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Investigation of Bending Strength of Medium Density Fiber Board by Inserting Teak Wood

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ABSTRACT

Wood-based composites encompass a range of products, from fiberboard to laminated beams. Wood-based composites are used for a number of non-structural and structural applications in product lines ranging from panels for interior covering purposes to panels for exterior uses and in furniture and support structures in buildings. Medium density fiberboard (MDF) is one of the appreciated engineering materials among Wood composites. Regarding its better properties, there are some limitations in its applications, such as lower strengths under load constructions, higher creep in changing climates, etc. Reinforcement of an engineering material can open a wide spectrum of interesting applications. Since the last century, reinforcement of wood composites was in the interest of wood technologists. Our objective in this project is to try to increase MOR of MDF so as to widen its scope of applications.

Keywords : Wood based composite, Medium Density fiber board (MDF), Modulus of Rapture (MOR).

I. INTRODUCTION

Few building materials possess the environmental benefits of wood. It is not only our most widely used building material but also one with characteristics that make it suitable for a wide range of applications. As with any resource, we want to ensure that our raw materials are produced and used in a sustainable fashion. One of the greatest attributes of wood is that it is a renewable resource. If sustainable forest management and harvesting practices are followed, our wood resource will be available indefinitely.

Over the past decade, the concept of green building has become more main stream and the public is becoming aware of the potential environmental benefits of this alternative to conventional construction. Much of the focus of green building is on reducing a building's energy consumption (such as better insulation, more efficient appliances and heating, ventilation, and air-conditioning systems) and reducing negative human health impacts (such as controlled ventilation and humidity to reduce mold growth). However, choosing building materials that exhibit positive environmental attributes is also a major area of focus. Wood has many positive characteristics, including low embodied energy, low carbon impact, and sustainability.

Wood-based composites encompass a range of products, from fiberboard to laminated beams. Wood-based composites are used for a number of nonstructural and structural applications in product lines ranging from panels for interior covering purposes to panels for exterior uses and in furniture and support structures in buildings.

Malcolm (1992) patented a reinforced MDF in which glass and carbon-fibers were applied. The result of the reinforcement was increased strength, especially impact load resistance, and decreased strain in the boards. Troger et al. (1998) reinforced Particle boards with flax fibers. Flax fibers were applied in the surface layers of the board prior to pressing. Xiong (1998) patented ceiling panels by applying metal bars in the cement board. Mura and Mura (2001) also patented a reinforced particleboard by application of glass fibers, carbon fibers, KEVLAR. They applied reinforcements at 1/3 of the board's thickness. Dimakis et al. (2006) patented plywood, LVL, and OSB in USA. They applied reinforcing strings of metal, rubber, plastic, glass fibers, carbon fibers and also graphite within the wood based composites. Due to this invention, impact load resistance, toughness, and also tensile strength were increased significantly.

II. LITERATURE SURVEY

Behbood Mohebby (2011) [1]: Reinforcement of the MDF was studied by placing two types of metal and synthetic nets as reinforcements in the critical points of the board, top and bottom sides as shown in fig 1.The results for research was Reinforcement of medium density fiberboard increases its strength. Increase of strength depends on the type of reinforcement. Metal reinforcements are more effective in increasing the strength than synthetic woven reinforcements.Embedding of metal reinforcements in epoxy resin affects the strength of the boards.

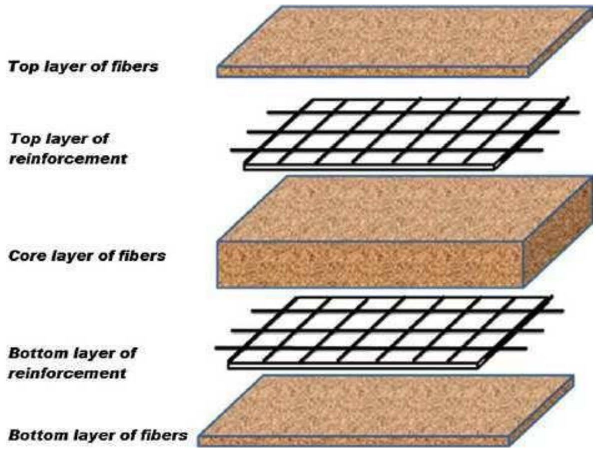


Fig.1 Schematic design of reinforcement placement in MDF; the reinforcements are placed at 1/4 of the board's thickness

Ciğdem dinçkal [2] this paper presents a convenient method to describe the degree of the elastic anisotropy in a given type of wood and then discusses its practical values. Besides mechanical and elastic behavior of wood are investigated in order to understand the optimum mechanical behavior of it in selected directions. Bounds on the wood elastic constants have been constructed in terms of elasticity and compliance tensors for any type of woods by developing Hill (1952) approach. So for any type of wood with known elastic constants, it is possible to choose the best set of elastic constants (effective elastic constants) which determine the optimum mechanical and elastic properties of it. Bounds on the wood elastic constants as well as the degree of elastic anisotropy are significant and critical cases in design of any engineering and structural materials made up of wood.

Jesse l. parisa [3] phenol formaldehyde (PF) adhesive was uniformly tagged with iodine such that it yielded sufficient X-ray computed tomography (XCT) gray-scale contrast for material segmentation in reconstructed wood-composite bond lines. Typically, untagged adhesives are organic and have a similar solid-state density as wood cell-walls, and therefore cannot be segmented quantitatively in XCT data. The iodinated PF development involved analysis and comparison of three trial adhesives containing rubidium, bromine, or iodine. Adhesive tag efficacy was measured in terms of X-ray absorption contrast enhancement and tag uniformity along the adhesive polymers. Cured adhesive density, tag element, and concentration were each found to significantly impact XCT contrast results, which in turn agreed with theoretical X-ray attenuation predictions for each resin. Ion chromatography confirmed the absence of free iodide in the liquid PF prior to bonding, and fluorescence microscopy and energy-dispersive spectroscopy (EDS) showed that iodine tags remained associated with the cured adhesive polymers. XCT and EDS results also demonstrated that when contrast agents are simply mixed into resins, rather than attached to the polymer chains, they are free to migrate independent of the penetrating adhesives during bonding. This then can cause complications with quantitative segmentation and analyses. The iodinated PF yielded consistent and uniform XCT gray-scale contrast; its formulation could be adjusted for other viscosity or molecular weight distribution, which would affect its penetration behavior.

Svetlana Roschina [4] Peculiar features of engineering and numerical calculations of wooden beams reinforced with polymeric composites with the local modification of the wood compression area under an insufficient volume of the initial data have been considered in this article. A technique for determining the physical and mechanical properties of materials and a stress-deformation diagram based on experimental investigation has been described. The enlarged algorithm of engineering calculation on the enumerated geometrical characteristics and numerical calculation by the consecutive loading technique and with correcting of the tangent modulus of elasticity at each step instantiated in PC Lira 10.6 has been presented. Analysis of the stress-strain state of wood-composite beams with local modification of wood has been made. Comparative analysis of engineering and numerical calculations has been performed within the limits of the calculated load. Conclusions on the results of theoretical investigations of the proposed beam construction have been formulated and compared with the existing investigations in the field of reinforcement of beam constructions with polymeric composites.

OBJECTIVE AND SCOPE

Aim of this work is to increase the Modulus of Rapture (MOR) of Medium density fiberboard (MDF) so as to widen its scope of applications (like structural applications).

Teak Wood

Teak is generally worked with moderate ease with hand and machine tools. However, the presence of silica often dulls tools. Finishing and gluing are satisfactory, although pretreatment may be necessary to ensure good bonding of and high cost. Because teak does not cause rust or corrosion when in contact with metal, it is extremely useful in the ship building industry, for tanks and vats, and for fixtures that require high acid resistance. Teak is currently used in the construction of boats, furniture, flooring, decorative objects, and decorative veneer.

Elastic Properties of Wood:

As indicated in Figure 2, three major axes – longitudinal (L), radial® and tangential (T) – describe the coordinate axes of wood. The designation of the axes makes sense if the whole tree trunk or a small incremental cube of wood is considered, with structural features defined by the axes. The whole tree is considered to be orthotropic in that the longitudinal direction is a single axis of an isotropy with optimum properties determined principally by the micro fibrils in the S2 cell wall. All radial directions have lateral symmetry and mechanical properties are inferior to those in the longitudinal direction. CES EduPack software allows longitudinal (l) and 'transverse' (t) moduli to be plotted as a function of density (Fig3) but the precise orientation of 'transverse' properties is not specified. There is a clear, approximately linear relationship between modulus and density for both the longitudinal and 'transverse' orientations. The oval fields represent the range of values for Young's modulus and density at 12% moisture content.

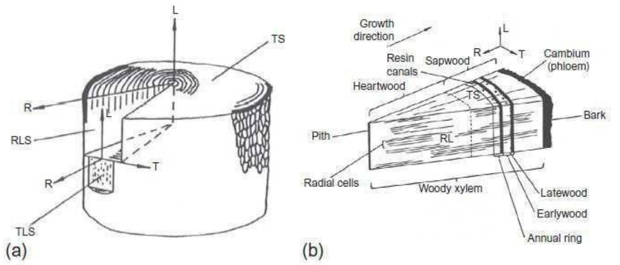


Fig. 2. Sketch diagrams of (a) tree stem and (b) wood wedge (softwood).

Common resins used in MDF:

1. **Urea formaldehyde**

Urea formaldehyde resin was developed in the 1930s and is widely used in the composites industry. Ninety percent of the world's particleboard is produced using UF resin.

The advantages of UF resins were listed by as follows:

1 The hardness of the resin.
2 The low flammability of the resin.
3 The good thermal properties of the resin.
4 The absence of color in the cured polymer.
5 The adaptability of the resin to a variety of curing conditions.

The initial water solubility renders UF resins suitable for bulk and inexpensive production.

However, UF resin has disadvantages, the major problem being that UF resin is subject to hydrolytic degradation when in the presence of moisture and/or acids. This degradation is mainly due to the hydrolysis of the amino plastic and the methylene bridges.

2. **Melamine urea formaldehyde**

Melamine formaldehyde resins are widely used in applications in which the product may come in to contact with water, such as exterior grade panel products and kitchen furnishings. This is due to its high resistance to water attack which distinguishes it from UF resins.

However, melamine formaldehyde is expensive (approximately 2.5 times the price of urea formaldehyde) and therefore a varying amount of urea is added to the resin so that a compromise between cost and performance is met.

Wood Composites:

Wood-based composites encompass a range of products, from fiberboard to laminated beams. Wood-based composites are used for a number of nonstructural and Structural applications in product lines ranging from panels for interior covering purposes to panels for exterior uses and in furniture and support structures in buildings.

The basic element for wood-based composites is the fiber, with larger particles composed of many fibers. Elements used in the production of wood-based composites can be made in a variety of sizes and shapes. Typical elements include fibers, particles, flakes, veneers, laminates, or lumber. Figure 3 shows the variation and relative size of wood elements. Element size and geometry largely dictate the product manufactured and product performance.

Fig 3. Variation and Relative Size of Wood Elements

III. METHODS AND MATERIAL

FINITE ELEMENT ANALYSIS

Finite element analysis is a method of solving, usually approximately, certain problems in engineering and science. It is used mainly for problems for which no exact solution, expressible in some mathematical form, is available. The method is now applied to problems involving a wide range of phenomena, including vibrations, heat conduction, fluid mechanics and electrostatics, and a wide range of material properties, such as linear-elastic (Hookean) behavior and behavior involving deviation from Hooke's law (for example, plasticity or rubber-elasticity).

The Three Point Bend Test

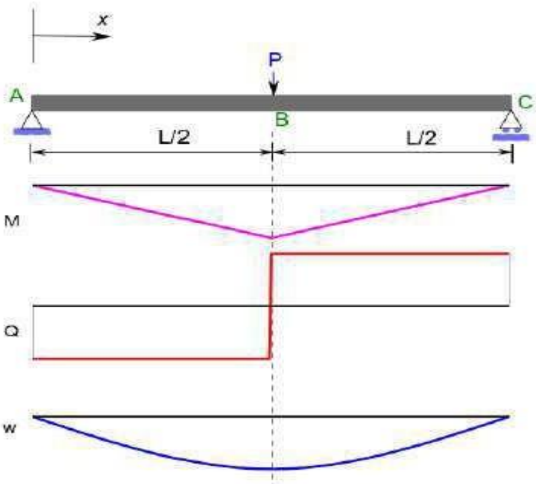


Fig. 4. Three Point Bend Test.

Shear Q and deflection w. Figure 4 produced for the deflection W_o at the centre of the beam is.

$$w_0 = \frac{PL^3}{48EI}$$

Where E is the Young's modulus. I is the second moment of area defined by.

$$I = \frac{a^3 b}{12}$$

Where α is the beam's depth and *b* is the beam's width. By measuring the central deflection ω_0 and the applied force P, and knowing the geometry of the beam and the Experimental apparatus, it is possible to calculate the Young's modulus of the material

Test Specimen

According to IS2380 "Each test specimen shall be 75 mm in width if the nominal thickness is greater than 6 mm, and 50 mm in width if the nominal thickness is 6 mm or less. The thickness shall be the thickness of the material. The length of each specimen shall be 50+24tmm where *t* is the nominal thickness of the board in millimeter."

L= 24t + 50
L= 24(18) + 50
L= 482 mm

'L' is the length (span) of specimen
't' is the nominal thickness of specimen

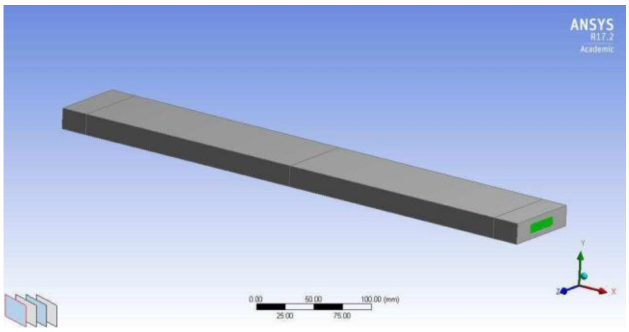


Fig 5. Ansys Modeler Generated 3D Model.

Table 1. Engineering Data

Material	Density(Kg/m³)	MOR (MPa)	MOE (GPa)	Poisson's Ratio
MDF	730	33.6	3.21	0.3
Teak wood	650	100.7	10.7	0.350

Boundary conditions:

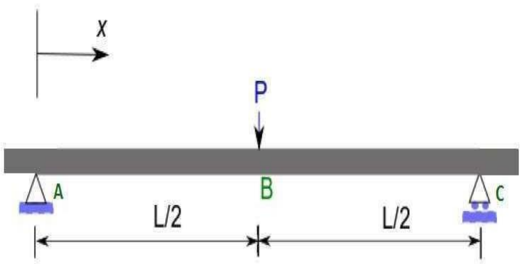


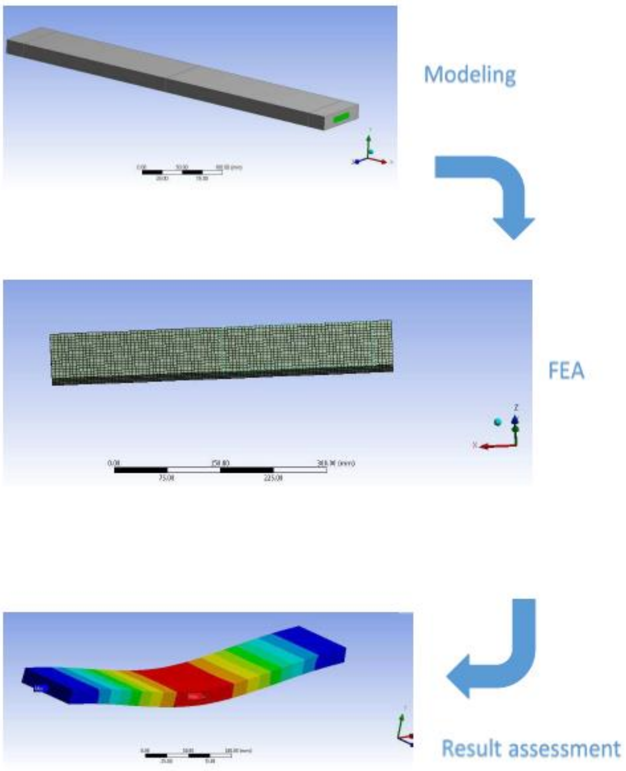
Fig 6. Three Point bending of beam

A: Fixed all DOF restrained

C:Displacement along X-axis all others DOF restrained

For FEA the boundary condition used is one side (25mm from specimen end) is fixed while other side all DOF restrained is fixed except along X direction (Longitudinal) Force is applied at mid-span of test specimen.

FEA Flow Chart:



Ansys result for MDF reinforced with 34.5 x 8 mm rib or strip Mesh Statistics:

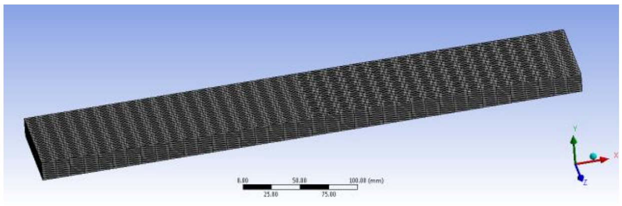


Fig 7. Meshed Model

Deflection of Different Cross Section of Specimen:

The selected cross section is rectangular, and constrained to 20% of wood strip (reinforcement) by volume to MDF board specimen. Few of the cross section analyzed using FEA at different b*h dimensions are shown below.

Table 2 . Shows cross section analyzed using FEA at different b*h dimensions

SL. No.	Reinforcement C/S dimensions b*h (mm)	Reinforcement C/S area (mm2)	Load (N)	Deflection (mm)
1	38.5*7	269.5	200	2.6938
2	45*6	270	200	2.7469
3	54*5	272	200	2.7940
4	39*7	273	200	2.6912
5	34.5*8	270	200	2.64

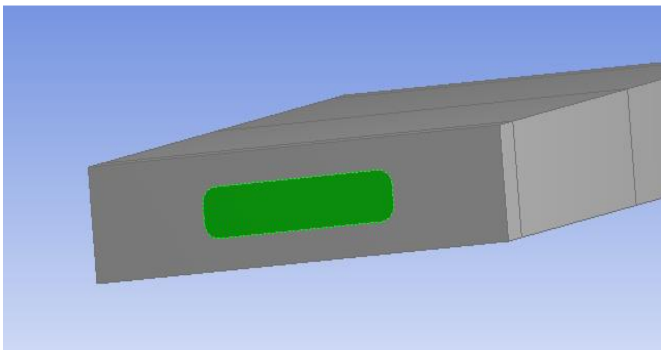


Fig 8. CAD modeled specimen

IV. RESULTS AND DISCUSSION

Results obtained from FEA is tabulated in table 3,also graph showing span Vs deflection,deflection in Y axis,span Vs stress and Maximum principal stress are shown in fig 9,10,11, and 12 respectively.

Finete Element Analysis Results

Table 5.1. Deflection at various lengths

Length [mm]	Deflection [mm]
7.5	0.45273
10.	0.42256
32.535	0.35349
40.07	0.42563
42.581	0.45614
65.186	0.79216
67.698	0.83241
100.35	1.3535
180.72	2.3628
183.23	2.3841
193.28	2.4619
195.79	2.4793
198.3	2.4959
200.81	2.5117
203.33	2.5266
205.84	2.5406
235.98	2.6367
238.49	2.6382
241.	2.6401
243.45	2.6377
245.91	2.6359
253.27	2.6239
277.82	2.5249
280.27	2.5102
331.82	2.0291
334.27	1.999
393.18	1.1302
395.64	1.0892
437.36	0.35775
474.5	0.31509
477.	0.36026
479.5	0.40543
482.	0.4506

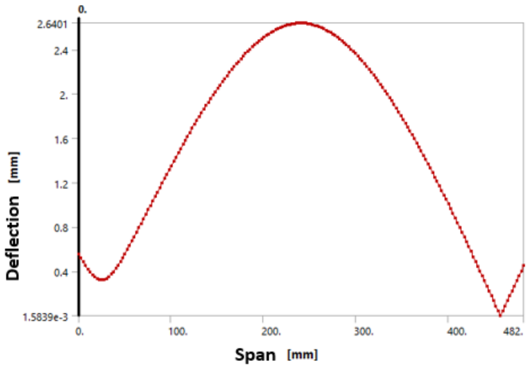


Fig 9. Span vs Deflection graph

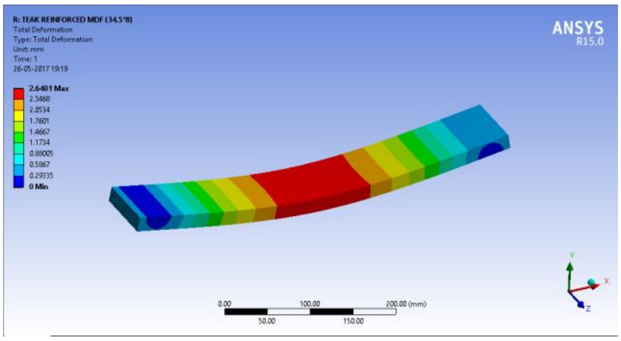


Fig 10. Deflection (Y axis)

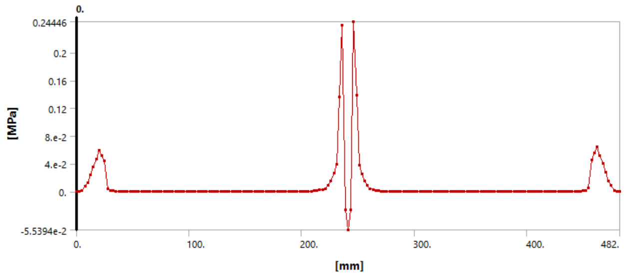


Fig 11 Span vs Stress graph

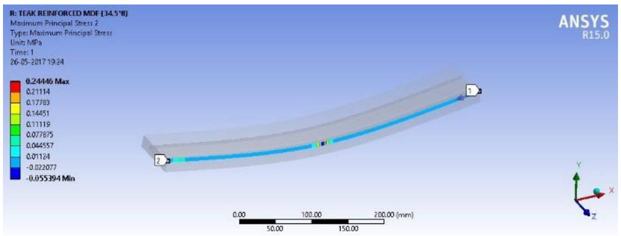
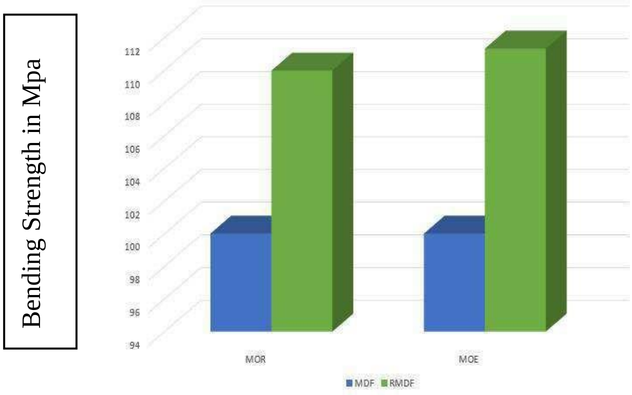


Fig 12. Maximum Principal Stress

V. CONCLUSIONS

- Reinforcement of medium density fiberboard where the prime objective of this project.
- Determination of bending strength in reinforced medium density fiberboards shows that the reinforcements increases modulus of elasticity (MOE) and modulus the rupture (MOR) by 11 % and 10 %.



Cite this article as :

VI. REFERENCES

[1]. Behbood Mohebby (2011), Mechanical properties of medium density fiberboard reinforced with metal and woven synthetic nets, DOI 10.1007/s00107-010-0412-3.

[2]. Cigdem dinçkal [2] this paper presents a convenient method to describe the degree of the elastic anisotropy in a given type of wood and then discusses its practical values. Besides mechanical and elastic behavior of wood are investigated in order to understand the optimum mechanical behavior of it in selected directions.

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