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Static Analysis of Notched Glulam Beams Reinforced by Fiber Reinforced Polymers

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Abstract **— Glulam or Glued Laminated Timber is an engineered wood product and is manufactured by gluing together pieces of timber laminates either vertically or horizontally. Glulams can be manufactured in larger size and longer length members, which can be curved or straight. It is used for structural and decorative applications. The notches can be also provided in the glulam at the supports. But for notched glulam beams, the occurrence of deformation is more. Fiber Reinforced Polymers can be provided in glulam structures as reinforcements due to its high corrosion resistance, strength to weight ratio and moderate modulus of elasticity. This paper portrays a brief study on the static analysis of the notched glulam beams to investigate deformation behaviors on beams based on different FRP reinforcements in FEM softwares.**

Keywords— Glulam, Fiber Reinforced Polymer, Finite Element Model, Carbon Fiber Reinforced Polymer, Glass Fiber Reinforced Polymer.

I. INTRODUCTION

In recent years, wood has a very big demand in the construction industry as a building material. From wood, various building members can be manufactured. So the Engineered Wood Product [EWP] is introduced in the construction industry. The glulam is an EWP and is also called glued laminated timber. It is made by gluing the timber laminates together by using industrial adhesives under pressure. Fig.1 shows the different stages in the glulam manufacturing process. The use of glulam in construction has significantly increased due to its strength, innovative and versatile properties. The durability of timber combined with the modern industrial techniques provides unique qualities for the glulam beams.

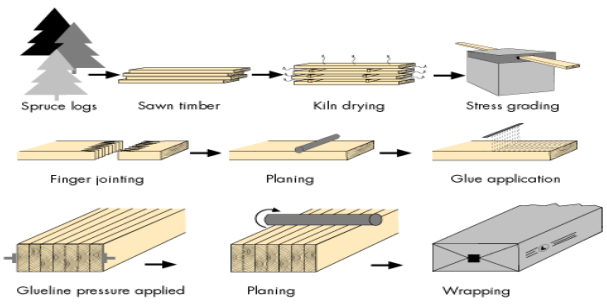

Fig 1: Glulam manufacturing process

The thickness of the laminates are depends on the application and species used. The length and shape of glulam sections is limited only depends on the manufacturing, transport and handling capabilities. The glulam is manufactured from seasoned timber so it has a high degree of dimensional stability. Glulam beams can be tapered or curved. In wooden beams, notching is needed in various places to run utilities or to fit with other structural members. The notch in the glulam beams may cause reduction in the strength. Also it may cause stress concentrations at corners of the beams. Glulams are mainly used in residential construction as main framing members and garage door headers. These members are also used for the structures in transportation, marine and dome applications and also for highway bridges.

Glulam beams loaded by bending moments will fail at the tension side at the position of knots or at finger joints. So that glulam beams are mainly reinforced at the tension side to strengthen the weak cross-sections. The reinforcement provided for glulam beams should have a high modulus of elasticity (MOE) and a large tensile strain at failure. Fibre reinforced polymer (FRP) have high MOE and high tensile strength [1]. For increasing the flexural strength and stiffness of the glulam beams, reinforcing elements are added that act compositely with the existing member. The flexural strengthening of the glulam beams can be done by carbon fiber reinforced polymers. [2]. The bearing capacity of the glulam is an important thing that is to be considered. The beam in which reinforcement provided on the bottom and upper edges of the beam had higher bearing capacity compared to the beam in which the reinforcement provided only at the bottom edge of the beam [3]. Glued laminated beams (glulams) have less allowable shear stresses relative to competitive engineering wood products. To increase the shear strength, a series of fiber-reinforced polymers (FRP) are transversely provided on the glulam. The transverse reinforcing scheme provides a significant shear strength improvement to the small scale glulam beams [4]. Fiber-reinforced polymers associated with glulam timber beams provide significant increase in terms of strength and stiffness and modify the failure mode in bending of these structural elements [7].

This paper presents an attempt to model the nonlinear behaviour of beams until the failure occurs. The beams were reinforced with CFRP & GFRP plates. Validation is done analytically and the objectives of the project are

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- To understand the concept of notched glulam beams
- To model beams with different FRPs.
- To conduct static analysis to determine deformations.

II. VALIDATION

For the validation, an experimental study on the flexural behavior of FRP reinforced glulam beams conducted by Huifeng Yang was used. A three dimensional FE model with simply supported at the ends was created using ANSYS software using the collected data. Load was applied untill the failure. The results of the FE analysis were compared against the experimental work. Fig 2 shows the load deflection curve for carbon fiber reinforced glulam beam from the experimental study. From fig 2, the deflection obtained for 60 kN was 100 mm. Fig 3 shows the load deflection curve from the FE analysis. From fig 3, the deflection obtained for 59 kN was 98.5 mm.

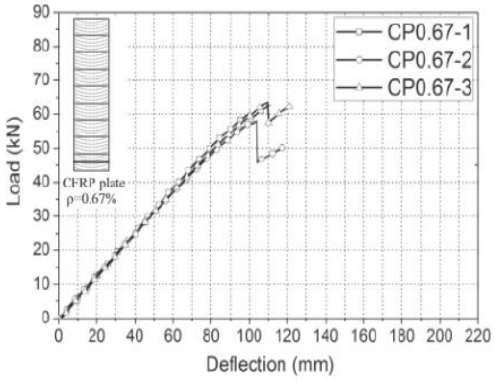

Fig 2: Load deflection curve from the experiment

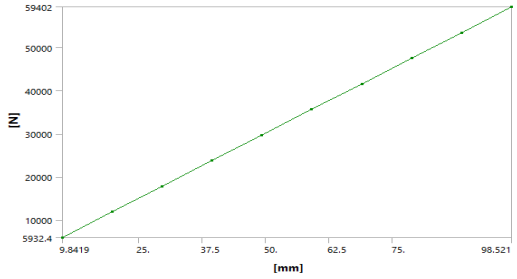

Fig 3: Load deflection curve from FE analysis

III. FINITE ELEMENT ANALYSIS

The finite element method is a numerical method for solving differential equations in an approximate manner. By using the finite element method, the entire model is divided into smaller parts (finite elements) and the analysis is carried out over each element instead of the approximation for the entire region. In this study, non-linear finite element analysis was conducted to investigate the static analysis of notched glulam beams reinforced with CFRP and GFRP.

A. Details of Geometry

In this study three notched glulam beams of size 100 mm x 315 mm with a span of 4000 mm were modeled with same geometric properties. Seven laminas of thickness 45 mm were used in the glulam specimen. The beams were notched at each end and the notch dimensions are 400 mm x 110 mm. the beam is simply supported at the ends. In three glulam beams, one is unreinforced and the other two beams were reinforced with GFRP and CFRP. Finite element model is developed using ANSYS 16.2 version. Table 1 shows the material properties of the notched glulam beam.

TABLE 1: Material properties of glulam beams

Density	400 Kg/m^3
Tensile strength parallel to the grain	17.6 MPa
Tensile strength perpendicular to the grain	0.4 MPa
Compressive strength parallel to the grain	25.4 MPa
Compressive strength perpendicular to the grain	2.7 MPa
Modulus of elasticity parallel to the grain	13000 MPa
Modulus of elasticity perpendicular to the grain	410 MPa
Shear strength	2.7 MPa
Poissons ratio	0.5

The reinforcement was provided at the two sides of the notched corner at 45degree inclination. FRP plates of 1.2 mm thickness were provided in this study. Load was provided until the failure occurs.

B. Results and Discussions

Non linear static analysis was carried out and the results obtained analytically from the ANSYS software. From the analysis, it was observed that max deformation of the unreinforced notched glulam beam was 100.62 mm at the midspan. For carbon fiber reinforced notched glulam beam, the deflection was 85.108 mm and for glass fiber reinforced notched glulam beam, the deflection was 88.37 mm. Fig.4 (a) to (c) indictes the deformation of the unreinforced, carbon fiber reinforced and glass fiber reinforced notched glulam beam respectively.

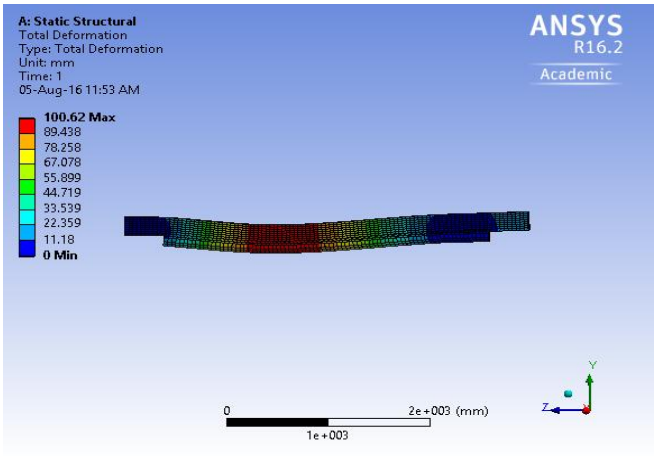

Fig 4 (a): Deformation of unreinforced notched glulam beam

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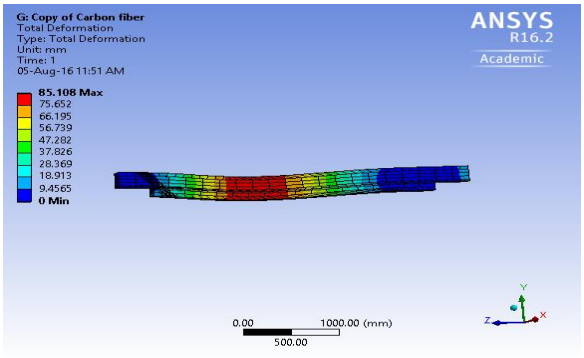

Fig 4 (b): Deformation of carbon fiber reinforced notched glulam beam.

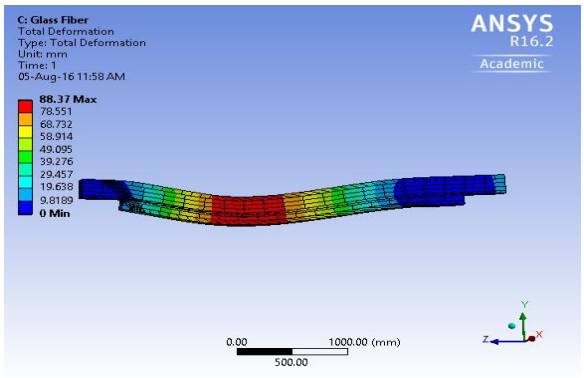

Fig 4 (c): Deformation of glass fiber reinforced notched glulam beam.

IV. CONCLUSION

From the static analysis of finite element model of the notched glulam beams, it was clear that the FRP reinforcement greatly affects the performance of the glulam beams. The deformation of the FRP reinforced notched glulam beam was smaller than the unreinforced notched glulam beam. Also the deformation of carbon fiber reinforced notched glulam was little smaller than glass fiber reinforced notched glulam beam. So that carbon fiber was preferred for the reinforcement for getting good performance of the notched glulam structures.

V. FUTURE STUDY

In the glulam structures, the notches at the supports causes shear stress concentrations at the notch corner. Due to shear concentrations brittle failure may occurs rapidly for the beams. So the study about the stress concentrations at the notch corner needs to be studied.

REFERENCES

[1] M Romani, H J Blaß, (2001), "Design Model for FRP Reinforced Glulam Beams", International Council for Research And Innovation in Building And Construction.

[2] Jobin Jacob, Olga Lucia Garzon Barragán, (2007), "Flexural Strengthening of Glued Laminated Timber Beams with Steel and Carbon Fiber Reinforced Polymers", Master's Thesis in the International Master's Programme Structural Engineering.

[3] T. Jurícek, (2009), "Analysis Of Composite Beams Bases On Wood And Reinforced Fibers", Slovak Journal of Civil Engineering, PP 13-21.

[4] T. Russell Gentry, (2011), "Performance of Glued-Laminated Timbers with FRP Shear and Flexural Reinforcement", Journal of Composites for Construction (ASCE), PP 861-870.

[5] Wan Hazira Wan Mohamad, Mohd Azran Razlan, Zakiah Ahmad, (2011), "Bending Strength Properties of Glued Laminated Timber from Hardwood Timber", International Journal of Civil & Environmental Engineering, Volume 11.

[6] José Sena Cruz, Marco Jorge, Jorge M. Branco, Vítor M.C.F. Cunha, (2013), "Bond Between Glulam and NSM CFRP Laminates", ELSEVIER, PP 260-269.

[7] Antonio A. Dias, Juliano Fiorelli, Julio C. Molina, (2015), "Numerical Analysis of Glulam Beams Without and With GFRP Reinforcement", 10th International Conference on Composite Science and Technology.

[8] Juliano Fiorelli, Nolan Rempe, Julio Cesar Molina, Antonio Alves Dias, (2015), "Natural Fiber Reinforced Polymer for Structural Application", Springer International Publishing Switzerland.

[9] Umaima Muhammed. C.K, Arya.R, (2015), "Analytical Study on Flexural Behaviour of Glued Laminated Timber", International Journal Of Innovative Research In Science, Engineering And Technology, Volume 4.

[10] Weidong Lu, Zhibin Ling, Qifan Geng, Weiqing Liu, Huifeng Yang, Kong Yue, (2015), "Study on Flexural Behaviour of Glulam Beams Reinforced by NSM CFRP Laminates", ELSEVIER, PP 23-31.

[11] Huifeng Yang, Dongdong Ju, Weiqing Liu, Weidong Lu, (2016), "Prestressed Glulam Beams Reinforced With CFRP Bars", ELSEVIER, PP 73-83.