Journal of Agroecology and Natural Resource Management
p-ISSN: 2394-0786, e-ISSN: 2394-0794, Volume 4, Issue 4; July-September 2017, pp. 288-291

http://www.krishisanskriti.org

Performance of Finger Jointed Sections of *Melia azedarach* under Static Bending

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Abstract—*An experiment was conducted to assess the static bending strength of finger jointed sections of Melia azedarach. A finger profile of 21 mm length, 7 mm pitch and 1.4 mm tip thickness was used in the study. The sections were joined using UF adhesive. For comparison, joint-free sections also were tested. The results showed that the jointed sections resulted in MOE of 6568 N/mm^2 which was 84.5% that of unjointed sections. However, the MOR (27.9 N/mm^2) was only 45.4 % compared to unjointed sections. The study showed the usefulness of finger jointing in using up short sections of this natural wood resource where good elasticity is a basic requirement. Further, the bending strength of the jointed wood can be improved by using better adhesives.*

Keywords*: Finger joint, wood as a natural resource material, Melia azedarach, static, urea formaldehyde*

1. INTRODUCTION

Wood is one of the best manufacturing materials naturally available and facilitating almost boundless applications. It has an appealing appearance and a long life expectancy. Finger-joined lumber is now widely used in structural products such as glued- laminated timber, I-joists, wall studs and trusses. Because of its desirable properties, finger-joints determine the strength of glulam which depends on parameters like finger geometry, assembly pressure, curing time, adhesive type, wood density and moisture content as well as pre-treatment of wood (Ajdinaj and Habibi 2013). Finger-joined studs are also considered equivalent to unjoined studs and are therefore used interchangeably by builders (Gong et al. 2014).

Finger jointing is a very convenient technique used to produce wood products from short pieces of lumber. Such joints are expected to have excellent mechanical properties compared to many other types of joints. A finger joint may be considered as a series of short scarf joints separated by blunt tips at the ends of the scarves.

A Joint is often the weakest point in a finished wooden product. The edge to edge grain joint interface is a necessary entity among furniture and laminate industries (Janowiak et al. 1993). The strength of a finger joint comes from the long-grain to long-grain contact between the fingers, which provide a solid gluing surface. Reported strength values indicate that finger joints can be used as replacement for mortise and tenon or dowel joints. Finger joints also contribute to advantages such as reduced variability in strength, self alignment, material reduction, ease of machining and automation (Murphey and Rishel 1972).

Flexural properties form an important aspect in the utilization of each wood species for structural and semi-structural uses. The literature is abound with various methods and findings on various species under static bending. Komatsu et al. (1998) reported a series of four point bending tests to evaluate such flexural properties as the modulus of elasticity (MOE), modulus of rigidity (G), stress at promotional limit (σ_p), modulus of rupture (MOR). The easiest and most practiced method is the central loading technique on small clear specimens.

Pena (1999) studied the suitability of producing nonstructural finger joints made from beach wood *(Fagus sylvatica*) and European oak (*Quercus petraea*). He examined the effect of geometry of finger joint in bending strength, using 9 mm and 12mm finger lengths glued with Melamine Urea Formaldehyde (MUF) and epoxy resin and concluded that MOE of the jointed specimens did not differ significantly from the unjointed one. On the contrary the jointed specimens presented lower values of MOR compared to that of the unjointed ones (46%).

Melia azedarach, commonly known as white cedar or Indian lilac, belongs to the mahogany family, *Meliaceae* and is native to India also. The main utility of this species is as timber. The timber is of medium density (510-660 kg/m^3), and ranges in colour from light brown to dark red. The timber is used for Boxes and crates, Fixtures, Furniture, Plywood etc.

The Indian wood insect database describes the timber of this species as durable and as resistant to termites (www.icfre.org:8080/ woodsci/Wooddetails.jsp?id=643). It is reported to season well without cracking or warping and is resistant to fungal infection. The wood is of aesthetic texture and takes polish well.

This paper reports the results of a study on the static bending strength of finger jointed sections of *Melia azedarach* wood joined with Urea formaldehyde (UF) adhesive.

2. MATERIALS AND METHODS

Planks of *Melia azedarach* of 63mm thickness were seasoned up to a moisture content of 12 %. Sections of 50x50 mm^2 cross sections were cut from the seasoned planks. The sections were selected from visually inspected defect free portions. These were further cut into suitable lengths so that 750mm long samples could be obtained when joined. Fingers of 21 mm length, 7 mm pitch and 1.4 mm tip thickness with slope of 1 in 10 were profiled using a commercial finger shaping machine.

Urea formaldehyde (UF) adhesive was prepared using a commercial grade UF resin powder by mixing it with 2% of ammonium chloride (NH_4Cl) hardner. The adhesive was applied to the profiled fingers using a brush. Immediately after adhesive application, the sections were mated and pressed on a pneumatic pressing vice at an end pressure of 6 MPa. The sections were made in such a way that the joint occupied the centre position of the specimen. The jointed samples (with approximate dimensions of 750x50x50 mm^3) were left at room temperature for curing for 48 hours. Before performing static bending measurements, the samples were given a light planing to remove any adhesive ooze out during pressing operation. Fifteen such jointed samples were prepared for static bending measurements. However, during joining on the pressing vice, one sample got damaged and hence only fourteen finger jointed samples could be used for bending tests. Fifteen clear wood samples of similar dimensions were also prepared for comparison.

Static Bending measurements were carried out on a Universal testing machine (UTE-10) following IS-1708 (BIS, 1986). The span used was 700 mm. The specimen was placed such that the load is applied at right angle to the specimen at its centre. The load was applied continuously throughout the test such that the movable head of the testing machine moves at 2.5 mm/min. Deflections corresponding to progressively applied loads were noted at regular load intervals till the specimen broke. The load at which the specimen broke was recorded as the maximum load (P'). The load deflection graph was then plotted on a spread sheet with the deflections in mm on the abscissa and corresponding loads in Newton (N) on the ordinate. Load (P) and deflection (D) at the limit of proportionality were noted. For finding out D, a line parallel to the linear portion of the load-deflection graph was drawn from the origin.

The parameters Modulus of Rupture (MOR) N/mm^2 and Modulus of Elasticity (MOE) N/mm^2 were calculated for each sample with the formulae given in table 1

Table 1: Formulae used for estimating the mechanical properties under static bending

Mechanical Property	Unit	Formula
Modulus of Rupture (MOR)	N/mm^2	$3P'L/2bh^2$
Modulus of Elasticity (MOE))	N/mm^2	$PL^3/4Dbh^3$

Where,

P= load at limit of proportionality (N)

P'= maximum load (N)

L= span of sample (mm)

b= breadth of sample (mm)

h= height of sample (mm)

D= the deflection corresponding to the elastic limit (mm)

The methods of Sample preparation and static bending measurements are detailed in an earlier publication (Kishan Kumar et al. 2013).

3. RESULTS AND DISCUSSION

The static bending parameters of clear wood and finger jointed sections of *Melia azedarach* were computed by calculating the modulus of rupture (MOR) and Modulus of elasticity (MOE) as discussed in the previous section. The calculated MOR and MOE are given in table 2.

Table 2: Static Bending measurements of the clear wood and finger jointed samples

	Clear Wood		Finger Jointed Samples	
Sample No.	MOR (N/mm^2)	MOE (N/mm^2)	MOR (N/mm^2)	MOE (N/mm^2)
1	50.0	6194	22.3	6530
2	52.0	7636	23.3	4494
3	52.0	7634	23.6	6565
4	54.0	6922	24.9	6946
5	60.7	8380	26.4	7236
6	61.4	8893	26.7	5961
7	62.7	7017	28.0	6725
8	62.7	7015	28.0	6725
9	63.0	7076	29.6	6952
10	63.1	7080	30.0	6561
11	66.1	7949	30.4	5470
12	67.8	7974	30.9	7091
13	68.2	8310	31.3	6964
14	69.3	9579	31.5	7134

15	69.9	8986	-	-
Mean	**61.5**	**7776**	**27.9**	**6568**
S.D.	**6.6**	**929**	**3.2**	**745**
CV (%)	**10.8**	**11.9**	**11.6**	**11.3**

From table 2, it is seen that the MOR ranges between 50 and 69.9 N/mm^2 for unjointed clear wood samples. The average value of modulus of rupture is 61.5 N/mm^2. The mean value of modulus of elasticity is 7776 N/mm^2 which ranges from 6194 to 9579 N/mm^2. The MOR values of finger jointed samples range from 22.3 N/mm^2 to 31.5 N/mm^2 with a mean of 27.9 N/mm^2. The values of modulus of elasticity (MOE) varied from 4494 to 7236 N/mm^2 with a mean of 6568 N/mm^2. Thus, the data in table 2 indicate that after finger jointing *M. azedarach* sections with UF adhesive, the MOR and MOE have reduced. To find out the extent of reductions in the bending parameters, the efficiency of jointed samples were calculated with respect to those of unjointed clear wood samples which are given in table 3.

Table 3: Efficiency of bending parameters of finger jointed samples of *Melia azedarach*.

Parameter	Sample	Average (N/mm^2)	Efficiency of finger joint (%)
MOR (N/mm^2)	Clear wood	61.5	45.4
	Finger jointed	27.9	
MOE (N/mm^2)	Clear wood	7776	84.5
	Finger jointed	6568	

Table 3 shows that the efficiency of modulus of rupture (MOR) the finger jointed samples is less than half of the value of the clear wood samples. A similar result was reported for Eucalyptus sections when joined with the same adhesive and fingers of the same profile (Kishan Kumar et al. 2013). In that study, the efficiency of MOR of finger jointed samples were 42.2%. One of the reasons could be the adhesive used. With resorcinol formaldehyde adhesive, African hard woods showed efficiencies up to 94% depending on the finger parameters and end pressure (Ayarkawa et al. 2000a). Usually, elasticity shows better efficiencies after finger jointing. In mango wood, very high retention of MOE (>100%) with UF adhesive was reported for finger jointed samples. (Kishan Kumar et al.2011). High MOE retentions in African hard woods and eucalyptus have also been reported (Ayarkawa et al. 2000b; Uday et al. 2005; Kishan Kumar et al. 2013). Thus, better retention of MOE of finger jointed samples in the present study is consistent with the literature.

It is evident that this technique is promising to join short sections of *Melia azedarach.* When glued with UF, the jointed sections are capable of being used in applications where MOR upto 25 N/mm^2 and MOE upto 6000 N/mm^2. The bending strength can be improved by using better adhesives like resorcinol formaldehyde or fortified UF like MUF.

4. CONCLUSIONS

Finger jointing of *Melia azedarach* with UF adhesive provides nearly half the efficiency of MOR and more than 3/4th efficiency in MOE compared to unjointed specimen. Thus, finger jointing of this wood with UF can perform well in elastic behavior though the bending strength would be reduced. However, this technique is quite useful in applications that require bending strengths less than 25 N/mm^2. There is scope of improving the bending properties by using better adhesives for this hard wood.

5. ACKNOWLEDGEMENTS

The authors place on record the help rendered by the staff of WWF Discipline in making the samples. The help in conducting the static bending measurements by the staff of TM Discipline is highly appreciated. The encouragement by Head, Forest Products Division during the study is gratefully acknowledged.

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