American Journal of Science and Technology
2015; 2(3): 86-91
Published online April 20, 2015 (http://www.aascit.org/journal/ajst)
ISSN: 2375-3846

American Association for Science and Technology

Keywords
Medium Density Fiber Board,
Tensile Strength,
Flexural Strength,
Glass Fiber

Received: February 27, 2015
Revised: March 25, 2015
Accepted: March 26, 2015

Finite Element Simulation of Mechanical Behaviour of Sandwiched Medium Density Fibre Board

Mohammad S. Alsoufi[1], Mohammed Y. Abdellah[2, *], G. T. Abdel-jaber[2], Hanan S. Fahmy[2], A. M. Hashem[2]

[1]Mechanical Engineering Department, Collage of Engineering and Islamic Architecture, Umm Al-Qura University Makkah, KSA
[2]Mechanical Engineering Department, Faculty of Engineering, South Valley University, Qena

Email address
mohammed_yahya42@yahoo.com (M. Y. Abdellah)

Citation
Mohammad S. Alsoufi, Mohammed Y. Abdellah, G. T. Abdel-jaber, Hanan S. Fahmy, A. M. Hashem. Finite Element Simulation of Mechanical Behaviour of Sandwiched Medium Density Fibre Board. *American Journal of Science and Technology*. Vol. 2, No. 3, 2015, pp. 86-91.

Abstract
Medium density fiber board is one of the wood composites used widely in furniture industry. Therefore, strengthen of medium density fiber board is needed. Sandwiched material is manufactured by inserting medium density fiber board between the glass fiber reinforced laminates as sandwich. Finite element model is built to predict mechanical properties of sandwiched medium density fiber board in tension and bending. The simulation results are in good agreement with the experimental data.

1. Introduction

Fiberboards are composite wood-based material made from lignocellulosic fibers bonded together by synthetic resin under pressure and heat. Medium Density Fiber (MDF) boards are distinguished with their good machining, edge-screwing and painting properties. MDF is one of the wood composites most widely used in housing furniture [1].

Ümit Büyüksarı et al. [2] evaluate some of the physical and mechanical properties of medium density fiberboard (MDF) panels laminated with veneer sheets compressed at different levels of pressure and temperature. They illustrated that both modulus of elasticity (MOE) and modulus of rupture (MOR) of the specimens increased with increasing pressure and press temperature. Bending characteristics of the samples tested parallel to the grain orientation resulted in significantly higher values than that perpendicular to the grain orientation for each manufacturing parameter.

Li X et al. [3] in their work, soybean protein was modified with sodium dodecyl sulfate (SDS) as an adhesive for wood medium density fiberboard (MDF) preparation. They obtained results showed that IMC of coated fiber was the dominant influencing factor and also mechanical and soaking properties improved as IMC increased.

A new sugarcane fiber modification was carried out to increase the fiber-phenolic polymer interactions at the interface[4-9]. This modification was based on a selective oxidation of some chemical additive. These chemical can bring some preservation against biological degradation in wood protection[5].

Sugiarto and Darsono [10] conducted surface coating of MDF using epoxy resin either for pigmented coatings and clear. Titanium dioxide was used for white pigmented coatings. Experimental results showed that abrasion resistance and pendulum hardness slightly increased whereas transparency, gloss and adhesion resistance decreased with increasing coating thickness, Whereas, solvent, chemical and stain resistance remain similar. In general, clear coating provides better properties than pigmented coating.

Hoareau et al [11] made modification for sugarcane bagasse fibers chemically. Oxidation with these chemical solvent lead to create polymer quinones or muconic derivatives. Their results shown that to ensure good interaction between the fibers and the resin it is important to apply pressure during the curing and the necessity to dilute the lignin phenolic pre-polymer.

Hassan et al. [12] investigates fracture toughness of composites laminates using finite element method through j-integral calculation. Their results were in good agreement with the experimental ones. The main goal of the present study is to build Finite element model to predict the strength properties in both tension and bending and compared it with the experimental study.

2. Constitutive Equations

The mechanical behaviors of the produced sandwich are linear. The elastic values for medium density fiber board and glass fiber reinforced laminates are listed in Table 1. Therefore, Finite element model is based on simple theories of elastic failure and hook's law.

The total stress is defined from the total elastic strain as [13]:

$$\sigma = D^{el}\varepsilon^{el}$$

Where($\boldsymbol{\sigma}$) the total is stress ("true," or Cauchy stress in finite-strain problems), $D^{el}$is the fourth-order elasticity tensor, and ε^{el} is the total elastic strain (log strain in finite-strain problems). The material for all composites phase is assumed isotropic. The stress-strain relationship for isotropic elasticity is given by [13]:

$$\begin{Bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ \gamma_{12} \\ \gamma_{13} \\ \gamma_{23} \end{Bmatrix} = \begin{bmatrix} 1/E & -\nu/E & -\nu/E & 0 & 0 & 0 \\ -\nu/E & 1/E & -\nu/E & 0 & 0 & 0 \\ -\nu/E & -\nu/E & 1/E & 0 & 0 & 0 \\ 0 & 0 & 0 & 1/G & 0 & 0 \\ 0 & 0 & 0 & 0 & 1/G & 0 \\ 0 & 0 & 0 & 0 & 0 & 1/G \end{bmatrix} \begin{Bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ \sigma_{12} \\ \sigma_{13} \\ \sigma_{23} \end{Bmatrix}.$$

The elastic properties are completely defined by giving the Young's modulus, E, and the Poisson's ratio, (v). The shear modulus, G, can be expressed in terms of E and (v) as:

$$G = E/(2(1 + v))$$

3. Finite Element Domain and Meshing

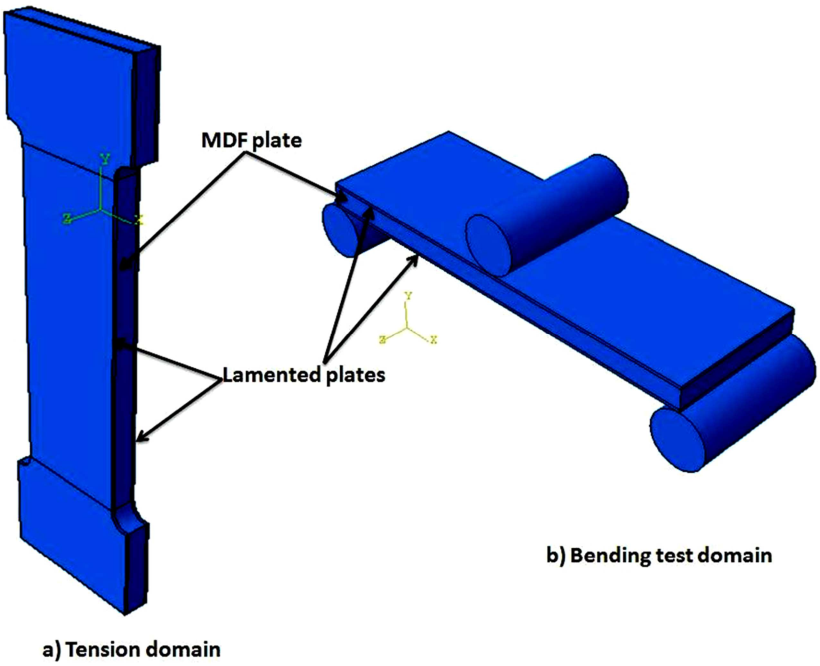

Fig. 1. Finite element domain a) Tension b) Bending

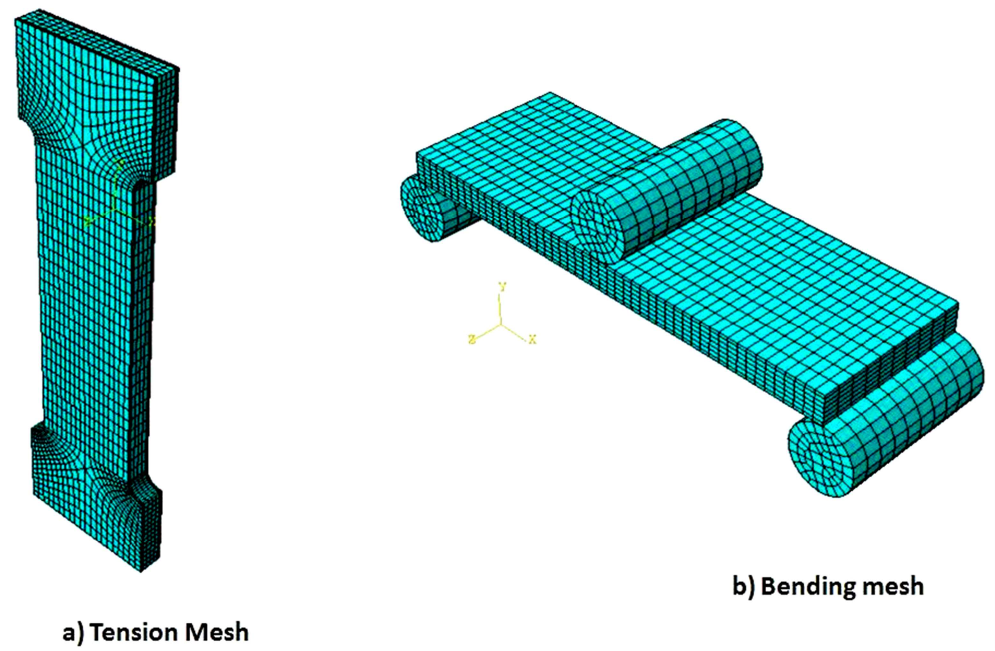

Fig. 2. *Mesh domain for a) tension specimen b) bending specimen*

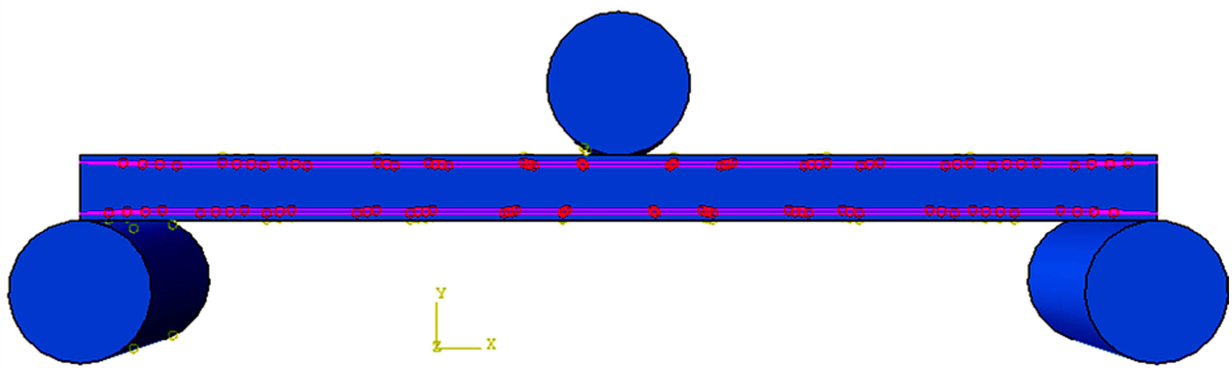

Fig. 3. *Shows interaction module*

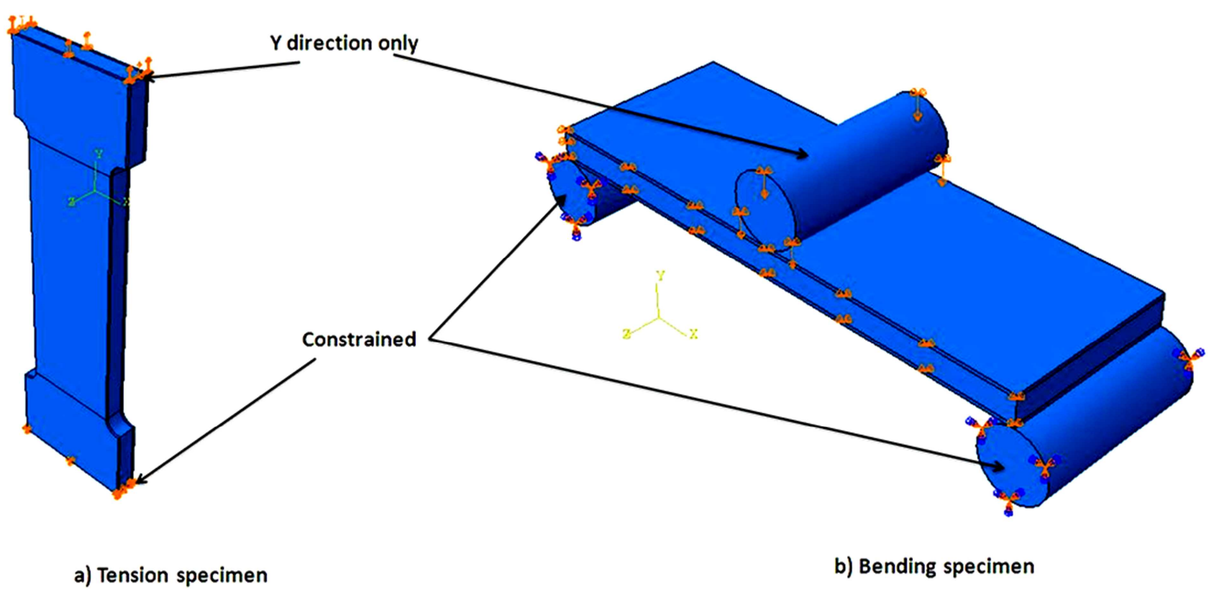

Fig. 4. *Boundary condition a) tension test b) bending test*

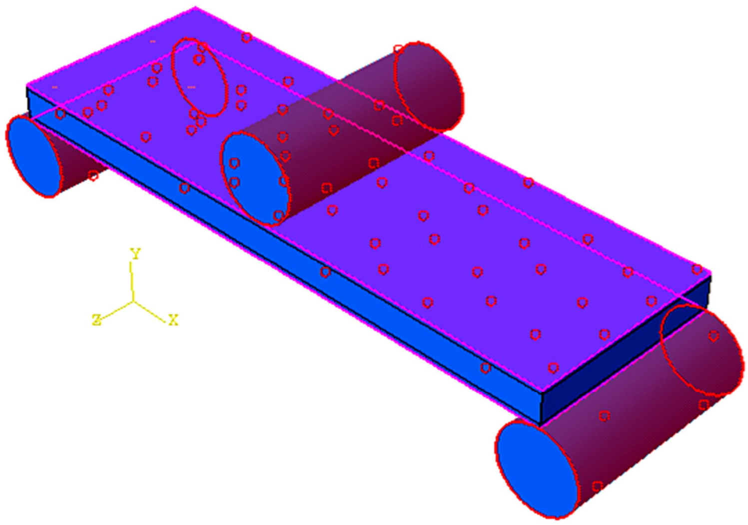

Fig. 5. *Interaction between supporting and load roller*

Finite element numerical model is created to simulate the tensile and bending behavior for sandwiched medium density fiber board. 3D 8-node brick elements (C3D8R) are used. The material properties for studied material are taken from simple tensile and tree point bending test and are listed in Table 1. The displacement control loading technique is used with swept meshing technique. The material for MDF only is given properties while the laminates are assembled for MDF by interaction module and are given other properties. It is tied with the MDF plate in both sides. Fig. 1 shows finite element domain while Fig. 2 shows domain with mesh for both tests. Fig. 3 shows interaction modules for composite plate.

It is given displacement in (y) direction for upper end of the composite plate while constrained in other two directions (X, Z axis) for tension test to simulate the actual case of test. For three points bending test the roller supports is completely constrained while the loading roller is given displacement in y direction only. The interaction between roller and the plate is considering panty friction with nearly 0.3 values. Fig. 4 shows Finite element domain boundary conditions. Fig. 5 shows interaction modules for roller.

Table 1. *Elastic properties of sandwich constitutes*

	Young modules	Passion ratio
MDF	450 MPa	0.3
Laminates	2500 MPa	0.3

Experimental Validation

The produced specimens are tested in tension and bending according to according to ASTM D3039 and ASTM D790 – 10 test standard [14, 15] respectively. The tensile specimens are of dimension shown in Fig. 6, whereas bending specimens are of dimension shown in Fig. 7. All testing are carried out at universal testing machine (Model MachineWDW-100) of load capacity 200 KN and at a controlled speed of 2 mm/min.

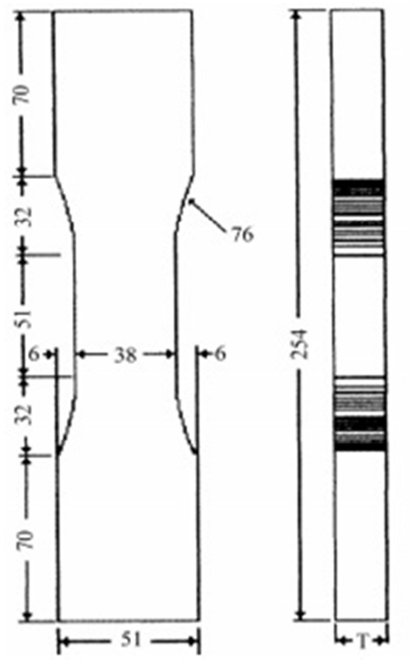

Fig. 6. *Stander tensile test specimens (dimension in mm)*

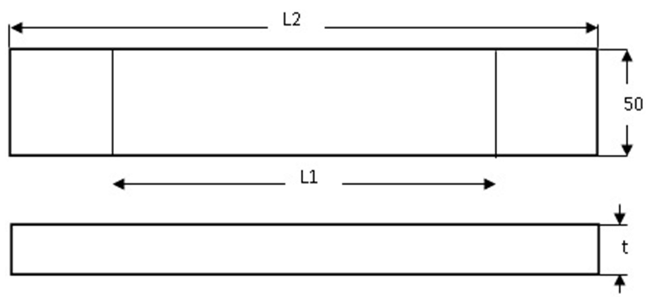

Fig. 7. *Stander three point bending test specimen (dimension in mm)*

4. Results

Fig. 8 show validation between finite element and experimental results, it is observed that the simulation is in good agreement with the experimental results especially at the beginning of the test. Fig. 9 shows the relation between load deflections in three point bending test, it is clearly observed the good agreement between the supposed model and the experimental results. The failure model is clearly shown in contour image which are shown in Fig. 10 and Fig. 11, for von-mises stress and total displacement of the domain under test.

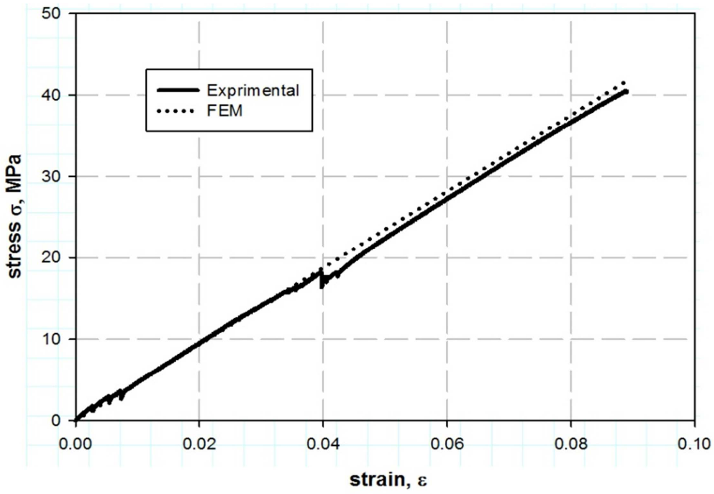

Fig. 8. *Stress Strain curve validation*

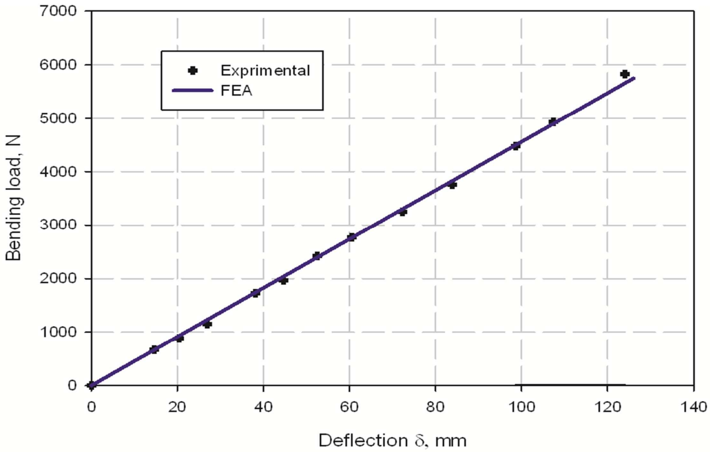

Fig. 9. *Load vs. deflection relation validation*

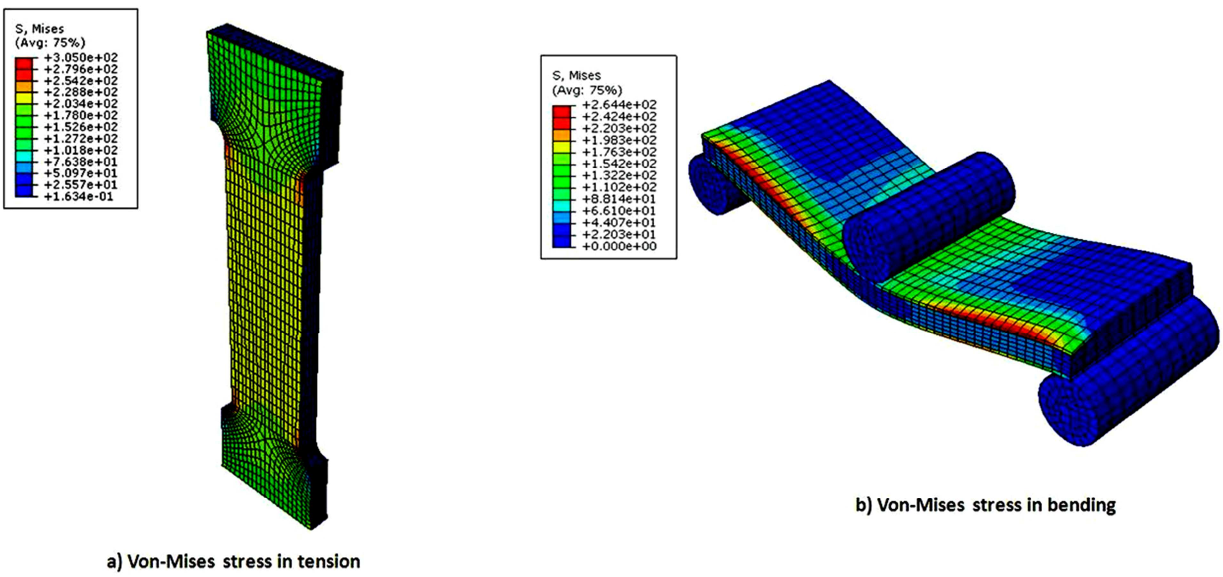

Fig. 10. *Von-misesstresses prediction in a) tension test b) bending test*

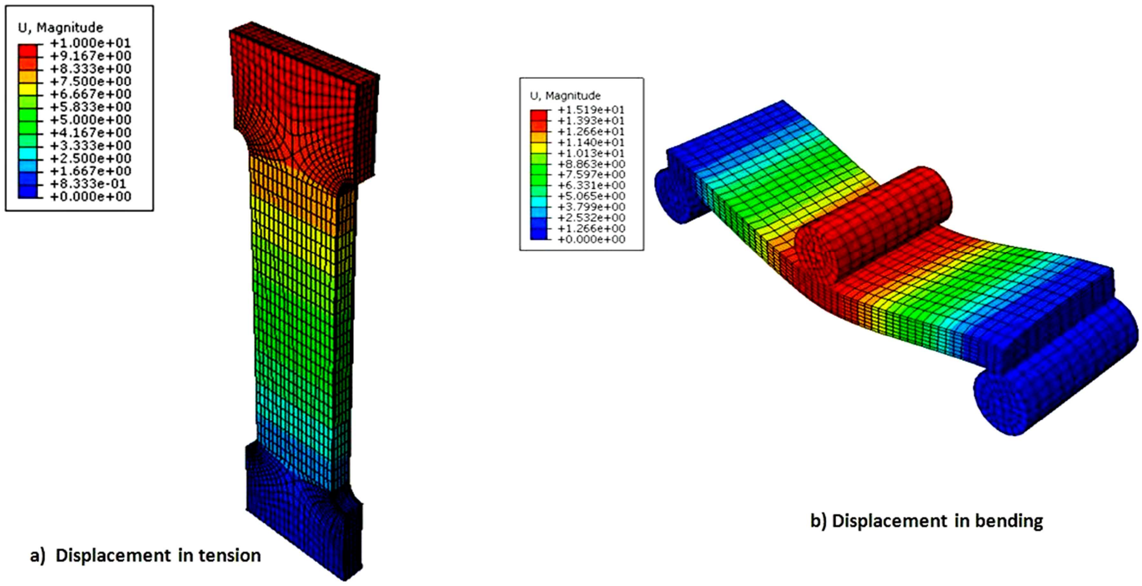

Fig. 11. *Finite element displacement prediction in a) tension test b) bending test*

5. Conclusion

The study completely described finite element model to simulate mechanical properties of sandwiched medium density fiber board. The model is in good agreement with the experimental results for both tension and bending test results. This model is simple and consider as a fast model for calculating the strengths of such sandwiches material having different material.

References

[1] T. M. Maloney, Modern Particleboard and Dry-Process Fiberboard Manufacturing, Miller Freeman, San Francisco 1977.

[2] Büyüksarı, Ü.,Hiziroglu, S., Akkılıç, H., &Ayrılmış, N. (2012). Mechanical and physical properties of medium density fiberboard panels laminated with thermally compressed veneer. Composites Part B: Engineering, 43(2), 110-114.

[3] Li, X., Li, Y., Zhong, Z., Wang, D., Ratto, J. A., Sheng, K., & Sun, X. S. (2009). Mechanical and water soaking properties of medium density fiberboard with wood fiber and soybean protein adhesive. *Bioresource technology*, *100*(14), 3556-3562.

[4] W. G. Trindade,W. Hoareau, I. A. T. Razera, R. Ruggiero, E. Frollini, A. Castellan, Fiberboards Based on Sugarcane Bagasse Lignin and Fibers, Macromol. Mater. Eng. 2004, 289, 728.

[5] W. G. Trindade,W. Hoareau, J. D. Megiatto, I. A. T. Razera, A. Castellan, E. Frollini, Biomacromolecules 2005, 6, 2485.

[6] Ozelton, E. Carl, and Jack A. Baird. Timber designers' manual. John Wiley & Sons, 2008.

[7] Mazumdar, Sanjay. Composites manufacturing: materials, product, and process engineering. CrC press, 2001.

[8] Mallick P.K, Fiber-reinforced composites, Marcel Dekker Press, 2nd Edition, (1993).

[9] M.Westin, S. Lande, M. Schneider, Proceedings of the First European Conference on Wood Modification, Ghent, Belgium, April 3–4, 2003, 289.

[10] Danu, Sugiarto, and DarsonoDarsono. "Electron Beam Curing Of Epoxy Acrylate Coatings On Medium-Density Fiberboard." Indonesian Journal of Chemistry 8.2 (2010): 207-214.

[11] Ozelton, E. Carl, and Jack A. Baird. Timber designers' manual. John Wiley & Sons, 2008.

[12] Mohammed, Y., Hassan, M. K., &Hashem, A. M. (2010). Finite Element Computational Approach of Fracture Toughness in Composite Compact-Tension Specimen. *International Journal of Mechanical and Mechatronics Engineering, IJMME-IJENS*, *12*(04).

[13] ABAQUS 6.9 help

[14] Standard, A. S. T. M. "Standard test method for tensile properties of polymer matrix composite materials." ASTM D3039/D 3039M (1995).

[15] Standard, A. S. T. M. "D790, 2010, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, ASTM International, West Conshohocken, PA, 2003, DOI: 10.1520/D0790-10."