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Experimental Study on Glass Fiber Reinforced Glued Laminated Timber Beams in Flexure Perpendicular to the Timber Grain

Sumayya P. Kabeer[1], Anima P.[2]

[1] PG Scholar, Dept of Civil Engineering, Universal Engineering College, Vallivattom, Thrissur, Kerala, India.

[2] Associate professor, Dept of Civil Engineering, Universal Engineering College, Vallivattom, Thrissur, Kerala, India.

Abstract

Although the use of wood as a building material is ancient, these days it still presents good structural qualities compared to steel and concrete materials. Its stress ratio to specific weight makes it suitable for one way floors and, in particular, timber beams without knots or cracks have high values of compressive and tensile strength. However, elastic modulus and shear strength have very low values compared with steel materials. Nowadays, building reutilization and the current technical standards lead to an increase in service loads and to a decrease in maximum deflection limits. In order to improve the structural safety and reliability of structural wood systems in existing buildings, composite-based reinforcement techniques are demanded. In this regard, Fibre Reinforced Polymers (FRP) is an adequate alternative to improve structural capacity. This paper presents a brief study on the flexural behavior of glued laminated timber beams perpendicular to the timber grains.

Keywords: Glulam, Fiber Reinforced Polymer (FRP)

Introduction

In recent years, timber has a very big demand in the construction industry as a building material. The use of timber structural elements is also an interesting earthquake resistant solution compared to other traditional construction materials like concrete and masonry, based on its lightness, large deformation capacity and high tensile strength and strength-to weight ratio. From timber, various building elements can be manufactured. The glulam is also an Engineered Wood Product (EWP) and is called Glued Laminated Timber (GLT). Glulam is manufactured from layers of parallel timber laminations. Pieces of sawn timber are graded for strength, before being glued together under pressure with the grain in the laminates running parallel to the longitudinal axis of the section. Carbon Fibre Reinforced Polymer (CFRP) is the best type of FRP strengthening. But because of its high cost, its use is being limited. Thus, this makes Glass Fibre Reinforced Polymer (GFRP), the most commonly used type of FRP strengthening technique. This paper presents an attempt to model the nonlinear behaviour of timber beams until the failure occurs. The timber beams were reinforced with GFRP. The objectives of the project are

- To study the flexural strength of timber beams strengthened with GFRP
- To analyse the behaviour of glued laminated timber beams strengthened with GFRP

Experimental Study

The timber specimens considered for the experimental investigation includes pine, mango and coconut. Thickness of GFRP used is 0.450 mm. A total of 24 specimens were made. Fig 1 shows the timber specimens for testing.

- Size of specimen (100mm X 100mm X 500 mm)

- ✓ Specimen 1 - 2 pieces of 50mm X 100mm X 500 mm without GFRP
- ✓ Specimen 2 - 2 pieces of 50mm X 100mm X 500 mm with GFRP
- ✓ Specimen 3 - 4 pieces of 50mm X 50mm X 500 mm without GFRP
- ✓ Specimen 4 - 4 pieces of 50mm X 50mm X 500 mm with GFRP

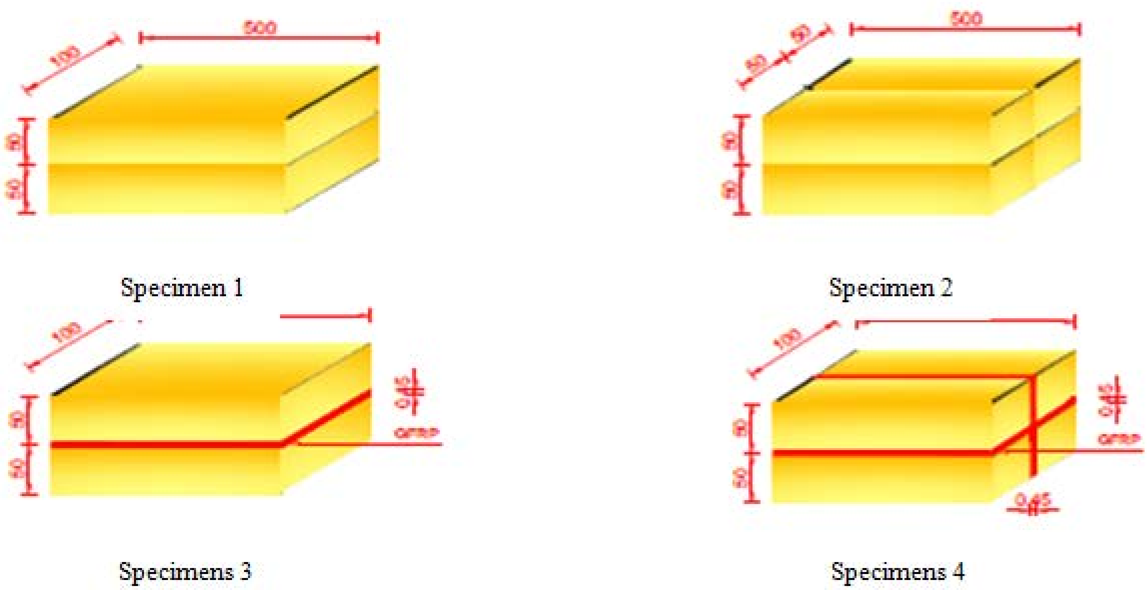

Fig. 1 Timber Specimen 1, 2, 3 and 4

Methodology

The flexural strength of the timber beam is tested as two point loading system using a hydraulic jack attached to the loading frame. The behavior of beam was keenly observed from beginning to the failure. The loading was stopped when the timber beam was just on the verge of collapse. The values of load applied and deflection are noted directly and further the plot of load vs. deflection was performed which is taken as the output. The load in kN was applied by uniformly increasing the value of the load and the deflection under the different applied loads was noted. The applied load is increased up to the breaking point or till the failure of the material.

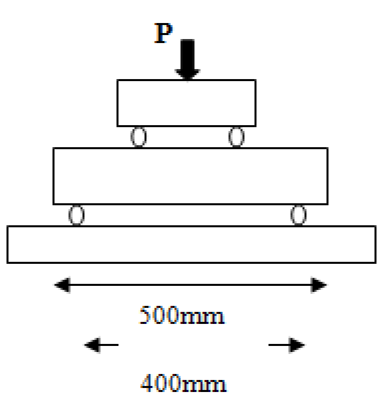

Fig. 2 Schematic Setup for Testing

Fig. 3 Test Set up

Results

- Coconut take much higher load than other two specimens
- Specimens with GFRP take more load compared with specimens without GFRP
- Variation in strength is more for pine than others
- Comparing specimen size, 50mm x 50mm x 500mm specimens shows better results.

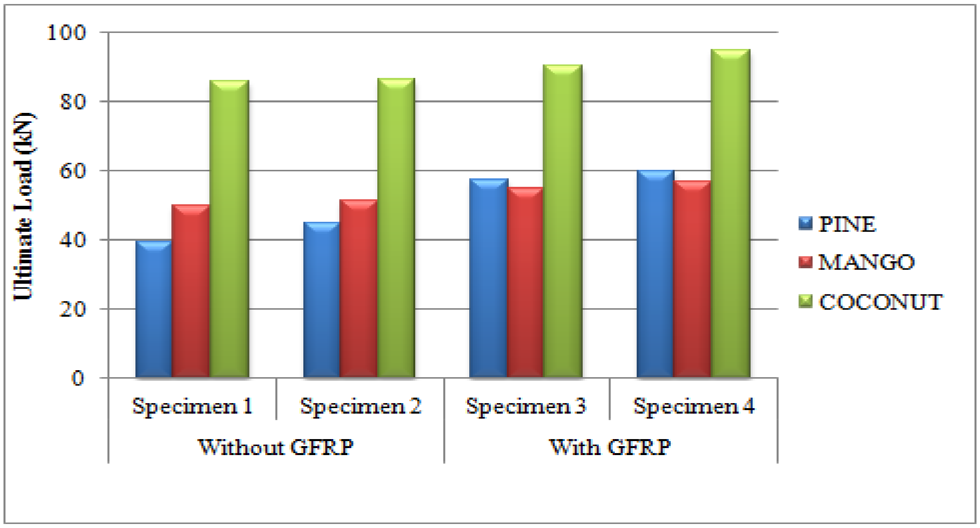

Fig.4 Ultimate Load Carrying Capacity

Conclusions

The research work included the testing of timber beams, each having a span of 500 mm and glued with GFRP to increase the flexural strength of beams. Flexural strength comparison between control beam and other types of beams made for the present investigation is illustrated as follows:

a) Coconut take much higher load than other two specimens
b) Specimens with GFRP take more load compared with specimens without GFRP
c) Variation in strength is more for pine than others
d) Comparing specimen size, 50mm x 50mm x 500mm specimens shows better results
e) The area of timber used in specimen 3 and 4 are 0.09% less than the conventional timber beam
f) The ultimate load carrying capacity of specimen 2 is 45% and the specimen 4 is 33% more than the conventional timber beam made with pine
g) The ultimate load carrying capacity of specimen 2 is 10% and the specimen 4 is 11% more than the conventional timber beam made with mango
h) The ultimate load carrying capacity of specimen 2 is 5% and the specimen 4 is 10% more than the conventional timber beam made with coconut

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