

Original Research Article

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## Assessing the Suitability of *Sterculia foetida* for Plywood Production

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### ABSTRACT

The results revealed that the mean value for green wood density and drywood density varied from 802.42 Kg m<sup>-3</sup> to 830.40 Kg m<sup>-3</sup> and from 460.12Kg m<sup>-3</sup> to 520.40 Kg m<sup>-3</sup> respectively. The static bending strength ranged from 320 Kg cm<sup>-2</sup> to 357 Kg cm<sup>-2</sup>, tension parallel to grain differed from 354 Kg cm<sup>-2</sup> to 418 Kg cm<sup>-2</sup> and tension perpendicular to grain ranged from 135 to 170 Kg cm<sup>-2</sup> for different girth classes of wood. The compression strength parallel and perpendicular to grain differed from 280 to 340 Kg cm<sup>-2</sup> and 110 to 136 Kg cm<sup>-2</sup> respectively. The maximum veneer recovery with a value of 60% was recorded in higher girth class (90-120 cm) and minimum veneer recovery (48%) in lower girth class (30-45 cm) and the veneer shrinkage varied from 5.5% to 6.3% for different girth classes. With regard to physical properties of plywood, the plywood density ranged from 520 to 610 Kg m<sup>-3</sup>; water absorption from 16.37 to 21.50 % and thickness swelling from 4.85 to 5.86 %. The mechanical properties of plywood are the important parameters to be considered for plywood utility as a structural material. The modulus of elasticity (MOE) across the grain varied from 4371 to 5124N mm<sup>-2</sup> and MOE along the grain ranged from 6040 to 6536 N mm<sup>-2</sup>, the modulus of rupture (MOR) across the grain ranged from 28.71 to 32.60 N mm<sup>-2</sup> and MOR along the grain differed from 38 to 49 N mm<sup>-2</sup> and glue shear strength from 1219 to 1380 N mm<sup>-2</sup> for different girth classes. The results of the present investigation have shown that *Sterculia foetida* wood has good physical and mechanical properties to the IS 1708 standard for plywood production. Hence, *Sterculia foetida* wood could be recommended for core veneer in manufacturing plywood.

#### Keywords

*Sterculia foetida*,  
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### Introduction

There is a huge demand of solid wood for various utility in building construction. Nowadays, because of increased demand and high cost, plywood has been developed as an alternative to solid wood products. The plywood has increased dimensional stability, uniformity and higher mechanical strength, improved stress distributing properties,

reduced processing cost and better appearance. There is a huge demand for plywood due to ever increasing real estate sector. At this juncture, it is reported that *Sterculia foetida* wood is suited for plywood making and other types of interior work in house construction. This besides, this species wood is easily workable with tools and glue and takes a finish well. It has been proven that the strength of this wood offers the ability to

be used in the construction of a wide variety of wooden structures (Nazma *et al.*, 1981). Considering the properties of *Sterculia foetida* wood and specifically the properties of plywood in various literature, this study was conducted with the objective of assessing the plywood properties of *Sterculia foetida* of different girth classes.

## Materials and Methods

Ten year old *Sterculia foetida* trees were selected and the logs were categorized into three different girth classes viz., 30-45 cm, 45-90 cm and 90-120 cm with four replications. The physical properties viz., green wood density, dry wood density and moisture content and the mechanical properties viz., static bending strength, tensile parallel to grain, tensile perpendicular to grain, compression parallel to grain and compression perpendicular to grain were determined. The mechanical properties of *Sterculia* wood was assessed on Universal Timber Testing Machine in accordance with IS 1708.

The maximum static bending strength was calculated by dividing the load to failure by the cross sectional area of the specimen. The specimen size for measuring the tension parallel to grain was 32.5 x 5 x 1.5 cm. The specimen size for measuring tension perpendicular to grain was 32.5 x 5 x 2 cm. The compression strength parallel to grain was carried out using the specimen size of 2 x 2 x 30 cm.

The following plywood properties viz., veneer recovery, veneer shrinkage, thickness swelling, water absorption, density, modulus of elasticity across the grain, modulus of rupture across the grain, modulus of elasticity along the grain, modulus of rupture along the grain and glue shear strength were assessed as per the standard procedure.

## Results and Discussion

The results showed that the green wood density in *Sterculia foetida* wood ranged from 802.42 Kg m<sup>-3</sup> to 830.40 Kg m<sup>-3</sup>. Among the three girth classes, T<sub>3</sub> (90- 120 cm) showed significantly higher green wood density when compared to other two girth classes (30- 45cm cm and 45 -90 cm). The same trend was noticed for dry wood density also. The highest dry wood density of 520.40 Kg m<sup>-3</sup> was observed in T<sub>3</sub> whereas the lowest dry wood density (460.12 Kg m<sup>-3</sup>) was recorded in T<sub>1</sub>.

The reverse trend was observed in moisture content of wood wherein it was lowest (49.30%) in T<sub>3</sub> and highest (53.30 %) in T<sub>1</sub> (Table 1). The findings of the present study are in consonance with the results of the following tree species viz., *Populus* (Hafida *et al.*, 2020), *Melia dubia* (Saravanan *et al.*, 2014), *Tectona grandis* (Izekor *et al.*, 2010), *Acacia auriculiformis* (Shukla *et al.*, 2007), *Nauclea diderichii* (Fuwape and Fabiyi, 2003) and *Gmelina arborea* (Akachuku, 1980).

The static bending strength of *Sterculia* wood ranged from 320 Kg cm<sup>-2</sup> to 357 Kg cm<sup>-2</sup> for different girth classes viz., 30-45cm, 45-90 cm and 90-120 cm respectively. It was observed that the static bending strength increases with increase in girth size. Among the three girth classes, significantly highest static bending strength was recorded in T<sub>3</sub> compared to T<sub>1</sub> and T<sub>2</sub>. The results reported that the tension parallel to grain increased with increase in girth of wood with highest value in T<sub>3</sub> (418 Kg cm<sup>-2</sup>) and the lowest value in T<sub>1</sub> (354 Kg cm<sup>-2</sup>). The similar trend was observed in tension perpendicular to grain with a value of 170 Kg cm<sup>-2</sup> in T<sub>3</sub> and 135 Kg cm<sup>-2</sup> in T<sub>1</sub>.

The increase in static bending strength, tension parallel to grain and perpendicular to

grain in higher girth size of *Sterculia foetida* wood might be attributed to increments of growth rings, addition of more mature wood and the increasing age of cambium as the tree grows in girth. The similar trend of increase in MOE has been reported in *Melia dubia* (Saravanan *et al.*, 2014), *Tectona grandis* (Izekor *et al.*, 2010), *Acacia auriculiformis* (Shukla *et al.*, 2007), *Nauclea diderichii* (Fuwape and Fabiyi, 2003) and Slash pine (Macpeak *et al.*, 1990). The mean values of compression strength parallel to grain in *Sterculia* wood were 280 Kg cm<sup>-2</sup>, 310 Kg cm<sup>-2</sup> and 340 Kg cm<sup>-2</sup> for different girth classes. This study showed that significantly higher value was recorded in T<sub>3</sub> and lower value in T<sub>1</sub>. The similar trend was noticed in compression perpendicular to grain with the mean value ranged from 110 to 136 Kg cm<sup>-2</sup> (Table 2). The current study showed that compressive strength increases with increase in girth size which is in accordance with the findings of Saravanan *et al.*, (2014) in *Melia dubia*, Izekor *et al.*, (2010) in Teak, Shukla *et al.*, (2007) in *Acacia auriculiformis* and Fuwape and Fabiyi (2003) in *Nauclea diderichii*.

The veneer properties are the most important parameter to be considered in terms of plywood production. In this study, the veneer recovery in different girth classes of *Sterculia foetida* was determined and it showed that there was a significant difference in veneer

recovery among the girth classes. The maximum veneer recovery (60%) was obtained in higher girth class (90- 120 cm) and minimum (48 %) in lower girth class (30-45 cm). Regarding veneer shrinkage, T<sub>3</sub> recorded minimum shrinkage with a value of 5.5% as against 6.3 % in T<sub>1</sub> (Table 3). In the present investigation, plywood manufactured from *Sterculia foetida* wood of all girth classes showed nearer to prescribed standards, which endorse the suitability of *Sterculia* wood for plywood production. For all the parameters, there was an increase in values with increase in girth size. It may be due to the reason that as tree grows continuously and wood changes from juvenile to mature, the strength properties also gets improved (Tenorio *et al.*, 2011).

The dimensional stability of plywood closely related to thickness swelling, water absorption and density. In this study, the thickness swelling was minimum with a value of 4.85% in T<sub>3</sub> and maximum in T<sub>1</sub> (4.54%). It was observed that the mean value of water absorption for T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> was 21.5%, 17.77% and 16.37% respectively. The water absorption of *Sterculia* plywood was significantly lower in T<sub>3</sub> when compared to other two girth classes. The variation in water absorption is mainly attributed to the difference in cellulose and hemicellulose content in wood (Table 3).

**Table.1** Physical properties of *Sterculia foetida* wood

Treatments (Girth classes)	Green wood density (Kg m <sup>-3</sup> )	Dry wood density (Kg m <sup>-3</sup> )	Moisture Content (%)
T <sub>1</sub> ( 30-45cm)	802.42	460.12	53.30
T <sub>2</sub> (45cm-90 cm)	810.20	498.10	51.50
T <sub>3</sub> ( 90 cm-120 cm )	830.40	520.40	49.30
SEd	5.412	2.622	0.211
CD	10.824	3.244	0.422

**Table.2** Mechanical properties of *Sterculia foetida* wood

Treatments (Girth classes)	Static Bending strength (Kg cm <sup>-2</sup> )	Tension parallel to grain (Kg cm <sup>-2</sup> )	Tension perpendicular to grain (Kg cm <sup>-2</sup> )	Compression parallel to grain (Kg cm <sup>-2</sup> )	Compression perpendicular to grain (Kg cm <sup>-2</sup> )
T1( 30-45cm)	320	354	135	280	110
T2(45cm-90 cm)	336	398	145	310	123
T3( 90 – 120 cm)	357	418	170	340	136
SEd	1.544	1.192	1.802	2.124	1.235
CD (0.05)	3.088	2.284	3.604	4.248	2.460

**Table.3** Veneer properties and physical properties of *Sterculia foetida* plywood

Treatments (Girth classes)	Veneer recovery (%)	Veneer shrinkage (%)	Thickness swelling (%)	Water absorption (%)	Density (Kg m <sup>-3</sup> )
T1( 30-45cm)	48.00	6.30	5.86	21.50	520
T2(45cm-90 cm)	52.00	6.10	5.20	17.77	571
T3( 90 – 120 cm)	60.00	5.50	4.85	16.37	610
SEd	0.52	0.002	0.050	0.390	4.342
CD	1.04	0.004	0.105	0.880	8.684

**Table.4** Mechanical properties of *Sterculia foetida* plywood

Treatments (Girth classes)	MOE (across the grain) (N mm <sup>-2</sup> )	MOR (across the grain) (N mm <sup>-2</sup> )	MOE (along the grain) (N mm <sup>-2</sup> )	MOR (along the grain) (N mm <sup>-2</sup> )	Glue shear strength (N mm <sup>-2</sup> )
T <sub>1</sub> ( 30-45cm)	4371	28.71	6040	38	1219
T <sub>2</sub> (45-90 cm)	4960	32.80	6410	41	1320
T <sub>3</sub> ( 90 -120 cm)	5124	32.60	6536	49	1380
SEd	9.800	0.660	4.685	0.180	3.221
CD (0.05)	19.600	1.220	9.260	0.206	6.244

The density of plywood was directly proportional to girth classes wherein significantly highest density was noticed in T<sub>3</sub> (610 Kg m<sup>-3</sup>) and the lowest was observed in T<sub>1</sub> (520 Kg m<sup>-3</sup>) (Table 3). The results of the present study is in consonance with the findings in other fast growing species viz., *Bombax* (Rahman *et al.*, 2014 a, Alam *et al.*, 2012), *Melia azedarach* (Rahman *et al.*, 2014

b) and *Gmelina arborea* (Tenorio *et al.*, 2011).

The mechanical properties viz., the modulus of rupture and modulus of elasticity are most important parameters for the use of plywood as a structural material. The modulus of rupture is an indication of bending strength of plywood and whereas the modulus of

elasticity is an indication of stiffness. In this study, the modulus of elasticity across the grain was significantly maximum in T<sub>3</sub> (5124 N mm<sup>-2</sup>) and minimum in T<sub>1</sub> (4371 N mm<sup>-2</sup>). The similar trend was observed in modulus of elasticity along the grain. The modulus of rupture across the grain of Sterculia plywood was maximum in T<sub>3</sub> (32.60 N mm<sup>-2</sup>) and minimum in T<sub>1</sub> (28.71 N mm<sup>-2</sup>) (Table 4). The similar trend was recorded in modulus of rupture along the grain. The higher plywood strength of higher girth class might be due to higher density as there is a positive correlation between density and mechanical properties and higher density has a great influence on MOR (Ajayi, 2002; Zheng *et al.*, 2007).

The results showed that the glue shear strength of Sterculia plywood was significantly highest with a value of 1380 N mm<sup>-2</sup> in T<sub>3</sub> and it was lowest in T<sub>1</sub> (1219 N mm<sup>-2</sup>). The results of the present investigation showed that *Sterculia foetida* wood has nearer physical and mechanical properties to the IS 1708 standard. Hence, it is recommended that *Sterculia foetida* wood could be used as core veneer in plywood manufacturing.

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