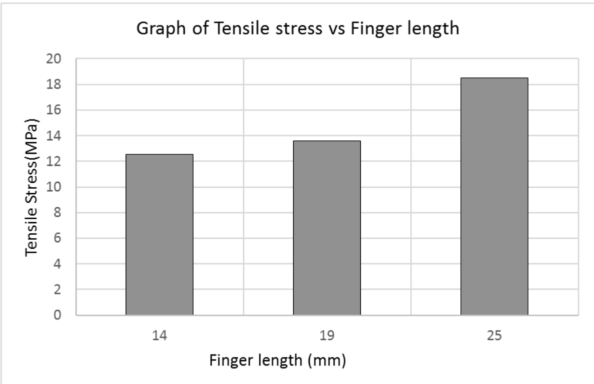

Figure 16: Graph of Tensile stress vs Finger length

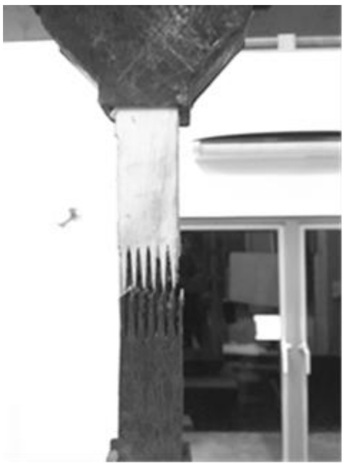

Figure 17: Failure mode of Tensile specimen

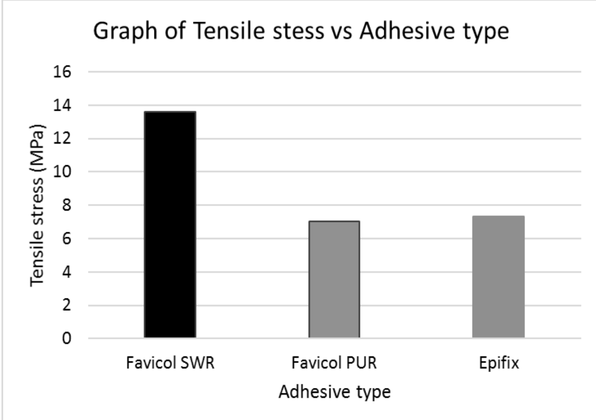

Figure 18: Graph of Tensile stress vs adhesive type

4. Conclusions

In this study it is analysed how the load bearing capacity of finger jointed timber is changed with the variation of several finger jointed configurations.

The ultimate compressive stress grain parallel variation was obtained between 24.17MPa to 36.09MPa. At the same time the serviceability compressive stress grain perpendicular value variation was between 22.02MPa to 26.15MPa. Here the highest value was obtained for the finger length of value 14mm.

Similarly, the ultimate compressive stress of grain perpendicular varies between 5.69MPa to 9.6MPa and the serviceability compressive stress of grain perpendicular varies in between 1.91MPa to 5.59MPa. The highest value was obtained for the finger length of 25mm. Also the shear stress values showed the variation between 2.5 MPa -3.14 MPa.

The Modulus of elasticity varies between 1.249GPa to 2.889GPa. The highest value was attained when the finger length was at 14mm. Also the ultimate Modulus of Rupture differs within the range of 12.44MPa to 27.37MPa where the highest value was gained for the finger length of 25mm. Ultimate tensile stress varies between 12.54MPa to 18.5MPa and highest value was attained when the finger length at 25mm. also Favicol SWR adhesive shows high Tensile stress value of 18MPa The Strength properties of Finger jointed timber show a non-linear variation with the finger length. Therefore, based on structural strength requirement finger length should be decided.

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