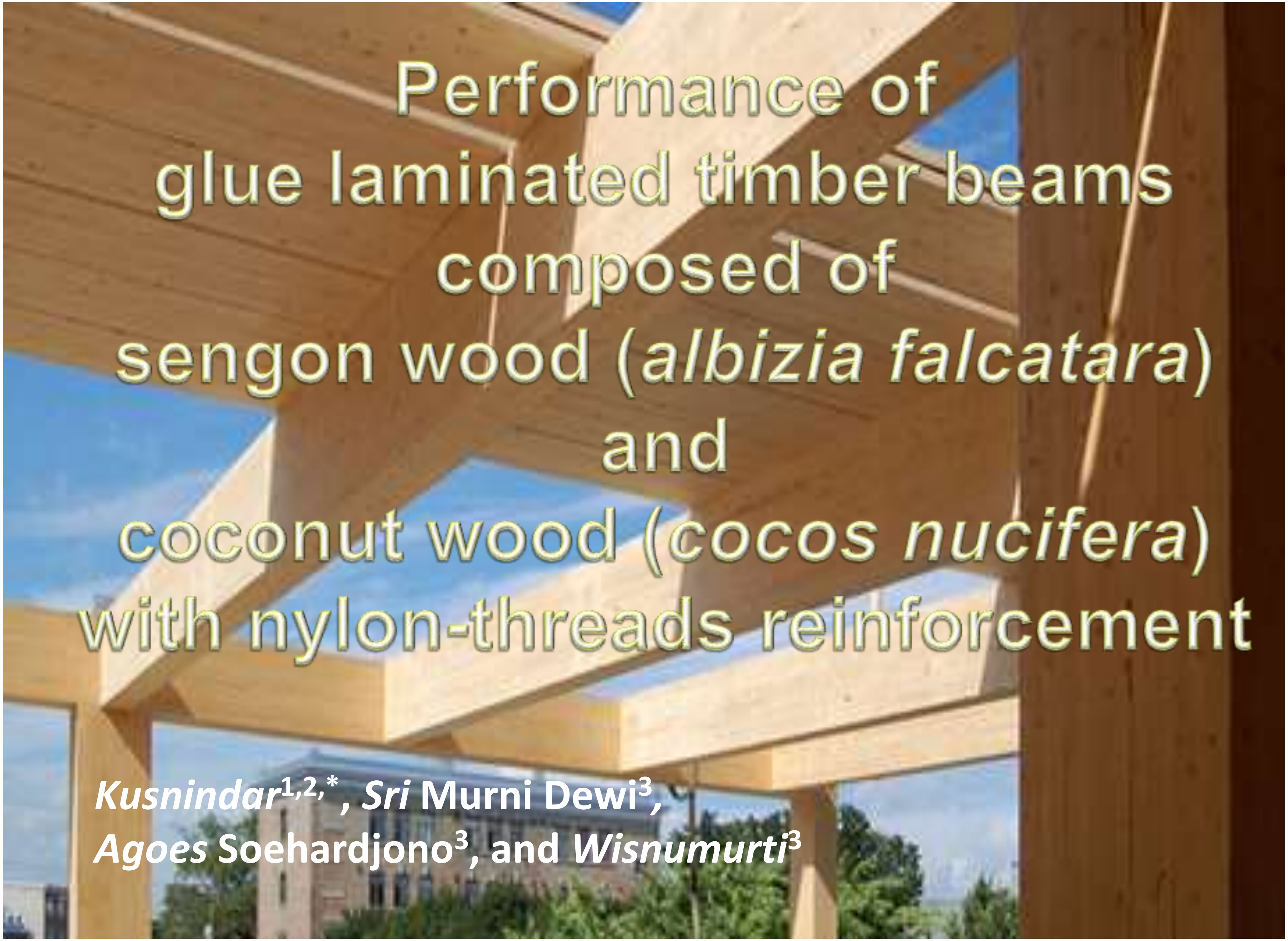

Performance of glue laminated timber beams composed of sengon wood (*albizia falcatara*) and coconut wood (*cocos nucifera*) with nylon-threads reinforcement

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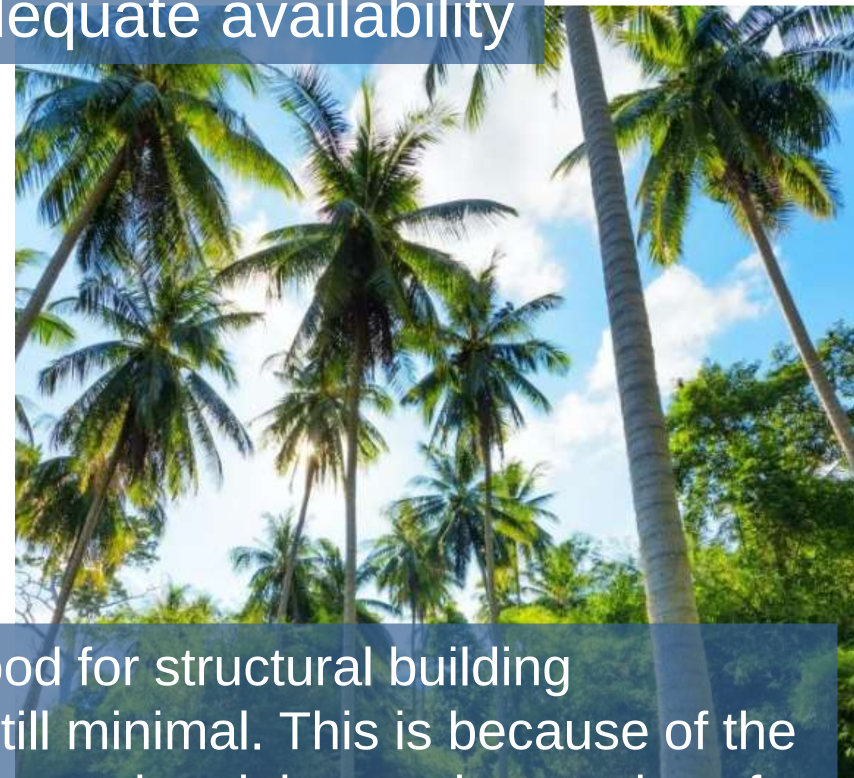
1 Introductions

potential for adequate availability



The utilization of these two species of wood for structural building components, especially in Indonesia, is still minimal. This is because of the low mechanical characteristics of sengon wood and the varying grades of coconut wood

Sengon wood (*Albizia falcatara*) is a low-grade timber (ρ = 0.29-0.314 gr /cm^3) .
Light weight structures

coconut wood (*Cocos nucifera*) has better mechanical properties (ρ = 0.64-0.96 gr/cm^3)

- Improvement of the performance of low-grade timber can be done through the mix-glulam timber system or reinforcement.

Therefore:

- This study aims to describe the performance of glulam-beams consisting of coconut wood on outermost laminations and sengon wood on core laminations.
- This will also explain the effect of nylon-strapped as external reinforcement.
- The development of this method is expected to expand the utilization of sengon and coconut wood and reducing the dependence of the timber supply from forests.

2. Experimental programs

2.1 Specimen preparation

Lamina materials

Dimension:

2.6 cm in thickness,

6 cm in width

200 cm in length.

sengon wood

ρ_{12} = 0.32-0.34 gr/cm^3

coconut wood, ρ_{12} = 0.58-0.85 gr/cm^3

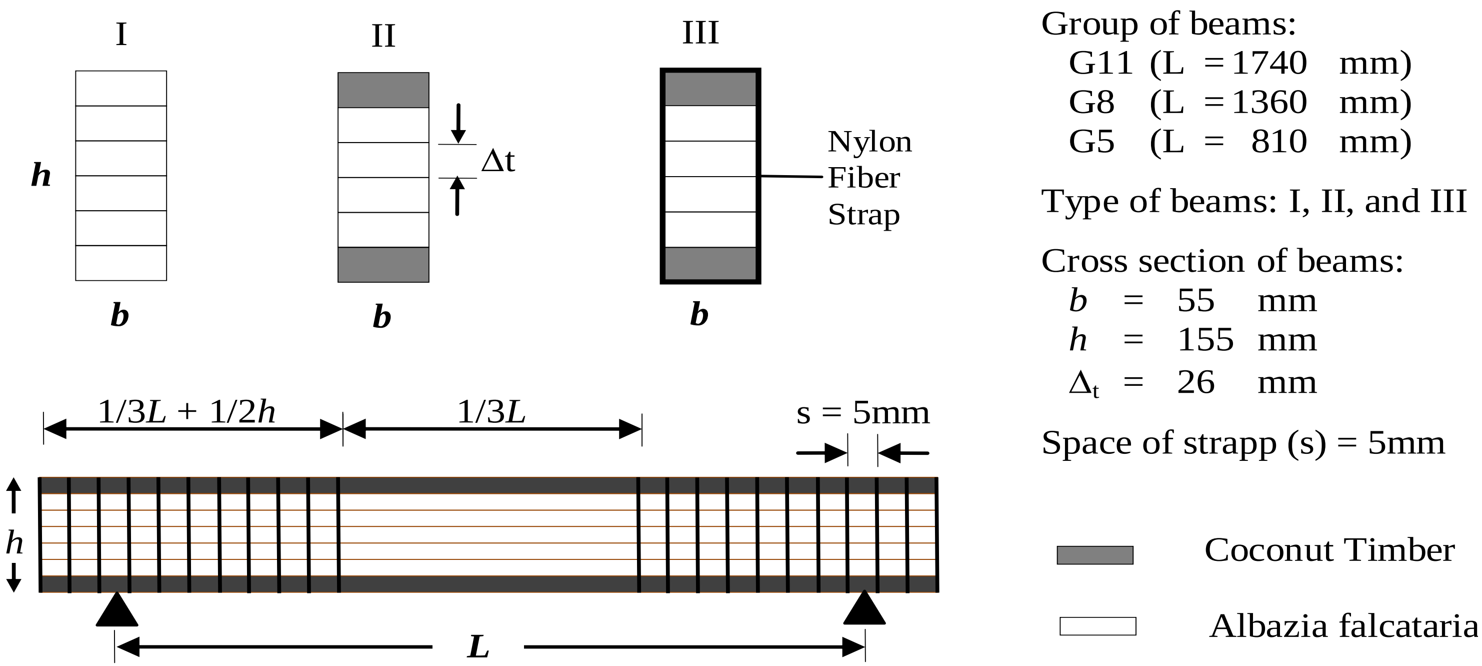


Fig. 1. Geometry and composition plan of beams

G11⇒ L/h = 11.2, G8 ⇒ L/h = 8.8 and G5 ⇒ = 5.2

Three types of each group:

Type I: 6 laminations of sengon wood;

Type II: 4 sengon in the core zone & 1 coconut wood on top and bottom;

Type III: similar to type II + external reinforced nylon straps. Every type consisted of three beams, so the total glulam beams were 27.

2.2 Glulam beams fabrications

1. The glue spread was done for a maximum of 15 minutes for every beam.

2. Then, it was followed by putting horizontal and vertical clamps with spaces of 25cm along the beams.

3. Cold pressure by applying a pressure force of 2.0 MPa

4. Application of nylon straps. The nylon used was in the form of 1.0 mm diameter threads.

The adhesive:

2gr UF resin : 1gr water is used.

The glue spread rate is 350 g/m^2.

- Pressure was done by using a hydraulic jack at the point where the clamp was attached. After the process of pressure was done, it was then followed by adhesion maturation. This was done by putting the beam with an attached clamp on a flat surface for about18 hours.
- When the gluing was perfectly done, then vertical clamp was released.

2.3. Static three-point bending test

The test is intended to obtain load-deflection data of each beam. The test was carried out according to ASTM D198-02. The instrument configuration is presented in Figure 3.

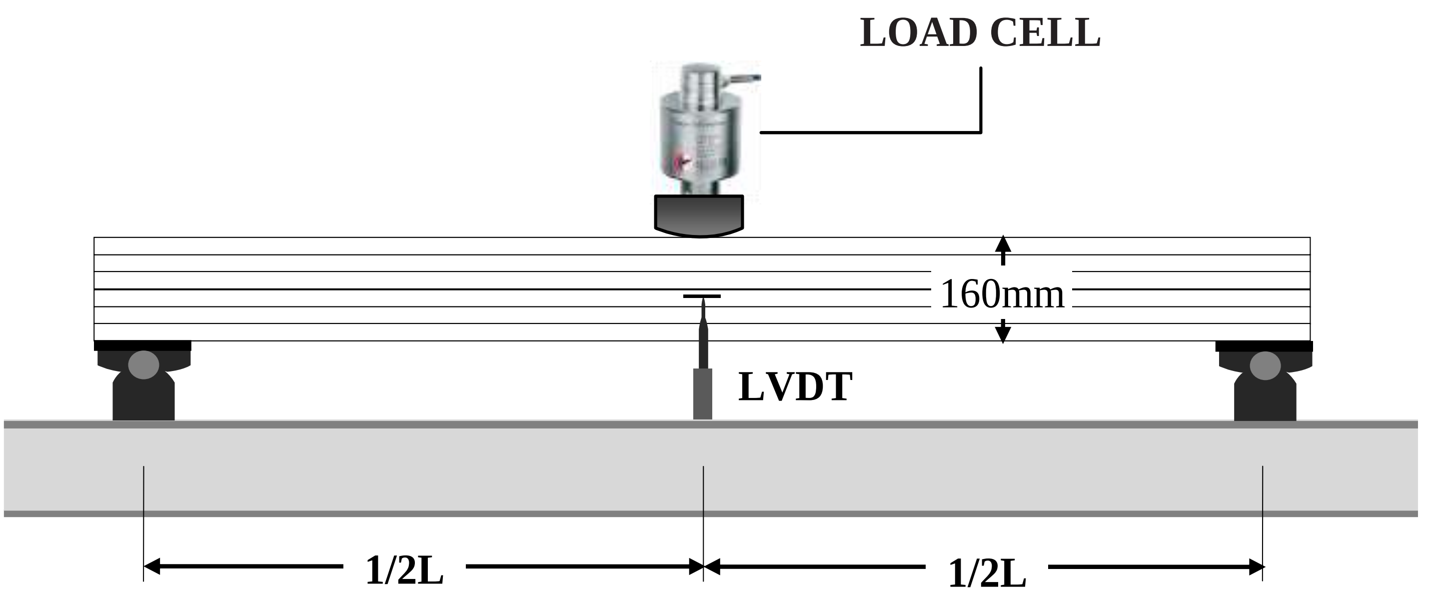


Fig. 3. Set-up of three-point bending test.

Tabel 1. Summary data result of three-point load bending test of glulam.

3 Experiment results

3.1 Mechanical properties of glulam beams

Average value of mechanical properties of glulam beams is presented in Table 1.

Beams Series	h (mm)	B (mm)	L (mm)	L/h	σ_{max} (MPa)	E (MPa)	δ_{max} (mm)
G11.I	155	55	1,740	11.2	38.9	5,070	32.8
G11.II					41.3	5,889	27.2
G11.III					38.1	6,077	20.5
G8.I	155	55	1,360	8.8	55.6	4,533	15.9
G8.II					49.8	4,934	14.4
G8.III					53.3	4,654	16.2
G5.I	155	55	810	5.2	51.3	2,947	7.6
G5.II					65.4	2,377	7.6
G5.III					72.4	2,333	8.9

3.2 Load-displacement curve

3.2.1 Glulam beams group G11

All beams went through a linear and nonlinear phase before reaching failure. The nonlinear phase of the type I-beams was longer than that of type II and III.

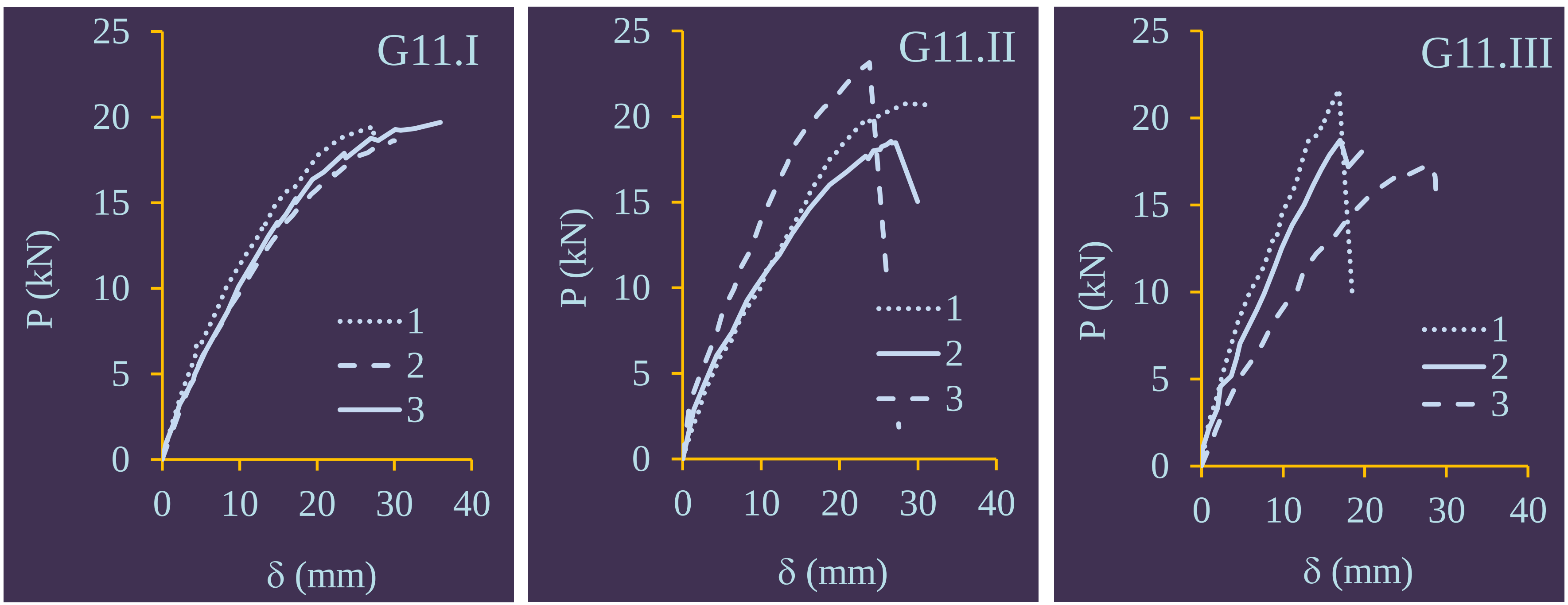


Fig. 4. Load-deflection curve for glulam group G11

3.2.2 Glulam beams group G8

There is no significant difference in behavior between the types of beams. The linear phase is more dominant for all of them until failure.

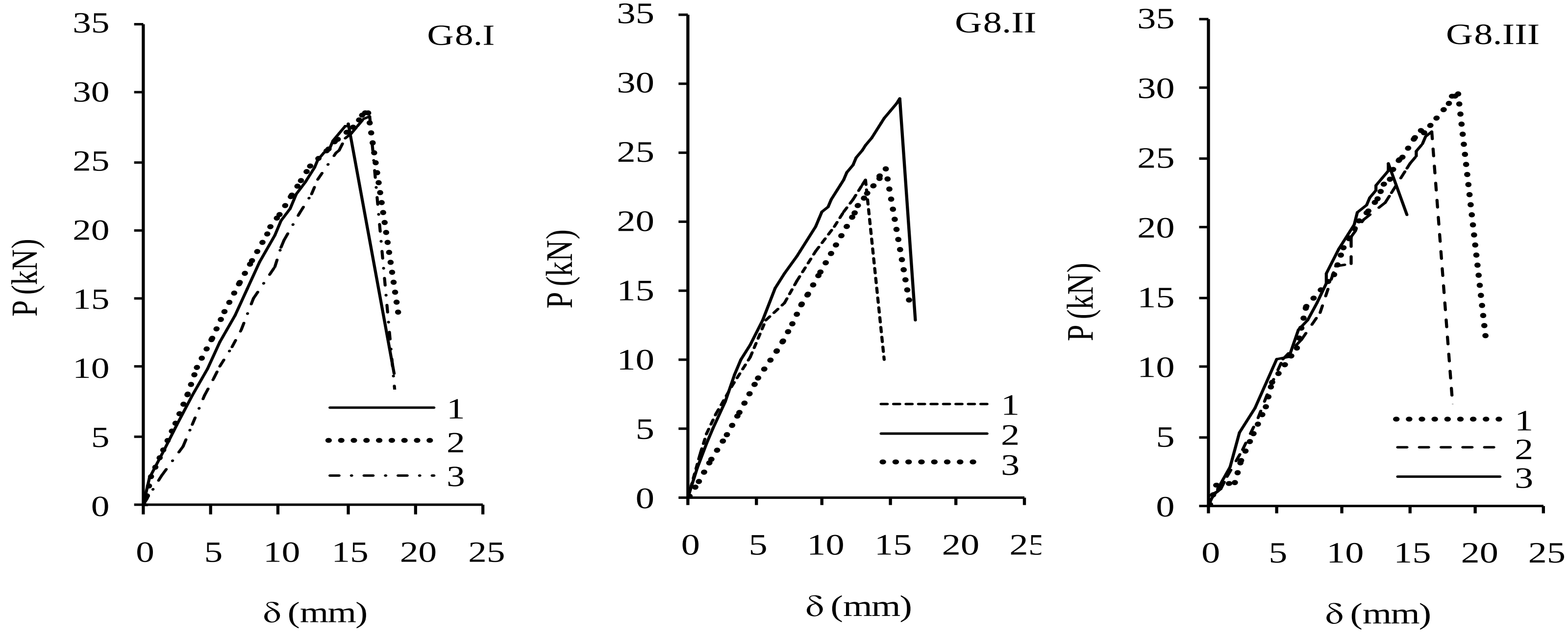


Fig. 5. Load-deflection curve for glulam group G8

3.2.3 Glulam beams group G5

Type I-beams show a linear and nonlinear phase, but not so for type I and III. There was a significant increase in the maximum load when compared with type I of glulam.

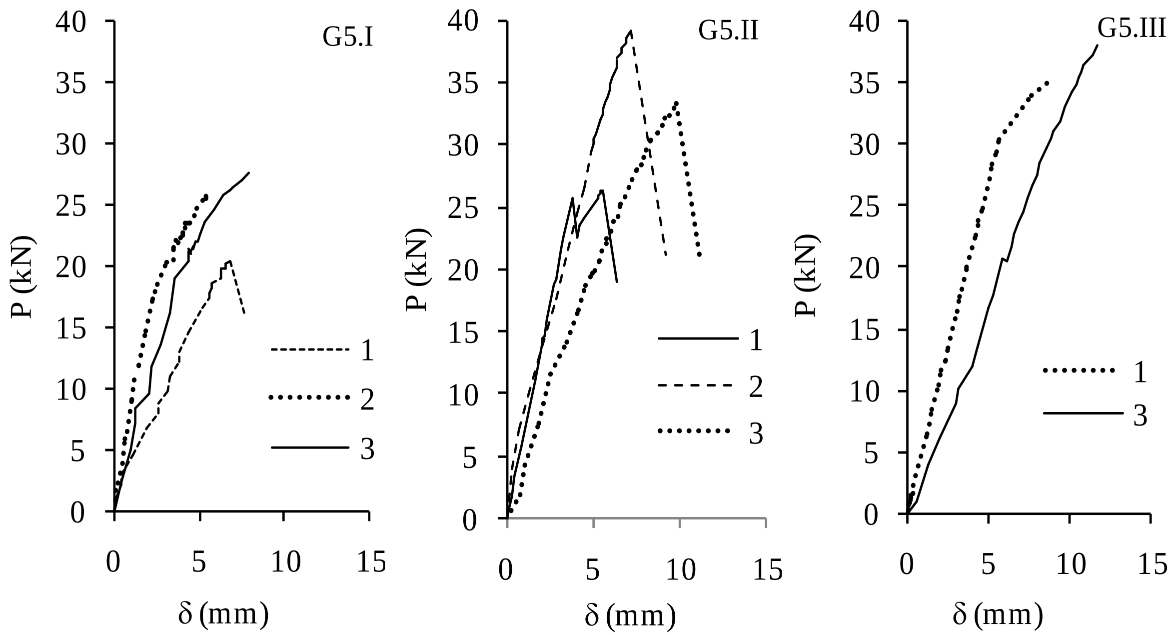


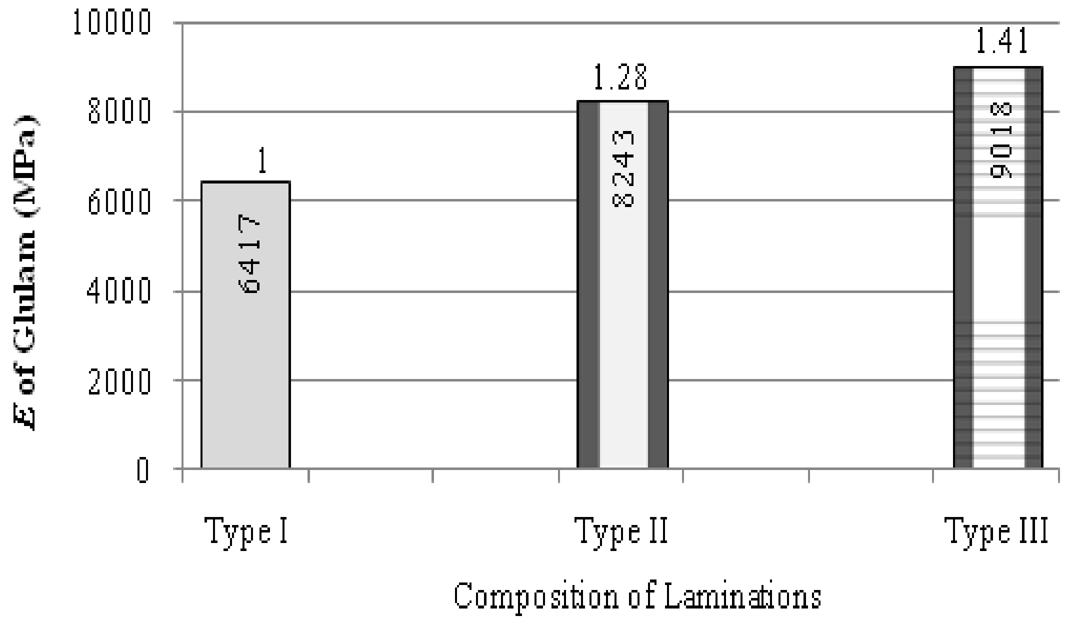
Fig. 6. Load-deflection curve for glulam group G5

4 Discussion

4.1 Effect of laminations lay up & reinforcement to elasticity

- The placement of coconut wood lamination increases the modulus of elasticity by 28%.

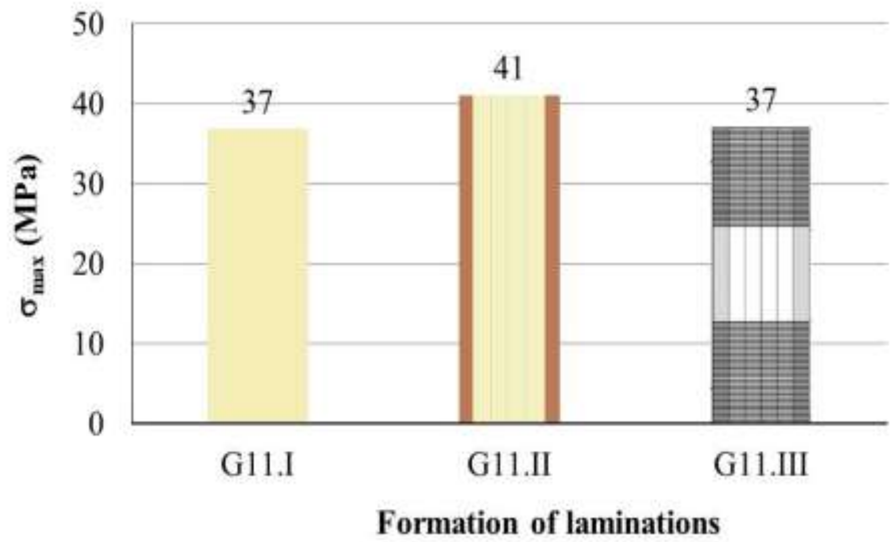
- The strengthening with the nylon strap increased the modulus of elasticity by 41%.



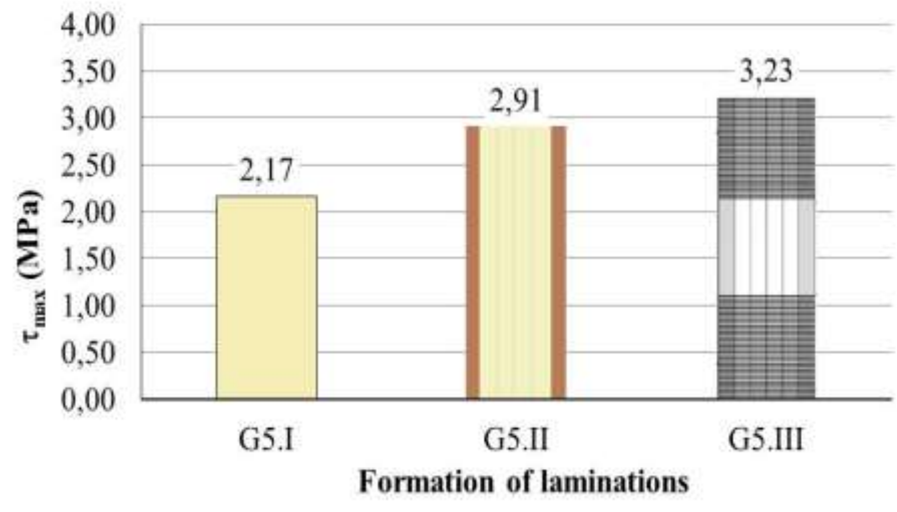
- Comparison between types II & III obtained the fact that the nylon straps improve the elasticity of the beams by 13%. This suggests that the strength increase of the outer zone lamination will increase the strength of the laminated beams.

4.2 Effect of formation of laminations & reinforcement to bending & shear strength

- The bending strength of glue-laminated timber beams is influenced by the configuration of the lamina. In the G11, the placement of coconut timber as the outer lamina & nylon reinforcement provides an improved bending strength by 13% and 2% respectively.

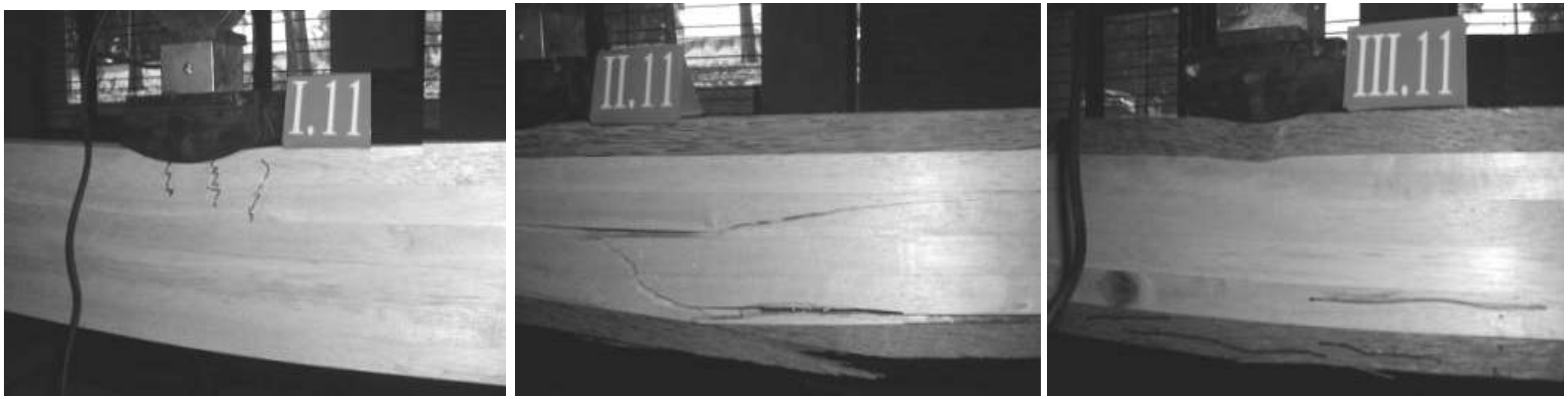


- The placement of the coconut wood laminations & the reinforcement produce a fairly high shear strength. The formations II & III produce a maximum shear stress of 34% and 49%, higher than formation I.



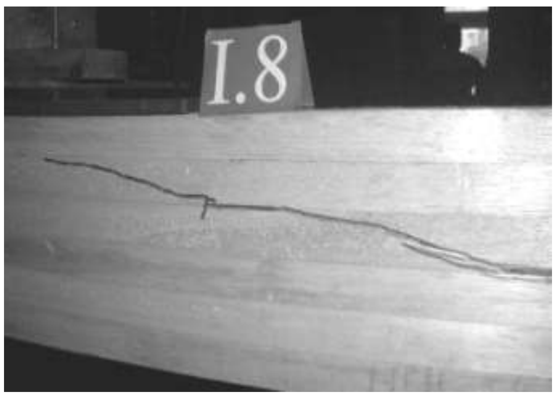
4.3 Failure mode of glulam beams

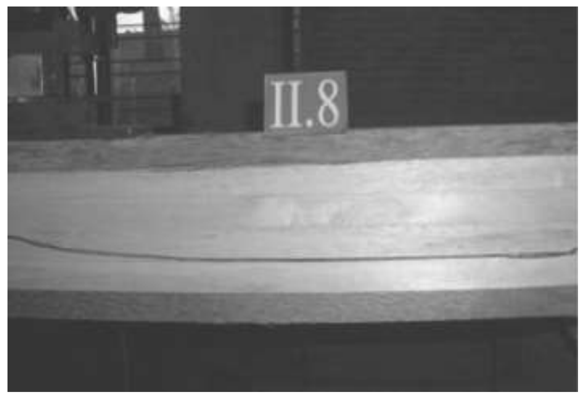
- The placement of coconut timber as the outer lamina is the reversal of the failure mode, from the compression to the tension failure.
- In this case, the failure mode of beam-type II and III are more brittle than that of type I.



- On the other hand, the beams reinforced with nylon fiber straps has contributed to a reduction in the damage intensity of the beams in failure.

- The shear failure was indicated by a horizontal crack propagation from the support area to the midspan of the beams. In this case, the use of nylon fiber reinforcement leads to changes in the mode of failure.





- The flexural failure of the beam was starting from the tension side that is not reinforced. So the application of nylon fiber reinforcement to glulam beams with caused the failure mode to change from shear mode to flexural mode

5 Conclusion

- Placement of coconut wood as outer lamination and strengthening using nylon is very effective to increase the bending and shear strength of glulam beams.
- The placement of the coconut wood as the outermost lamination succeeded in increasing the elastic modulus, the flexural and shear strength of beams by 28%, 13%, & 34%, respectively.
- The reinforcement with nylon straps results in an increase in the modulus of elasticity and shear strength of glulam by 41%, and 49% respectively.
- In the case of bending strength, the reinforcement with nylon yarn is relatively unaffected


Thank you
Assalamu Alaikum
Warahmatullahi
Wabrakathu