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Laminated Veneer Lumber (LVL) from Fast Growing Plantation Timber Species *Meliadubia*

Prakash V[1], Uday. D.N. [2], Sujatha. D.[3], Kiran. M. C.[4], Narasimhamurthy[5]

Abstract: ***Laminated veneer lumber (LVL) is a layered composite of wood veneers and a synthetic adhesive. It is produced by laminating the wood veneers with the grain direction in successive layers of veneers being parallel to each other and also parallel to the length of the laminate. Short rotation planation timbers when seasoned tend to develop defects like twist and warp there by resulting in poor yield for a given volume of raw material. Converting the short rotation plantation timber species in to veneers and subsequently laminating these veneers in to an LVL increases the possibility of using low value plantation timbers to be converted in to high strength laminates which can be used for structural applications. In this project study to develop LVL from fast growing plantation grown timber namely Melia dubia was carried out and evaluated the physical, mechanical and chemical properties as per IS 14616 – Specifications for Laminated Veneer Lumber. LVL produced from Melia dubia is found to conform to the requirements as specified in IS 14616 and with a chemical retention of 8.46 kg/m^3 achieved, the LVL finds its application for door and window frame.***

Keywords: *Meliadubia*, Laminated veneer lumber, plantation species.

1. Introduction

The natural defects like knots, cracks etc. that are present in trees/logs during its growth are inherited when these logs are converted in to sawn timbers. In order to remove the effect of these defects either in terms of physical and mechanical properties or in terms of aesthetic appearance, these logs may be peeled in to veneers and then gluebonded with suitable synthetic resin(preferably Boiling Water Proof (BWP)) either by removing the defects or by distributing the defects throughout the span. Laminated veneer lumber (LVL) is a structural composite made by bonding the veneers with suitable adhesive with the grain direction of all the veneers aligned along the longitudinal (length) dimension of the composite. Due to its composite nature LVL is stronger, straighter, more uniform and also much less likely than conventional timber to warp, twist, bow or shrink. Durability, light weight and dimensional stability makes LVL to be used for headers, columns, rim boards, I-beams, large span prefabricated house and other such structural applications. Uniformity trough out the span, ability of production from short rotation plantation timbers has made LVL to be considered as an important solution concerning raw material economy as converting the logs in to veneers results in higher percentage of recovery from short rotation small girth logs.

Meliadubia (MalaiVembu – Tamil, Kadbevu or Hebbevu – Kannada) is a promising tree highly suitable for farm forestry and agro forestry. It is a fast growing tree and the wood from this tree is used in plywood industries (K. Kannan et. al, 2003). *Melia dubia* also known as Malabar Neem is a low density species (450 kg/m^3 – Warrier, 2011), straight grained, coarse and somewhat uneven textured. Sap wood is greyish white. Heart wood is light pink to light red, when first exposed and ageing to pale russet brown subject to grey stain, lustrous with dry feel, without characteristic odour or taste. It is used chiefly for packing case, ceiling planks and tea boxes.

This timber species is gaining lot of interest among farmers in southern parts of India as it is known to fetch a good income to the farmer with minimal investment and maintenance. This timber species can either be planted exclusively as a single species plantation or can be mixed with other crops in the form of Agroforestry. Though *Melia dubia* is known for its suitability for manufacturing plywood, recent research has shown that this species is also suitable for manufacturing particle boards (Prakash. V et al, 2014).

2. Literature Review

Bejo and Lang (2004) has stated that increasing demands for wood based structural material with decreasing quality and quantity of raw materials are forcing industries to utilize fast growing trees to manufacture wood composites for structural applications. Bing et al. (2013) has observed that the awareness among society concerning the natural environment and the acceptance of wooden building materials in the form of solid wood and wood composites has increased during the past decades. Ramazanet al. (2010) has recommended that possibility of utilization of plantation tress as a source of raw material for wood composite industries must be studied carefully. Any tree species can be used to produce LVL as long as their physical and mechanical properties are acceptable for the LVL production including off-grade and fast growing species. AyhanOzcifci (2007) has stated that a higher strength product (LVL) can be produced from a low-grade log by dispersing the defects from veneer to veneer. Though LVL's were manufactured from Douglas fir and pine during the early days of its induction, research has shown that the LVL can also be manufactured from underutilized species such as aspen, poplar and other such species. Research conducted by Bal and Bektas (2012) has shown that the LVL can be manufactured from softwood species and low to medium – density (290 to 693 kg/m^3) hard wood species. Kojima et al. (2009) have recorded that the fast growing species would contain a large volume of juvenile wood bearing unstable properties which is an obstacle for the use of fast-growing tree species for structural applications. Ayhan Ozcifci (2007) Veneering and gluing process enables large beams to be made from relatively small diameters logs of many species, thereby providing for efficient use of forest resources. Kurt et al. (2012) have mentioned that there is a need to find the alternatives for sawn timber by using plantation timber by using short rotation plantation timbers and also utilization of fast growing species such as radiata pine, scots pine, eucalyptus and poplar are reported in the past. Mohandas et al. (2002) has determined that LVL of a given species will have better properties compared to solid wood of the same species and also LVL of better strength properties can be obtained by employing specific pressure normally employed for the manufacture of plywood. Deng et al. (2014) has noted that due to increase in demand for long-span structural components and a decreasing supply of large-size wood products, much attention is paid to develop the process for manufacturing lumber even from fast growing species like bamboo.

3. Objectives

Laminated veneer lumber (LVL) is one of the most widely used engineered wood products for constructional application. Short rotation plantation timbers are known to have juvenile wood and also natural defects like cracks, knots etc. These defects either individually or as a combination acts as hurdle if the tress are to be converted in to timber for structural applications. By peeling these low grade logs in to veneers causes the defects to disperse from veneer to veneer as compared to the dispersion realized by sawing the same low grade logs.

4. Materials and Methods

The LVLwas manufactured using rotary peeledveneers of thickness 1.6 and 2.4 mm which were clipped into 1250 mm length and1250 mm width and dried to 6 to 8%moisture content.

Preservative Treatment

CCB (Copper, Chrome and Boron)solution in the ratio of (3.5:4.5:1:1.5) as per IS: 10013 was prepared. From this stock solution the veneers were treated with 12% concentration by dip diffusion method. i.e. Veneers of Size 4' X 4' were immersed in the above mentioned solution for a period of 8 hrs. After the treatment the veneers were removed from the solution and were allowed to dry in air for 2 days. The moisture content of the veneers was brought down to 12% before stacking.

Phenol Formaldehyde Resin

100 parts of phenol and 180 parts of formalin of 37 percent formaldehyde were charged into a resin reactor. Reaction was carried out in presence of a catalyst i.e., sodium hydroxide, at a temperature of 80-82^{o}C for about 90 minutes. The resin thus prepared had a flow time of 24 seconds when measured in IS:3944 - B4 flow cup and a solid content of about 49 percent and a solid content of about 49 percent at ambient temperature. The conventional resin formulation was adopted in this study.

Manufacture of LVL

2.5 mm and 1.6 mm thick treated veneers from *Melia dubia* were dried to a moisture content of 6% to 8% and then glued with PF resin followed by an open assembly time of about 2 – 3 hours to achieve glued moisture content of 12 – 14 %. LVL of 1250 mm (Length) X 1250 mm (Width) and 58 mm thick was manufactured by hot pressing the veneer assembly at 145^{o}C to 150^{o}C with a specific pressure of 16 kg/cm^2 to obtain a LVL of thickness of 58 mm. The curing time provided was thickness + 5 minutes.

Testing

LVL manufactured was subjected to testing as per IS: 14616 – 1999 (Laminated Lumber Specification) to find out its conformity to the prescribed limits. The results are tabulated in Table -1.

5. Results and Discussions

The test results of the LVL produced from *Melia dubia* is given in Table - 1. It is found that even with the minimum density of 600 kg/m^3 the LVL has achieved prescribed limits. The preservative retention value achieved (8.46 kg/m^3) indicates that the species has absorbed the requisite chemicals by normal dip diffusion method. The species does not require any modification in the conventional resin system for bonding in spite of treating the veneers with preservative chemicals of 10% concentration of Copper, Chrome and Boron. The PF resin of 49% solids having flow time of 24 seconds and viscosity 80 Cp has quite sufficiently yielded BWP grade quality of the product.The grain direction being same all along LVL has yielded very strong productwhen edge loaded as a beam. The physical and mechanical strength properties achieved (Table – 1) indicates that the chemical treatment provided to enhance the durability of the product does not have any adverse effect on the structural properties of the LVL. The density of the produced LVL is found to be 600 Kg/m^3. Higher value of density can be achieved by increasing the specific pressure during hot pressing. Moisture content is found to be 6.8% where as the prescribed range in the standard is 5-15%. The LVL conforms to the knife test for adhesion of plies for BWP grade. MOR and MOE are found to be 106.8 N/mm^2 and 9149 N/mm^2 against the required value of 50 N/mm^2 and 7500 N/mm^2 respectively. Compressive strength perpendicular to grain obtained is 37.6 N/mm^2 against 35 N/mm^2. Compressive strength perpendicular to grain obtained is 38.2 N/mm^2 and 65.8 N/mm^{2}against 35 N/mm^2 and 50 N/mm^2 in a direction parallel to laminate and perpendicular to the laminate.

Horizontal shear strength obtained is 13.4 N/mm^2 and 9.1 N/mm^2 against 6 N/mm^2 and 8 N/mm^2 in a direction parallel and perpendicular to grain. Tensile strength obtained is 59.9 N/mm^2 against 55 N/mm^2. Screw withdrawal strength is 2831 N and 3358 N against 2300 N and 2700 N at edge and face respectively. Chemical retention of 8.46 Kg/m^{3}was obtained.

6. Conclusion

Based on the study it can be concluded thatLVL manufactured from short rotation plantation grown timbers namely *Melia dubia* conforms to the requirements prescribed in Indian standard IS: 14616.From the literature it can be said that higher strength properties can be obtained by employing higher specific pressures during the time of hot pressing.Based on the chemical retention of 8.46 Kg/m^3 achieved, this LVL finds its application for window and door frame as specified in IS: 401. It can also find otherend use application by enhancing the density and the chemical retention of preservative chemicals. Based on the above conclusion it is recommended that fast growing species *Melia dubia* can be successfully used for the manufacture of LVL that complies with the requirements of IS: 14616.

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Table 1: Test Results of Laminated Veneer Lumber manufactured from *Meliadubia* as per IS-14616 (Laminated Veneer Lumber – Specifications)

Sl. No	Tests	Minimum Conformity	Tested Value
1	Density (Kg/m^3)	600 – 750	600
2	Moisture content (%)	5 -15	6.8
3	Adhesion of plies (Knife test) a) Dry state avg. b) After 72 hrs. boiling c) After subjection to attack by Microorganism as annex B	 Min Pass Std Min Pass Std Min Pass Std	 Pass Std Pass Std Pass Std
4	Modulus of Rupture (N/mm^2)	Min. 50	106.8
5	Modulus of Elasticity (N/mm^2)	Min. 7500	9149
6	Compressive Strength Parallel to grain, (N/mm^2)	Min. 35	37.6
7	Compressive strength perpendicular to grain (N/mm^2) i) Parallel to Laminate ii) Perpendicular to Laminate	 Min. 35 Min. 50	 38.2 65.8
8	Horizontal shear, (N/mm^2) i) Parallel to grain ii) Perpendicular to grain	 Min. 6 Min. 8	 13.4 9.1
9	Tensile strength parallel to grain, N/mm^2	Min. 55	59.9
10	Screw withdrawal strength (N) a) Edge b) Face	 Min. 2300 Min. 2700	 2831 3358
11	Preservative Retention	8.46 Kg/m^3 *	

* Based on this value the LVL may be used for door and window frame applications

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