

Analysis of Hybrid Steel Trussed Concrete Beam Using ANSYS

Najla Yas V¹, Mohammed Lasin K², Priyanka Dilip P³P.G. Student, Department of Civil Engineering, AWH Engineering College, Kozhikode, Kerala, India¹P.G. Student, Department of Civil Engineering, AWH Engineering College, Kozhikode, Kerala, India²Assistant Professor, Department of Civil Engineering, AWH Engineering College, Kozhikode, Kerala, India³

ABSTRACT: The role of steel reinforcement in reinforced concrete beams is to handle the bending and shear stresses that develop within a beam. The horizontal longitudinal bars designed to carry the bending stresses and vertical stirrups to carry the shear force. Alterations in the reinforcement pattern within the beam affect the flexural as well as shear carrying capacity of the beams considerably. A steel truss reinforcement concrete beam is constituted by a prefabricated steel truss installed within the concrete core. The truss usually is composed by a system of a system of steel rebars welded to form the diagonals of the truss and the main bars used to form the upper and bottom chords of the truss. Numerical analysis is to be conducted using Finite Element Analysis (ANSYS) by varying the truss configuration leading to the improvement of confinement in the shear and flexural region.

KEYWORDS: Hybrid steel trussed concrete beam, Steel plate, Confinement, Shear reinforcement.

I. INTRODUCTION

When concrete and steel are combined together they form a composite member. The composite construction has gained importance due to its ability to combine the advantage of steel and concrete. Concrete is best utilized in compression and steel in tension. As concrete is incapable of resisting tensile load and steel section that are slender are most likely to undergo buckling under critical load. But when combined together to form composite member their individual weakness are overcome both their strength are utilized fully to increase the strength, stiffness and durability of the structure. Reinforced concrete beams are used to transfer the imposed loads from slabs and walls to columns. A beam must have adequate safety margin against bending and shear stresses, so that it will perform effectively during its service life. Reinforced concrete structures being the most commonly used structures need proper design and utmost care in the joint construction.

In reinforced concrete beams of usual proportions, subjected to relatively high flexural stresses, and low shear stresses, the maximum principal tensile stress is given by the flexural stress in the outer fibre at the peak moment locations, the resulting cracks are known as flexural cracks. On the other hand, in short span beams which are relatively deep are subjected to high shear stresses and low flexural stresses, it is likely that maximum principal stress is located at the neutral axis level at an inclination of 45° to the longitudinal axis of the beam. The resulting cracks occur near the supports termed shear cracks or diagonal tension cracks. At the quarter span of the beam, where the effect of bending and shear stresses are predominant, flexure-shear cracks are formed. These cracks are formed when a flexure crack occurs in combination with a diagonal tension crack.

Due to the problems of conventional shear reinforcement, the use of independent inclined and horizontal bars in the high shear region are recommended by many researchers in the past few decades and they conducted experimental studies to explore the effect of orientation and position of the different shear reinforcements in deep

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

beams. He used various stirrup arrangements viz. horizontal, inclined and vertical stirrups were used in beams. Beams with inclined stirrups were found to show more ultimate strength and less deflection than vertical and horizontal bar systems..

A special steel-concrete composite beam called Hybrid Steel Trussed Concrete Beams (HSTCBs) was appeared recently in the construction industry, in which prefabricated truss reinforcement is embedded within the concrete. The truss structure is usually made with or without steel plate or a precast concrete slab, which represents the bottom chord. A system of ribbed or smooth steel bar is welded in order to form the diagonals of the truss. HSTCBs represent a structural typology of composite beams typically employed as efficient structural solution for light industrialization and constituted by prefabricated steel truss embedded within a concrete matrix cast in situ. HSTCBs are typically constituted by a steel truss embedded in a concrete core. The truss is usually made up of a steel plate or a precast concrete slab, which represents the bottom chord, a system of ribbed or smooth steel bars welded to form the diagonals of the truss, with some single or coupled rebars constituting the upper chord. Among the large variety of beams currently produced, HSTCBs with a bottom steel plate, inclined tensile and compressed web bars, coupled upper rebars, and space cross-sections are considered. Such beams represent a structural solution for light industrialization; their main advantages are higher construction speed with minimum site labor, the possibility of covering wide spans with low depths, and economic benefits. Furthermore, they are frequently introduced in seismic-framed structures.

II. RELATED WORK

The concept of using truss system with a base plate as reinforcement within the concrete was developed since the Seventies termed as Hybrid Steel Trussed Concrete Beams (HSTCBs). They are widely employed in civil constructions because they allow industrializing the building process, avoiding substantial alterations in the construction processes and organizational protocols of the industries.

[1] Nimmy Thomas et al, 2015 performed an experimental study to assess the flexural capacity of Composite Beams using Truss beams under two point loading with span 2m. Beam consist of top and bottom chord with cold formed light gauge steel plate (width 100 mm and thickness varying from 1.5mm to 2mm) and light gauge angle section welded at the ends of the plate. Top and bottom chord members were connected by steel rods of diameter 8mm making inclined connections with horizontal using Fe 250 grade steel at both faces of angles. Truss was filled with M25 concrete to form a Composite Beam. A comparative study was made between truss beam and composite beam to assess the ultimate load carrying capacity, Flexural strength, Ultimate Deflection, displacement ductility. Tests were conducted on truss beams and composite beams for different thickness. From the result it was observed that for truss beams as the thickness varied from 1.5mm to 2mm load carrying capacity increased by 1.08 times but when the same truss beam encased by concrete load carrying capacity raised by 2.26 times. When concrete was encased and thickness was increased load carrying capacity increased by 2.6 times. As the thickness increases from 1.5 to 2mm displacement ductility factor increased by 4.8% for truss beam but when concrete is encased displacement ductility factor get increased by 76.47% . Flexural strength of composite beam is 2.46 times more than truss beam when the thickness of light gauge cold formed steel plate is 2mm and when the thickness of light gauge cold formed steel plate is 1.5mm Flexural strength of composite beam is 2.27 times more than the flexural strength of truss beam. A marginal increase in load carrying capacity, flexural strength, displacement ductility occurs after encasing concrete.

[2] Fasil V P et al, 2015 did a Study of Hybrid Precast Beam Column Connection. Connections are the vital element in the precast construction. A new type of connection which is having the aesthetics of hidden corbel is investigated in this study. This type of connection can be used as simply supported as well as moment resisting type in precast skeletal frames. Both the cases are evaluated in this study. In simply supported case confinement has a major role and hence it is investigated. STRAND7 software is used for the confinement study. In moment resisting type of this connection, a mathematical model of failure by using elementary solid mechanics is used to calculate stiffness of connection. By incorporating this stiffness performance is evaluated. ETABS software is used for this study. In the

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

performance evaluation the behaviour of precast building with different types of precast connections are compared. From the confinement study, stress distribution at the support region is studied and the importance of the stiffener in the connection is identified. From the performance evaluation it is identified that the semi rigid connection with shear wall is performing better than ordinary monolithic connection model.

[3] N.J.A.Vambersky, 2014 conducted a study on two recent examples of hybrid construction in the Netherlands, The “Malietoren” office tower, constructed over the motorway entering the city of The Hague, and the 100 m high sloping “Belvedere” office tower in Rotterdam, where the aim of the architect Renzo Piano was to create appealing but competitively priced buildings was realized through hybrid construction. The planned concepts, alternatives, final solutions and detailing of these two architecturally appealing buildings were discussed in this paper, to illustrate this development. A development in which ,especially in the Netherlands, precast concrete is playing an important role.

[4] Sooryaprabha M Saju et al, 2016 conducted an experimental study to find out the flexural behavior of reinforced concrete beams. Many authors were concentrated on the study of the use inclined stirrups to increase the shear capacity of the reinforced concrete beams. It can be concluded from the review of the literature that, apart from the use of vertical stirrup reinforcements in RC beams, there is scope of inclined arrangement of stirrups within the precast beam with base plate also and they are found to be effective. Here we concentrate to find out the structural capacity of the composite beam, with a prefabricated truss system within concrete to improve the shear strength capacity and also the flexural capacity of the reinforced concrete beams.

III. SCOPE

The scope of this study is to find out suitability of adopting a reinforcement system, which is better and economic than the usual way of providing vertical stirrup reinforcement system in reinforced concrete beams. The system is a prefabricated steel truss, the diagonal bars of which act as the stirrups in reinforced concrete beams.

IV. MODEL

In this paper shear reinforcement or arrangement of shear reinforcement/type of shear reinforcement is varied for each model. Basic details like cross sectional dimensions, diameter of bars used are kept constant for all models. In total of five models are modelled and analysed in ANSYS software. One of which is modelled as conventional beam and other for with different types of shear reinforcements. The Table below shows the ANSYS diagrams and Autocad drawings of models analysed in the project.

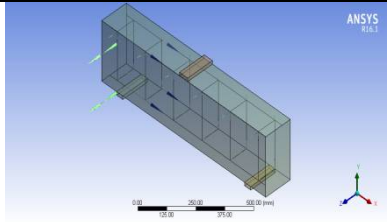
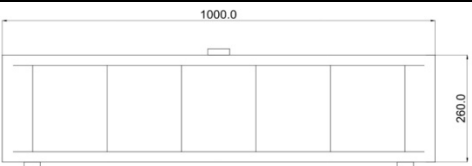
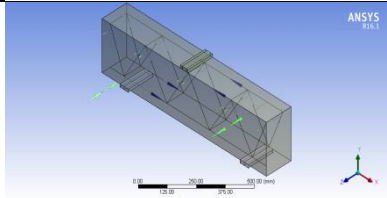
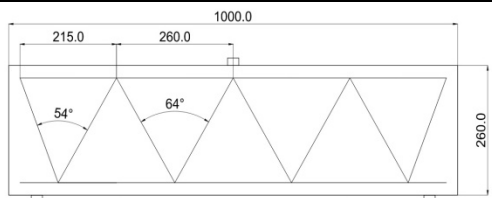
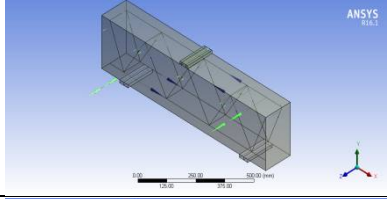
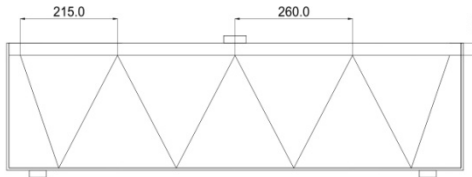
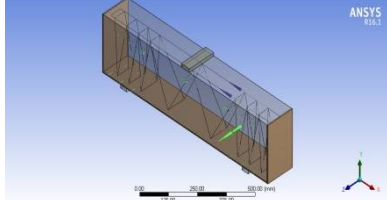
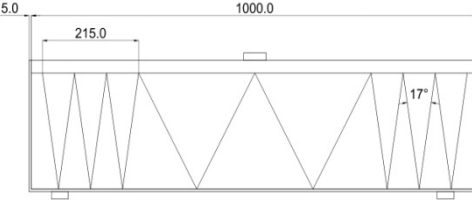
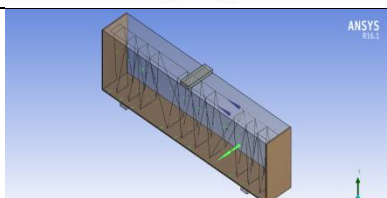
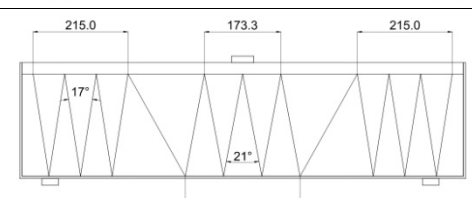
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

Table 1 The ANSYS and AUTOCADD models used for the paper

SL NO:	MODEL NAME	ANSYS MODEL	AUTOCAD MODEL
1	Beam with conventional vertical stirrup		
2	Beam with inclined stirrup		
3	Beam with hybrid steel trussed concrete beam without confinement		
4	Beam with hybrid steel trussed concrete beam with shear confinement		
5	Beam with hybrid steel trussed concrete beam with shear and flexural confinement		

V. RESULTS

The Hybrid Steel Trussed Concrete Beam specimens were analysed using finite element analysis in ANSYS workbench. The results of the finite element analysis are included in this chapter. The deformations values, stress-strain relations and the ultimate load carrying capacity of each specimen are included in the results. Their corresponding graphs and figures are given below. The comparison of the ultimate load carrying capacity of various arrangements is discussed below.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

After analyzing the specimens with a load range of 100-300 kN acting at the centre of the beam under three point loading, the deformations occurred to the beam arrangements were analyzed. The deformations at each and every load were obtained from ANSYS. Non-linear analysis was carried out for all the specimens.

Specimen with Conventional Vertical Stirrup

This was the first specimen analyzed using ANSYS Workbench. The load bearing plate is placed at the centre, on the top of the specimen and load is applied over it. A load range of 100-300 kN is applied at the centre of the beam element. The figure 1 shows deformed model after Ansys analysis and the graph showing load deformation relation of model. The deformation values after the analysis and the deformed shape of the specimen is shown in the fig 1(a). The graph plotted between load and deformations were shown in fig 1(b). From the graph, the ultimate load carrying capacity of the specimen was found out to be 121 kN.

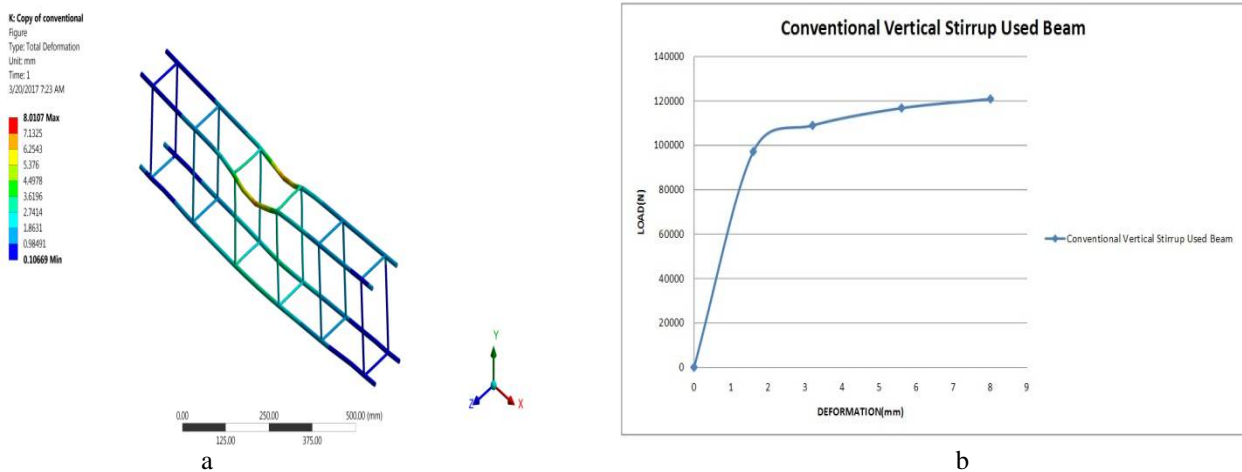


Fig 1 Software analysis result (a) Deformation of specimen With Conventional Vertical Stirrup (b) Load – Deformation curve for specimen With Conventional Vertical Stirrup

Specimen with Inclined Stirrup

This was the second specimen analyzed using ANSYS Workbench. The load bearing plate is placed at the centre, on the top of the specimen and load is applied over it. A load range of 100-300 kN is applied at the centre of the beam element. The figure 2 shows deformed model after Ansys analysis and the graph showing load deformation relation of model. The deformation values after the analysis and the deformed shape of the specimen is shown in the fig 2(a). The graph plotted between load and deformations were shown in fig 2(b). From the graph, the ultimate load carrying capacity of the specimen was found out to be 161 kN.

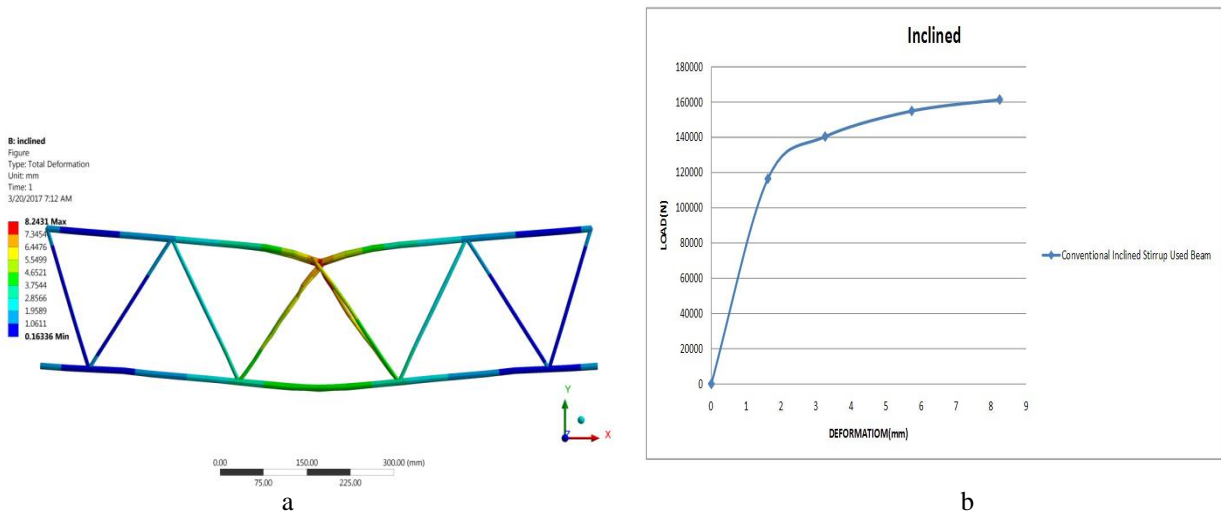


Fig 2 Software analysis result (a) Deformation of specimen with Inclined Stirrup(b) Load – Deformation curve for specimen with Inclined Stirrup.

Specimen with Hybrid Steel Trussed Concrete Beam without Confinement

This was the third specimen analyzed using ANSYS Workbench. The load bearing plate is placed at the centre, on the top of the specimen and load is applied over it. A load range of 100-300 kN is applied at the centre of the beam element. The figure 3 shows deformed model after Ansys analysis and the graph showing load deformation relation of model. The deformation values after the analysis and the deformed shape of the specimen is shown in the fig3(a). The graph plotted between load and deformations were shown in fig 3(b). From the graph, the ultimate load carrying capacity of the specimen was found out to be 216 kN.

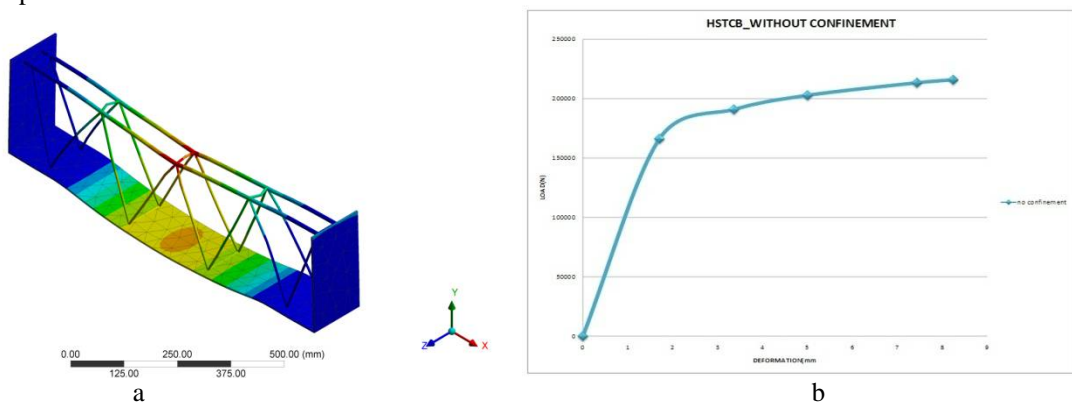


Fig 3 Software analysis result (a) Deformation of Specimen with Hybrid Steel Trussed Concrete Beam without Confinement(b) Load – Deformation curve for Specimen with Hybrid Steel Trussed Concrete Beam without Confinement.

Specimen with Hybrid Steel Trussed Concrete Beam with Shear Confinement

This was the fourth specimen analyzed using ANSYS Workbench. The load bearing plate is placed at the centre, on the top of the specimen and load is applied over it. A load range of 100-300 kN is applied at the centre of the beam element. The figure 4 shows deformed model after Ansys analysis and the graph showing load deformation relation of model. The deformation values after the analysis and the deformed shape of the specimen is shown in the fig 4(a). The

graph plotted between load and deformations were shown in fig 4(b). From the graph, the ultimate load carrying capacity of the specimen was found out to be 227 kN.

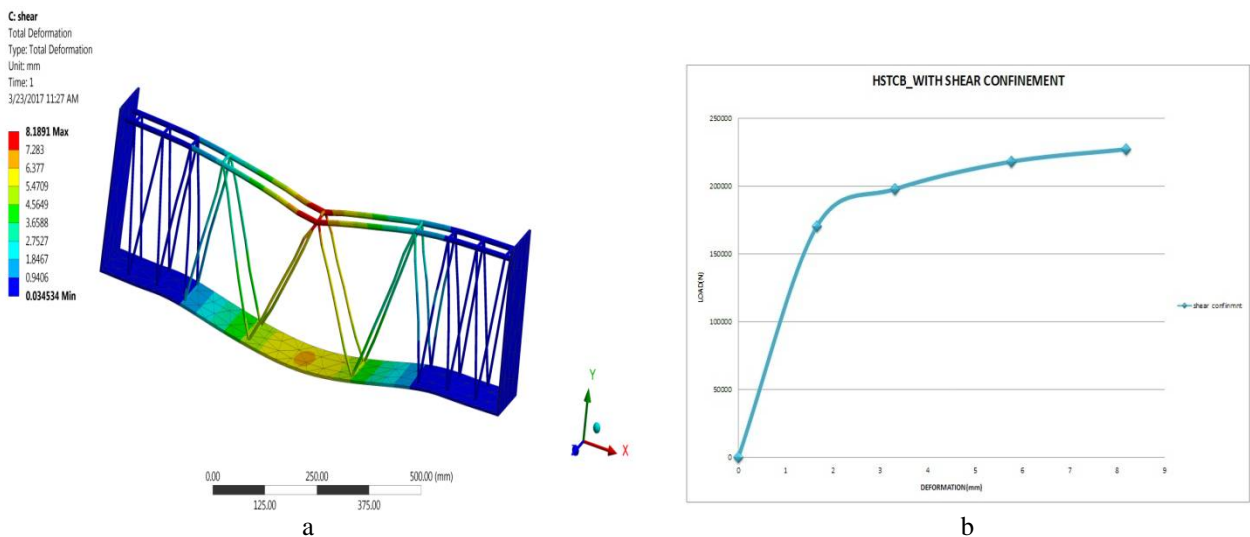


Fig 4 Software analysis result (a) Deformation of Specimen with Hybrid Steel Trussed Concrete Beam with Shear Confinement (b) Load – Deformation curve for Specimen with Hybrid Steel Trussed Concrete Beam with Shear Confinement.

Specimen with Hybrid Steel Trussed Concrete Beam with Shear And Flexural Confinement

This was the fifth specimen analyzed using ANSYS Workbench. The load bearing plate is placed at the centre, on the top of the specimen and load is applied over it. A load range of 100-300 kN is applied at the centre of the beam element. The figure 5 shows deformed model after Ansys analysis and the graph showing load deformation relation of model. The deformation values after the analysis and the deformed shape of the specimen is shown in the fig 5(a).

The graph plotted between load and deformations were shown in fig 5(b). From the graph, the ultimate load carrying capacity of the specimen was found out to be 226 kN.

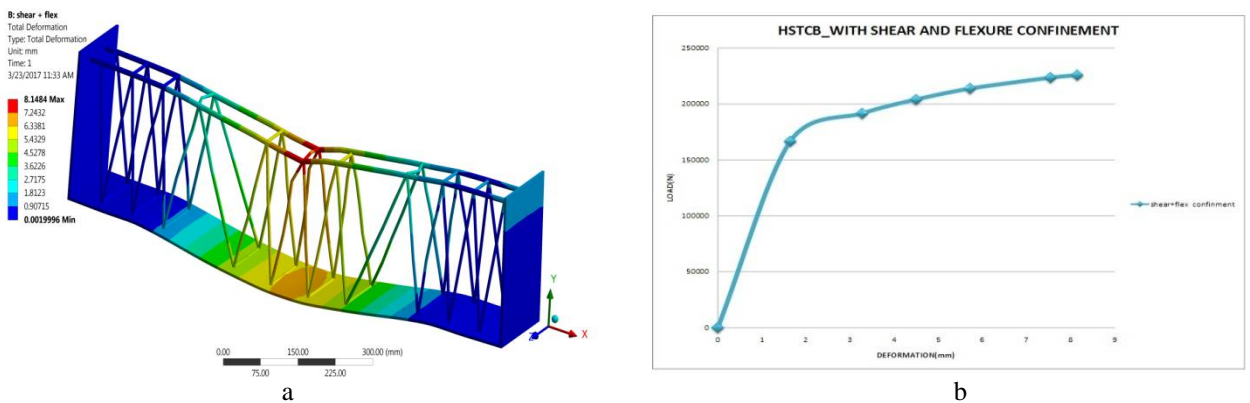


Fig 5 Software analysis results (a) Deformation of Specimen with Hybrid Steel Trussed Concrete Beam with Shear and Flexural Confinement (b) Load – Deformation curve for Specimen with Hybrid Steel Trussed Concrete Beam with Shear and Flexural Confinement.

VI. CONCLUSION

The finite element analysis of hybrid steel trussed concrete beam specimens were carried out for studying the ultimate load carrying capacity and behavior. Five different specimen models were analyzed for this. A conventional beam with vertical stirrup was first modeled and analyzed for validation. Then beam with inclined stirrup in a truss pattern, truss without confinement, truss with shear confinement and truss with both shear and flexural confinement were model and analyzed. It is seen that, the ultimate load carrying is higher for , truss with shear confinement and lower for conventional beam with vertical stirrup, that is the ultimate load carrying capacity of the specimen increases either by replacing a conventional beam with a truss arrangement or by providing inclination to the vertical stirrup. The figure below shows graph plotted against load and deformation which helps in the comparative study of the models analysed in this paper.

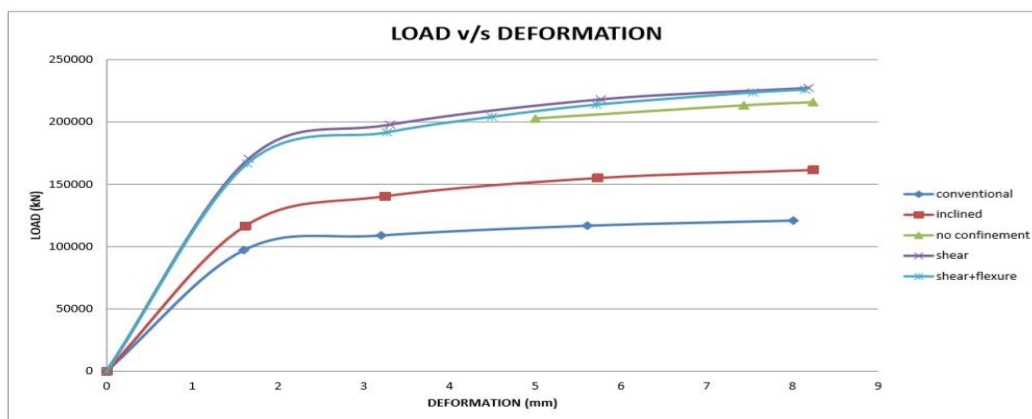


Fig 6 Comparison of Load – Deformation curve for all the Specimens

While providing inclination at both flexure and shear there is definitely a increase but it is less than the load carrying capacity of model with confinement at shear only. Further Parametric study is required to state the reason for this decrease in load carrying capacity.

REFERENCES

- [1] Nimmy Thomas, Dr. P.S.Joanna, and Eapen Sakaria "Flexural Capacity of Composite Beams Using Truss Beams", International Journal Of Engineering Science & Research Technology, ISSN:2277-9655
- [2] Fasil V P, Dr. P R. Sreemahadevan Pillai "Study of Hybrid Precast Beam Column Connection", International Journal of Research in Advent Technology, E-ISSN:2321-9637
- [3] Ghassan Aouad and Peter Barrett, "The Feasibility Of Using Hybrid Concrete Structures Within The Context Of Cost And Time", Research Centre for the Built and Human Environment, University of Salford.
- [4] N.J.A Vambersky, "High-Rise Buildings In The Netherlands: Hybrid Structures And Precast Concrete", Council on Tall Building and Urban Habitat.
- [5] Francesco Trentadue, Erika Mastromarino, Giuseppe Quaranta, Floriana Petrone, Giorgio Monti and Giuseppe Carlo Marano, "Bending Stiffness of Truss-Reinforced Steel-Concrete Composite Beams", Open Journal of Civil Engineering, Volume 4, 285-300.
- [6] Piero Colajanni, Lidia La Mendola and Alessia Monaco, "Experimental Investigation Of The Precast Steel-Concrete Trussed Beams", International Journal of Civil Engineering And Technology (IJCIET), Volume 6, Issue 5, pp 05-09
- [7] SooryaPrabha M Saju and S Usha, " Study On Flexural Strength Of Truss Reinforced Concrete Beams", International Journal of Engineering and Technology, Vol 7.
- [8] Zheng Wenzhong, " Experimental Study Of The Hysteretic Behaviour Of Prestressed Truss Concrete Composite Beams Under Cyclic Loading".
- [9] Naieem M, Asha, "Experimental Studies For Optimizing The Use Of Swimmer Bars As Shear Reinforcement In The Reinforced Concrete Beams", International Journal of Civil and Structural Engineering, ISSN 0976-4399.
- [10] Tesser, Scotta, "Study On The Flexural And Shear Strength Of Composite steel truss and concrete beam", International Research Journal of Engineering and Technology, Volume 02, Issue 07, pp1293-1301.