Research Journal of Agriculture and Forestry Sciences E-ISSN 2320-6063
Vol. **4(8),** 10-13, August **(2016)** *Res. J. Agriculture and Forestry Sci.*

Maximum Tensile Stress of Eucalyptus Sections Finger Jointed with PVA Adhesive

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Available online at: www.isca.in, www.isca.me
Received 24th June 2016, revised 23rd July 2016, accepted 3rd August 2016

Abstract

An experiment was conducted to assess the tensile strength of finger jointed sections of Eucalyptus wood. 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 PVA adhesive. For comparison, joint-free sections also were tested. The results showed that the joints resulted in poor tensile strength. The jointed samples gave only 23.57% efficiency of maximum tensile stress compared to 99.7 N/mm^2 shown by clear wood sections. The study illustrates the necessity of adopting suitable strong adhesives when making finger jointed sections out of eucalyptus species.

Keywords: Finger joint, Polyvinyl Acetate, tensile, Eucalyptus.

Introduction

Finger joint can be a valuable means to strengthen the sawn material volume and reduce the conversion cost per cft[1]. Finger joints have no substitute in the industry and the demand for them looks to remain stable. The entire solid timber wood working industry is looking towards finger jointing for recovery due to cost and environmental issues and high quality products. As the demand of solid clear wood in future does not seems to come down and it is not possible to cover the entire demand due to scarcity of timber, the use of finger jointing can be one of the major sources to cover this demand and must be put to use in a rational manner.

High end products like table tops, long moulding etc. are some of the applications of finger jointing technique as defect free wood is very difficult to obtain for such end uses.

Finger jointing is a process for recovering valuable natural resource. It is a process where unused short pieces can even be used for obtaining defect free longer lengths of timber. This seems to be especially true with high-end product manufacturers who tend to be more concerned with how they can be involved in recovery process. Finger jointed wood products have evolved into three main groups which are classified by their end uses: structural, sub structural and non-structural.

The structural group contains finger joined products that are produced with the highest possible tensile strength and adhesive used must meet strict exterior exposure including strength tests. The finger joint which has an advantage of being smaller than a scarf joint has been shown to possess required strength for structural applications as well[2].

A study on the effect of joint geometry over tensile strength for two softwoods and one hardwood shows that the tensile strength for softwoods is in the range of 8000 to 10000 pounds per square inch and that of hardwoods is in the range of 12,000 to 14000 pounds per square inch using finger tip of 0.045 inch thickness[3]. It is also pointed out that decreasing slope of finger give good tensile strength. Actually the gain in strength is generally very small as the slope reduced from 1:12 to 1:16.

A study reported that more than 90 % ultimate tensile strength was achieved when finger joints were made with isocyanate with 24 hours curing time[4]. It is also found that eucalyptus has 63 – 70% finger joint efficiency in comparison to the original defect free wood species[5]. Finger profile with thinner tip resulted in weaker joints under compression parallel to grain and in bending when Eucalyptus sections were joined with PVA adhesive[6]. A study reported that Urea Formaldehyde solid contents in the range of 36.8 % to 57.6% can perform equally well when eucalyptus sections are finger jointed and tested under compression[7].

Eucalyptus spp.*(E. tereticornis)* has been classified as a moderate timber with respect to its weight, strength and toughness[8]. Working quality index of this timber has been reported to be comparable to teak[9]. Its timber finds use in rural and urban India for furniture making, as rafters, beams, purlins etc. It is reported to have strength indices comparable to teak[10]. E. hybrid from Punjab and Haryana was found suitable for construction, joinery crates, furniture, poles etc[11].

This paper reports the results of a study on the tensile strength of finger jointed sections of *Eucaylyptus* spp. wood jointed with PVA adhesive.

Materials and Methods

Eucalyptus Planks of 38 cm thickness, kiln seasoned up to Moisture content (MC) of 12 % were used to prepare samples for the study. The sections were selected from visually inspected defect free portions. Fingers with parameters of 21 mm (length), 7 mm (pitch) and 1.4 mm (tip width) with slope of 1 in 10 were profiled on a commercial finger shaping machine.

The poly vinyl acetate (PVA) 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 central position of the specimen. The jointed samples were left at room temperature for curing for 48 hours. Before performing the tensile test, the samples were given a light planing to remove any adhesive ooze out during pressing operation. The samples were dimensioned to most appropriately 5 x1.5 cm^2 cross-sections and 32.5 cms in length. Ten such jointed samples were prepared for tensile strength testing.

Seven clear wood samples were prepared according to IS 1708[12]. Samples were made with dimensions of 7 X 7 mm (cross-section of the central portion of the specimen) and (5cm) gauge length.

The test was conducted on universal testing machine provided with suitable types of grips to hold the specimen firmly without any slip during the test. The load was applied continuously during the test such that the movable head travelled at a constant rate of 1 mm/min for clear wood as well as finger jointed samples. This procedure was continued till the maximum load was observed. Maximum Tensile Stress (MTS) was determined for each sample using the following formula.

$$\text{MTS} = \frac{\text{P}}{\text{A}}$$

Where, P = Maximum Load in N, A = Cross-Sectional area in mm^2, MTS = Maximum Tensile Stress in N/mm^2.

In the case of finger jointed samples, 3 samples which showed wood failure were not considered for MTS calculation.

Results and Discussion

The tensile strengths parallel to grain of clear wood and finger jointed sections of eucalyptus spp. were computed by calculating the Maximum Tensile Stress (MTS) as discussed in the previous section. The sample details and maximum loads and the calculated MTS are given in Table-1 (Clear wood samples) and Table-2 (finger jointed sections).

The Table-1 reveals that the average value of maximum tensile stress of 7 clear wood samples is 99.7 N/mm^2. From the table the values ranges from 81.6 to 117.1 N/mm^2. The reported MTS value for *E. camaldulensis* is 59.93 N/mm^2 for[13]. The maximum tensile strength values parallel to grain for *Eucalyptus* hybrid reported from India are 1281.73 N/mm^2 from Punjab and 766.88 N/mm^2 from Haryana[11].

Table-1
Tensile test details of the clear wood samples

Sample No.	Width (mm)	Thickness (mm)	Maximum load = P (N)	A (mm^2)	MTS (N/mm^2)
1	6.90	7.70	5760	53.13	108.4
2	6.99	7.22	4120	50.47	81.6
3	7.86	7.23	5560	56.83	97.8
4	7.38	7.08	6120	52.25	117.1
5	7.40	7.40	4990	54.76	91.1
6	7.44	7.44	6260	55.35	113.1
7	7.30	7.50	4850	54.75	88.6
				Mean	99.7
				S.D.	13.5
				CV (%)	13.5

Table-2
Tensile test details of the finger jointed samples.

Sample No.	Width (mm)	Thickness (mm)	Maximum load = P (N)	A (mm^2)	MTS (N/mm^2)
1	48.01	14.91	16820	715.83	23.50
2	48.59	15.11	17920	734.20	24.41
3	49.86	15.12	15620	753.89	20.72
4	48.54	15.13	20560	734.41	28.00
5	48.31	15.12	19660	730.45	26.91
6	48.51	15.3	17540	742.20	23.63
7	50.02	15.56	13560	778.31	17.42
				Mean	23.5
				S.D.	3.6
				CV (%)	15.3

Table-2 reveals that the average value of maximum tensile stress of 7 finger jointed samples is 23.5 N/mm^2. From the table, it can be seen that the values range from 17.42 to 28.00 N/mm^2. Thus the data indicates that after finger jointing Eucalyptus sections with PVA adhesive, the tensile strength drastically reduces.

Table-3 gives the efficiency of the finger jointed sections with respect to the tensile strength values of unjointed clear wood samples.

Table-3
Tensile stress Efficiency of finger jointed samples of E*ucalyptus* spp

Parameter	Sample	Average MTS (N/mm^2)	Efficiency of finger joint (%)
Maximum Tensile stress	Clear wood	99.7	23.57
	Finger jointed	23.5	

Table-3 shows that the efficiency of the finger jointed samples is just 23.57 % of the value of the clear wood samples. It would be interesting to see how PVA glued finger jointed samples of eucalyptus spp behave in other mechanical properties. In eucalyptus hybrid, an efficiency of 73.5% was reported for maximum crushing stress parallel to grain when section were joined using PVA with the same finger profile that was used in the present study[14]. However, the bending strength of *Eucalyptus tereticornis* was only 35.2% with the same finger profile-adhesive combination[6]. Thus, it looks that in spite of using same adhesive and same finger profile, the finger jointed samples of eucalyptus respond quite differently under compression bending and tension. The strength of any joint depends also on the adhesive used to mate the finger. A tensile strength efficiency of around 80% was reported for finger joints made out of *Pinus taeda* when joint with the much stronger resorcinol-formaldehyde adhesive[15]. By using Urea Formaldehyde adhesive, a compression strength efficiency of 85% could be achieved for eucalyptus using the same finger profile used in the present study[7].

Conclusion

Poly vinyl acetate adhesive results in poor finger joints with eucalyptus species when tested under tension parallel to grain. Against the maximum tensile stress of 99.7 N/mm^2 obtained with clear wood sections, the finger jointed sections yielded only 23.5 N/mm^2 maximum tensile stress. The study illustrates the role of suitable adhesive in making strong finger joints with eucalyptus.

Acknowledgements

The authors place on record the help rendered by the staff of WWF discipline in making the samples. The help in conducting the Tensile strength Test 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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