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ANALYSIS OF TIMBER-CONCRETE COMPOSITE SLAB

Mukthar V Basheer[1,*], Bennet Kuriakose[2]

[1,2]Department of Civil Engineering, St. Joseph's college of Engineering and Technology, APJ Abdul Kalam Technological University, Palai- 686579 , India
[*]mukhtharvbasheer10@gmail.com

ABSTRACT

Composite construction of any building construction involving when two different materials are bound together so strongly that they act together as a single unit. Because of the low self -weight, fast construction, fast repairing, high resistance to bending and deflection, high load capacity, good dynamic behaviour we select the cross-laminated timber concrete composite in floor system. The design, construction, and performance of the CLT-concrete system are dependent on timber properties, connection systems, and slab details. The construction is economical and eco-friendly because of the reduction of concrete and steel. In this study shear performance of different connections in Cross-laminated timber Concrete Composite floors are conducted. Twenty specimens were prepared as five groups and tested in this study and find the load carrying capacity of each connection. Compare the result and find the best one. Timber embedding failure, and concrete crushing failure were also observed around the shear-compression loaded screws. In this project parametric study is done in CCC with various connectors using ABAQUS software. The project summarizes the information of CCC and connection's properties, testing and its reliability. This CLT-concrete composite possesses good performance under various loading conditions if we designed and constructed well.

Keywords - Cross-laminated timber concrete composite (CCC), self-tapping screws, Slip, Timber-concrete composite.

1. INTRODUCTION

A composite construction consists of two or more materials bonded together such that they function as a single entity. Timber-Concrete Composite (TCC) is a technology that focuses on maximising performance and material needs by creating a structural link between timber and concrete components. Different composite constructions have been used. By producing a composite action between the two materials, structural efficiency is attained. Construction uses both timber and cross-laminated timber. The timber component is placed in the lower portion of TCC components, and the concrete component is placed in the higher part. These two zones are coupled with an appropriate connection system.

For maximum composite action between timber and concrete, the TCC floor connection system is essential. Steel fasteners like self-tapping screws, steel dowels, and mesh plates are frequently used for connections (known as HBV connectors). TCC flooring has also employed adhesives, hybrid connectors, notched connections, and unique connections. Most shear connectors have a semi-rigid design, which limits the composite action that TCC floors may produce. The majority of shear connections are semi-rigid, which limits the composite action that TCC floors may produce. However, compared to dowel-type fasteners like screws, the notches, mesh plates and adhesives are stronger and stiffer. CLT has a wide range of potential applications, including the construction of walls, floors, and roofs; the dimension can be readily enlarged or condensed. This technique has advantages since it is environmentally friendly, emits little carbon dioxide, and has excellent thermal and acoustic insulation capabilities. With this technology, lightweight buildings are possible.

The main objectives are

- To develop a numerical model to analyze TCC slab.
- To understand the behavior of TCC slab using different connectors.
- To understand load carrying capacity of the connectors with different parameters
- To analyse the best connection type using parametric study

The study by Wang et al.(2022) was a discussion of self-tapping screw connectors' shear performance in CCC floors. Twenty-four specimens were casted and tested in this study and find the slip and failure using push-off test and endoscopy test. Additionally, failures of concrete crushing and timber embedding around the shear-compression laden screws were noted [1].

2. LITERATURE REVIEW

By using TCC, researchers conducted many studies, to strengthen and limit the crack opening in concrete, a practical reinforcing method in the notched connections was presented. The composite floor's ultimate bending stiffness and load carrying capability were both enhanced by the reinforced notched column [2]. This enhance the possibility of combined connectors. In a study the system incorporates flooring and prefabricated frames that are made of plywood laminated veneer ribs and glued laminated wood. Reinforcement bar is inserted into a cavity created by the timber concrete shear connection, which is then filled with concrete. And the gamma method is used to assess performance, and the findings show high strength joints with ductile failure and high composite effect [3]. In these studies using TCC found the good advantages and combined connectors give more load carrying capacity. All the studies gives the information about how to prepare, use of TCC also the connection types, connectors and there advantages.

3. METHODOLOGY

3.1 Detailed parametric study

ABAQUS software is used to conduct a parametric analysis. Numerous factors, including the number of screws, connectors, diameters, and angles, are used. The load-carrying capacity of the connectors, including screw connection, notched connection, and combined connection, with variations in numbers, diameter, and screw inclination, is also analysed using this parametric research.

A screw connection specimen with a rise in the number of screws by 7, 14, and 21 is used in group 1 and has a 6mm diameter and a 90 degree angle. The screw's length is 90 mm throughout the entire research. Notched connection is used in group 2. The number of notches has increased and analysed. The dimension of the notch is 150mm by 25mm. In the third parametric study, various connectors including notched and screw are combined. The dimensions of the notch and screw are the same as in the prior groups. In this research, the connection types of notch, screw, and combined are compared. Changes in the screw diameter of 8 mm and 10 mm are studied independently in the fourth group. The fifth model's bolt inclination is altered by 45, 60, and 90 degree angles.

3.2 Preparation of model

3.2.1 FEA analysis

Here, the study is conducted using the numerical technique known as Finite Element study (FEA). FEA is used in engineering and science to solve partial differential equations (PDEs) and simulate complex physical systems. A big system is divided into smaller, easier-to-manage components using FEA, and the behaviour of each component is modelled using mathematical equations. Numerical techniques can be used to solve the resulting system of equations in order to approximate the behaviour of the complete system. Pre-processing, analysis, result, and post-processing are all steps in the FEA procedure. The finite element study is performed using ABAQUS software

3.2.2 Dimensions and Properties

Using ABAQUS software, 5 sets of CLT-concrete composite specimens were analysed. Figure 1 illustrates the specimen shape in detail. A parametric analysis was conducted using this model on each 1 m by 1 m specimen, which was made up of a 40 mm thick concrete layer on top of an 85 mm thick CLT panel. The screws were spaced 100 mm apart in all specimens in the direction perpendicular to the load application. To analyse the slab's load carrying capacity, various diameters, including 6 mm, 8 mm, and 10 mm, are used. The screw's length is 90 mm. A 60 mm screw is inserted into the CLT. The concrete also has 30 millimetres embedded in it. Along the length of the block, there is a rectangular notch measuring 150 mm by 25 mm.

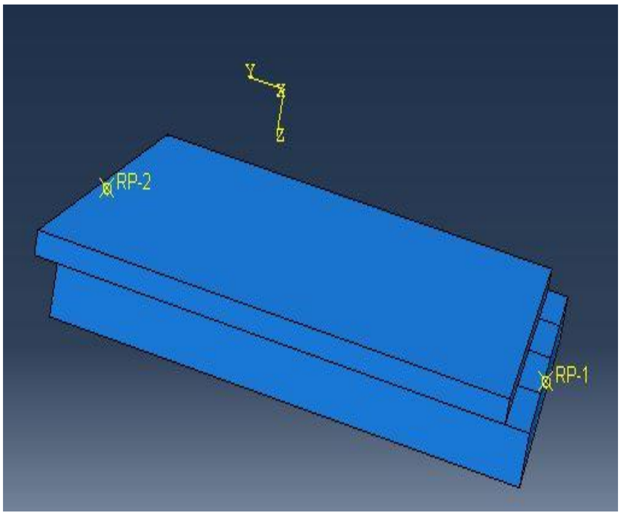


Fig.1 CLT-concrete composite shape

Table 1 Properties

Wood	Concrete	Steel
Density :425 kg/m3 Tensile longitudinal strength :64.8 MPa Tensile longitudinal elastic modulus: 10980 MPa	Density: 2400kG/m^3 Elastic modulus: 28823MPa Poisson's Ratio :0.3	Density: 7800kG/m^3 Elastic modulus: 210000MPa Poisson's Ratio:0.3 Yield stress: 390Mpa Ultimate stress 474Mpa

3.2.3 Meshing and Boundary conditions

Using an element type of C3D8R, and 8-node linear brick element, concrete and wood are meshing with a 20 millimetre element size. In screws, a 2-node linear 3-D truss element with a 2 mm element dimension is used. In this model, there are three points of contact: a screw inserted in concrete, a screw embedded in wood, and a frictional interaction with a friction coefficient of 0.2. In this model, a push-off test setup with one fixed end and the other end displacing 5 millimetres is used.

4. RESULTS AND DISCUSSIONS

After the analysis, ABAQUS provides us with findings like stress, deformation, ultimate load, and others. Each specimen also provides information on the impact of connectors on the slab. Figure displays the outcomes

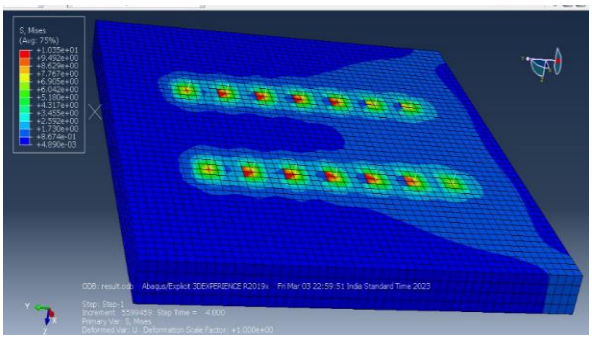


Fig. 2 Group1, parametric study with number of screws

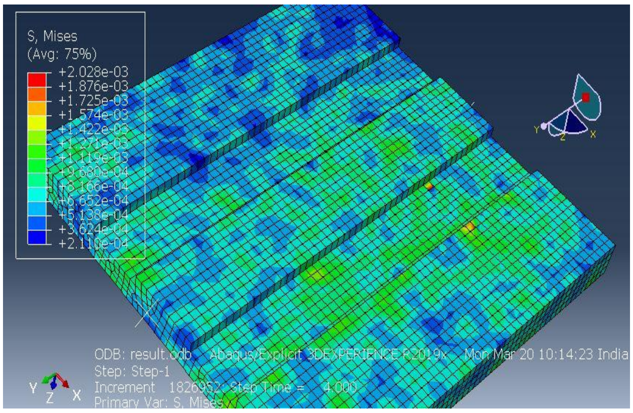


Fig.3 Group 2 Parametric study with number of notched

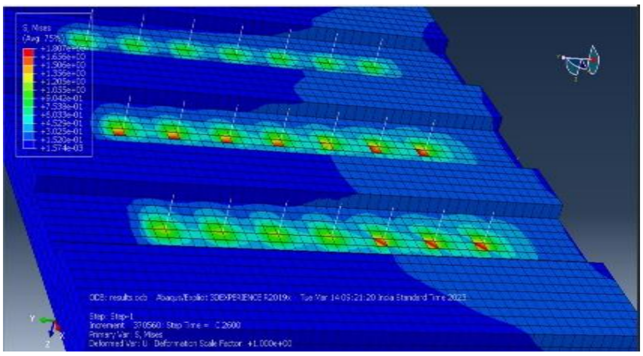


Fig.4 Group 3 Study with combined connection

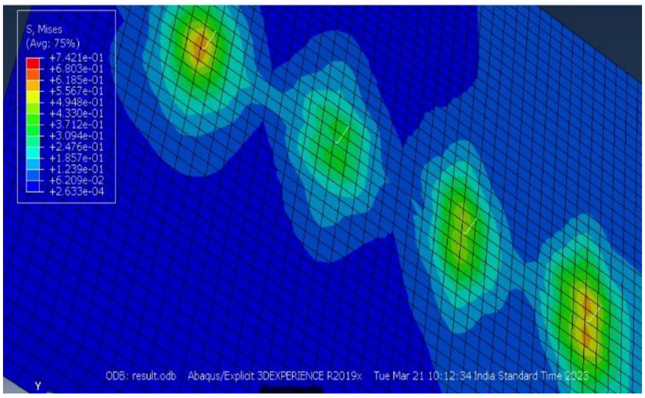
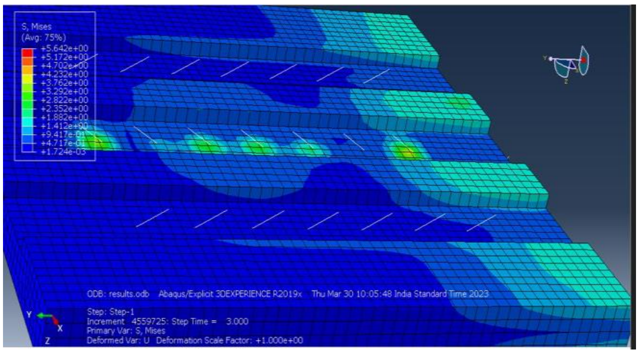


Fig. 5 Group 4 Parametric study with diameter



4.1 Load -Displacement curves

Fig.7-Fig.11shows the comparison load-displacement graph of each group.

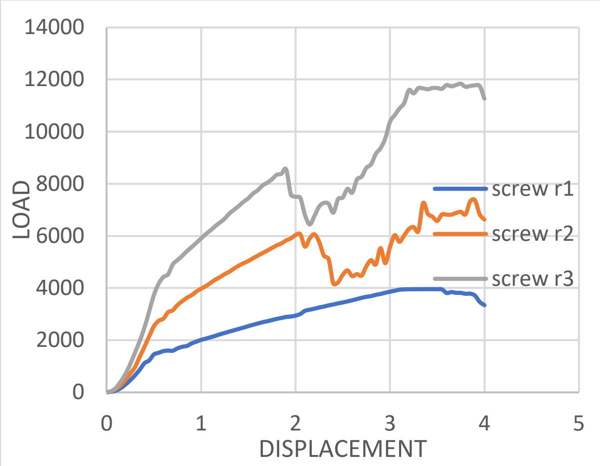


Fig.7 Group 1

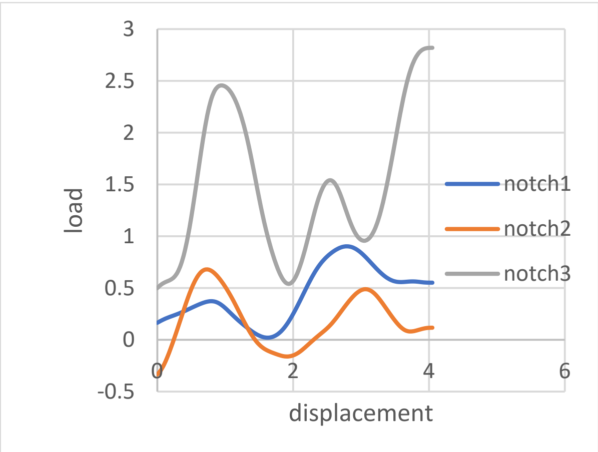


Fig.8 Group 2

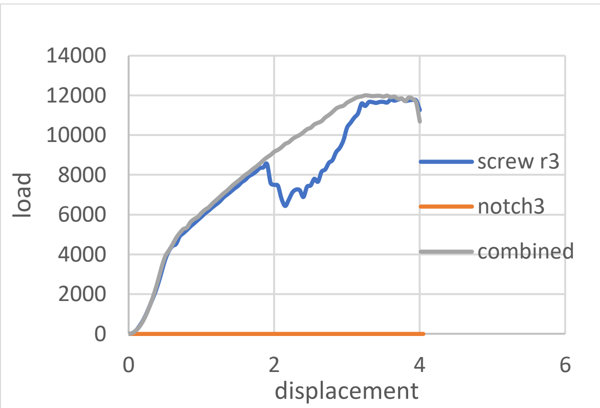


Fig.9 Group 3

Fig. 6 Group 5 Parametric study with screw inclination

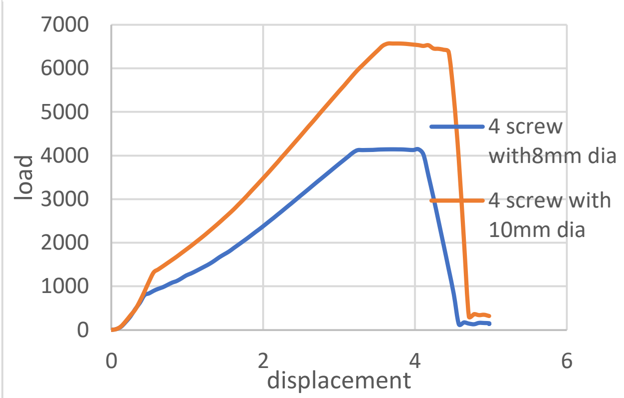


Fig.10 Group 4

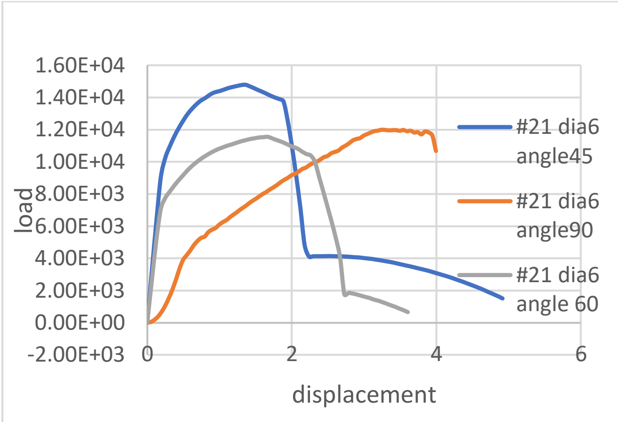


Fig.11 Group 5

This analysis shows that the ultimate load grows as the number of screws or connectors rises. Consequently, it is capable of transporting heavy loads. Rows of connectors make the arrangement. Additionally, we can observe that when a screw fails, the ultimate load suddenly decreases and progressively increases. The first specimen in this collection has 7 screws, the second has 14, and the third has 21. Second specimen has a 54% rise in comparison to the first, and third specimen has a 199% increase. This means that the load carrying capacity of connectors improves. Additionally, it applies to angled connections. The load carrying capability of the notch is extremely poor when compared to the screw connection.

Combination connectors have a significant increase in load carrying capability. Four screw connections in the fourth set have a diameter of 8 and 10 mm. Additionally, it is understood that the load carrying capacity rises significantly as diameter increases. With regard to 8mm diameter, there is a 58% increase. This indicates that the load carrying capability is significantly influenced by the diameter. In the fifth group, the load carrying capability diminishes as the angle rises.

5. CONCLUSION

An analytical analysis of the connections' shear performance in the CLT concrete composite system is given. For this research, various factors including connection type, screw count, diameter, and angle are taken into account. The studies' findings revealed that:

- The ultimate load increases as the number of screws or notches rises. That is, the load carrying capacity rises as the number of connectors increases. It has a rise in the connection of 58-200%.
- Connectors are combined together to get maximum shear capacity.
- In this research, diameter is very important; when it goes from 8 to 10 mm, load carrying capacity rises by 58%.i.e., the ultimate load rises significantly as diameter increases.
- When a screw is inclined, a decreasing angle increases the screw's ability to support more weight.
- According to these tests, TCC with combined connectors and an inclined screw have the greatest shear capacity, making them the finest.

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