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FLEXURAL BEHAVIOR OF CONCRETE COMPOSITE BEAM WITH DIFFERENT CONFIGURATION OF RIGHT-ANGLE TRIANGULAR (TTR) CONNECTORS

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ABSTRACT

In composite steel-concrete beams, shear connections are crucial. Fundamental parts of composite steel-concrete columns are shear connectors. Their purpose is to create a decent amount of interaction between the steel profile and the concrete slab. The majority of shear connections are welded to a steel profile's flange and set into the concrete component. By doing this, the shear connectors prevent the components' steel-concrete interface from transferring longitudinal and transverse forces. The right-angle truss connector is a newly developed shear connector that offers effective structural performance at an affordable cost for both production and installation. Studies that analyze this connector's behavior in greater depth must be developed, though, in order for use in beams that combine steel and concrete. In order to assess the Right-Angle Truss connector's shear resistance, this research will vary certain parameters that are necessary for the connection of composite steel-concrete beams. Study was also done on the connector's application orientation that offers the most shear strength. This also involves using the ABAQUS software to analyze various types and sizes of shear connectors.

Keywords: Composite beam, Shear connectors, TTR connectors.

1. INTRODUCTION

Economic, technological, and scientific advancements in the construction business led to the creation of various structural system types. From a structural and construction standpoint, composite steel-concrete buildings are superior. The use of composite structures, with all of its benefits for structural efficiency, ought to be promoted for bridge building, as well as made more common for medium- and small-scale projects. In this type construction connection is the important factor. The classification of shear connections is commonly split into two distinct categories based on their ductility: rigid connectors and flexible connectors. Rigid connectors have high stability without slip and because they are flexible connectors with large slipping displacement, they deform more when loaded.

The shear connectors referred to as Truss-Type (TT) they are made of common steel and are frequently used in reinforced concrete structures, are a novel type of alternate connector that is demonstrated in this study.it is low cost, easy to install etc…, and also other type connectors are used in this analysis. The Right-Angle Triangular (TTR) connector presents itself as a possible substitute for the isosceles Truss-Type (TT1) shear connection. It has large advantages when compared to bolts. By connecting the TTI and TTR legs on the steel I beam flange and filleting welding the connections to the steel I-beam, Afterward, it is possible to insert them into the concrete slab. The model was developed and processed in the finite element software ABAQUS. Calibration and validation of the model were performed using results from ABAQUS.

2. OBJECTIVES

- To analyze the concrete composite beam with different type shear connector in ABAQUS.
- To investigate the flexural characteristics of the composite beam. with Right-Angle Triangular (TTR) connector in different alignment.

3. METHODOLOGY

3.1 Analysis of Truss-Type Connector

Among other numerical techniques, the modern finite element approach can produce a much more accurate depiction of the total state of stress, strain, and displacement in a body under loading. As a result, this research created numerical modelling using FE analysis in the ABAQUS software.

3.1.1 Material properties and dimensions

Table1 shows the materials properties of connector, rebar and beam and fig.1 shows the detailed geometrical dimensions of the specimen.

Table 1 Material properties

	TT 12.5	Rebar	Beam
Es (MPa)	195300	194500	200000
Fy (MPa)	595.3	591.6	250
Fut (MPa)	716.6	722.4	400
€u (%)	0.6	0.6	1.0

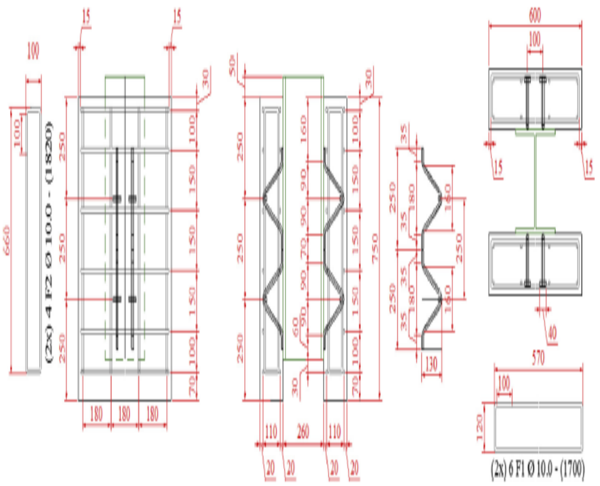


Fig.1 Geometrical dimension

The concrete properties are (a)initial modulus of elasticity 26GPa, (b)poison's ratio 0.2, (c)concrete weight density 2500Kg/m3 and (d)an angle of dilation 130.

3.1.2. Mesh and Boundary Conditions

Element type for two node elements (T3D2) are used to model the reinforcement bars. The reinforcement bars are modeled using two-node elements (T3D2) and the TT shear connectors are modeled using a combination of eight-node elements (C3D8R) and four-node elements (C3D4). The concrete slab and steel beam are modeled using four-node elements (C3D4) and eight-node elements (C3D8R), respectively. To ensure accurate results, a mesh dependency study is conducted to determine the optimal mesh size, which is found to be 17 in this study.

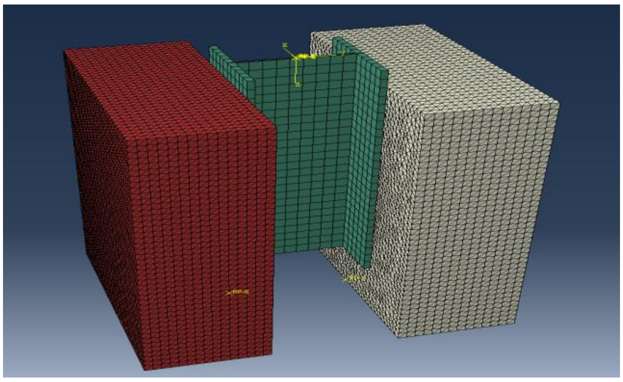


Fig.2 Meshing

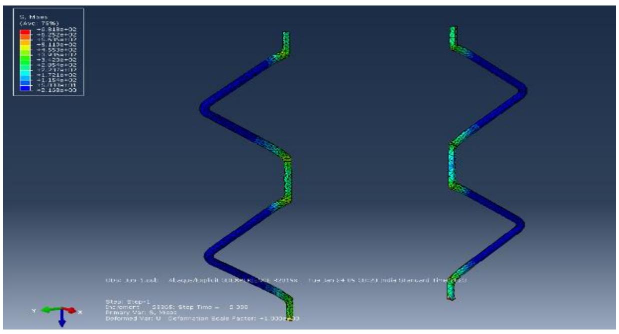
3.1.3. Loading and boundary conditions

Table 2 denotes the boundary and loading condition of the specimen with truss type connector.

Table 2 Loading and boundary conditions

Boundary condition and loading	**Location**	**DOF / Magnitude**
Fixed	Concrete block (Bottom)	U1=U2=U3=UR1=UR2= UR3=0
Prescribed displacement	Beam Top	20mm downward (as per journal)

3.1.4. Results and Discussions



The accuracy of the resistance prediction by the FE models is evident and the load slip behaviour of TT 12.5 shear connectors. It is noted that TT 12.5 legs work primarily under tension and compression. It can be also observed that higher stresses in the TT connector are concentrated at the base. From the observation of the numerical model behaviour near the failure, it can be established that this occurs due to the combined effect of

Fig.3 stress in truss type connector

earing, bending and tensioning located at the bottom of the connector.

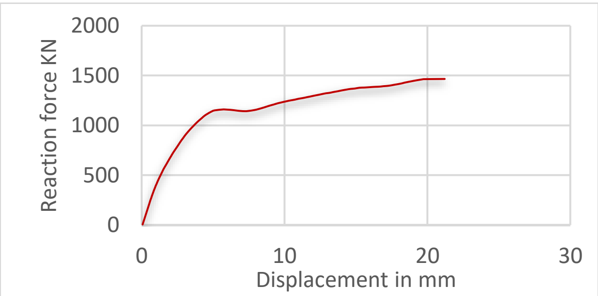
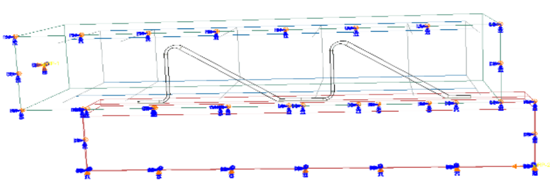


Fig.4 load vs displacement graph

A novel and effective alternative connector called truss type shear connector for steel composite beams was introduced. The ultimate resistance for TT connector is 1463.71KN. The ultimate load is gotten from the load-displacement graph from the analysis. That is shown in the fig.4. Moreover, the stress distribution is improved for the TT 12.5 connector. The length of the welds utilized at the ends of the legs of the TT 12.5 connector proved sufficient in withstanding the applied loads. TT 12.5 connectors can be supplied already folded in the triangular shape and ready for direct application on the steel I beam flange of a composite steel concrete structure. The TT 12.5 connector developed in this research may be an alternative for use in composite steel-concrete beams.

3.2 Analytical study of Right-Angle Truss Shear Connector with position orientation



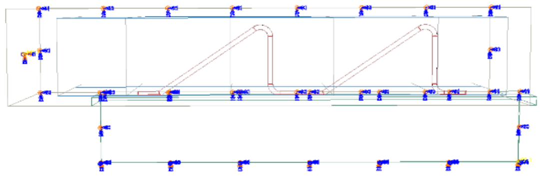


Fig.5 Position orientation of right-angle truss connector

3.2.1. Meshing and boundary conditions

Table 3 Mesh details

Parts	Element order	Element type
Concrete	Linear	C3D8R
Shear connector	Linear	C3D8R
Beam	Linear	C3D8R
Bars	Linear	T3D2

The push-out test boundary conditions and the model geometry can both be simplified than due to the displacement restrictions that were applied to the numerical model in order to create the symmetry boundary conditions. The steel beam's cross-section received the weight with an even distribution. The explicit dynamic analysis technique was used. As long as the inertia effects are managed from the slow load application, although primarily a dynamic technique, it can also be utilized for static analysis. The inertia effect was controlled by selecting the load application rate such that the kinetic energy of the numerical model during the entire analysis did not exceed 5% of the overall energy. The Plastic Damage Model (CDPM) was utilised when modelling the block out of concrete.

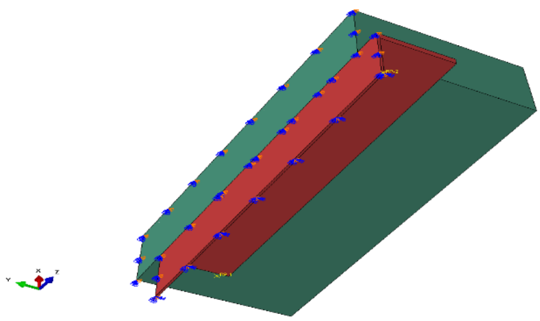


Fig. 6 Symmetric boundary condition

3.2.2. Results and discussions

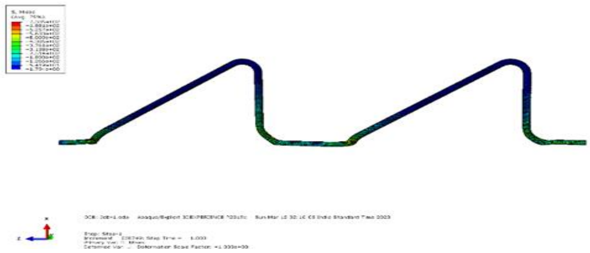
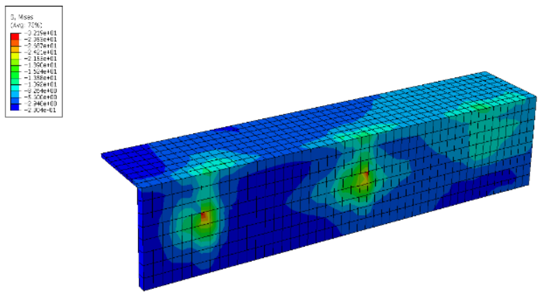


Fig. 7 Equivalent stress of TTR



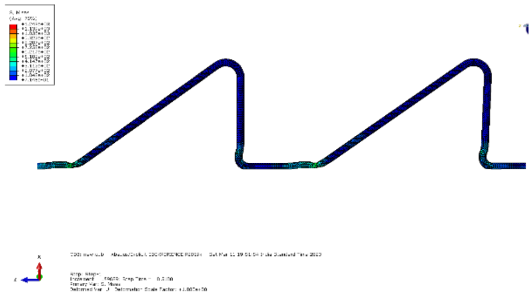
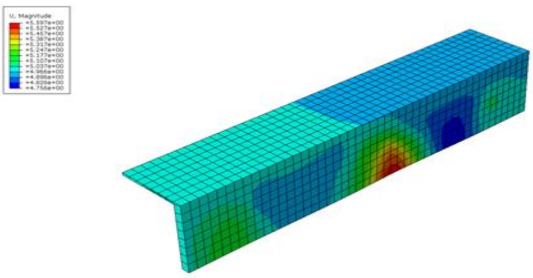


Fig.8 Equivalent stress of TT1



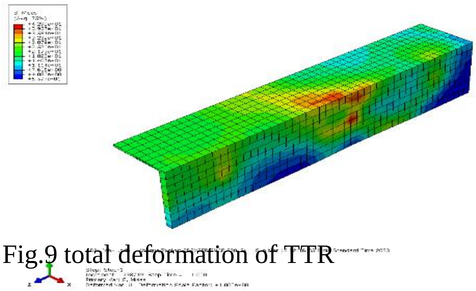
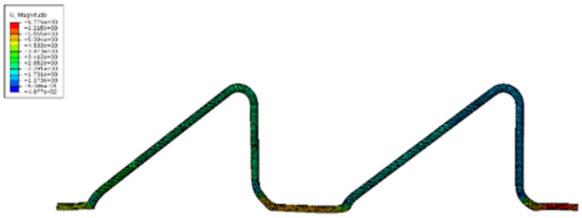
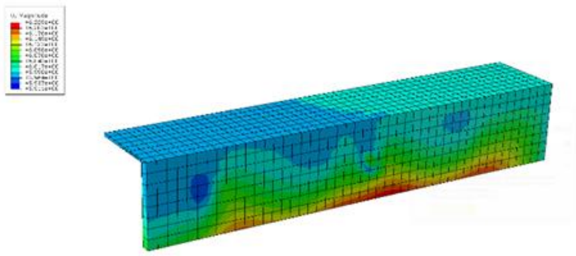


Fig.9 total deformation of TTR





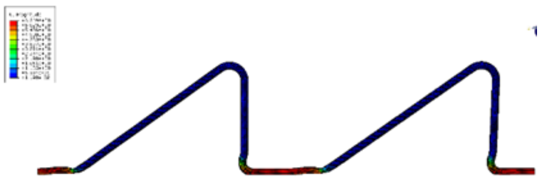


Fig.9 total deformation of TT1

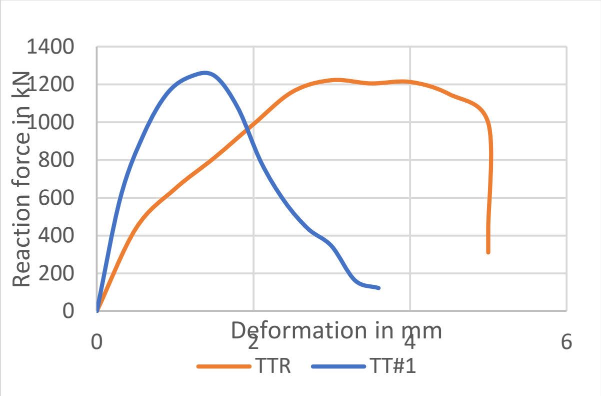


Fig.10 load vs displacement graph

During the transfer of forces from the steel I-beam to the concrete slab, the TTR connector legs undergo bending, with the vertical leg experiencing the most bending during the test and the inclined leg subjected to both compression and bending stresses. The inclined leg becomes unstable due to the compressive pressures, which may prevent the full strength of the substance that makes up the TTR connectors from being used. To increase the TTR connector's effectiveness, a numerical simulation was conducted to perform a push-out test on TTR connections that were installed in the reverse orientation on the steel I-beam. The TTR-I connection will be used for the reverse TTR connector. Under these conditions, the inclined leg will primarily operate under tension. All model components' shape and material characteristics were preserved. TTR1 has a higher maximum load carrying capability than TTR connector. The inclined legs' beginning to function primarily under tensile tension may be responsible for the TTR-I's increased shear resistance to the TTR. It is clear that the inclined limb continues to be straight and lengthens until it yields and then begins to neck. Under bending, the vertical limb keeps moving. TTR-I and TTR connectors also share a common characteristic in that the failure occurs due to concrete crushing near the base of the connectors, along with steel yielding at the connection leg's base

4. CONCLUSION

In this study, ABAQUS software is used to evaluate a new connection. The research found that truss type connectors are better to others in terms of effectiveness. 1464 KN is the maximum shear resistance for TT connectors. This connector exhibits better plastic deformation under a rupture situation and has excellent stress distribution. TT connectors are easy to manufacture and attach. For composite steel-concrete supports, the right-angle truss connector has been investigated as a shear connector substitute. To discover the best TTR connector orientation, various orientations were studied. Concrete crushing and the inclined limb of the TTR connector's yielding cause the rupture. The TTR connector's maximum load carrying capacity is 1222.99Kn. The load carrying capacity of TTR1 has increased significantly to 1246.739. These connector kinds exhibit greater resistance and are simple to use.

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