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Analytical Study on behavior of the Composite space truss

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ABSTRACT : *Space structures are economical and aesthetically pleasing in appearance. They provide the right solution to accommodate large areas. They also satisfy the requirements for lightness, economy and speed construction. The major problem that a space truss facing is the brittle type of failure, caused by the successive buckling of a series of critical compression-chord members. The present study investigates the possibility of using concrete slab acting compositely with the top chord to improve the behavior of space trusses. The concrete slab was expected to reduce the buckling problems of the top chord members, to increase the stiffness of the structure, and to induce a ductile type of failure by making the overall behavior dependent mainly on the tension characteristics of the bottom chord members. The Finite-Element Analysis of Composite Truss were carried out using ABAQUS against published experimental data of 4m x 4m space truss with concrete slab having thickness of 50mm. The analytical models were made for various Module size, Concrete Strength and Slab thickness. The analytical model is stiffer .The overall deflection for the composite space truss is reduced and make the truss resistant against bucking failure of the top chord member.*

Keywords - *Composite truss; ABAQUS; Module size; Slab thickness; Concrete strength*

1. INTRODUCTION

A space structure is a structural system in the form of a three-dimensional assembly of elements so arranged that forces are transferred in a three-dimensional manner. They are used for Industrial buildings, Exhibition halls, Community halls, Railway platforms, shopping malls, transmission towers and other structures. Mezzina at al. (1975), Schmidt et al. (1980, 1982) , have indicated that space trusses may fail in a brittle and unstable manner, in which the buckling of one member due to overloading can trigger a progressive collapse of the whole structure, in which successive members fail in a rapid sequence. El-Sheikh et.al(1993), have studied the experimental behavior of composite space truss and the over strengthening of top chord members of a non composite space system can introduce some ductility into the overall structure behavior , but this approach may be successful in providing adequate warning of a sudden collapse. The analytical study was carried out using finite element analysis using a computer program verified. El-sheikh (1998) fitted the force limiting devices in the critical compression member and observed the ductility and load carrying capacity are improved. The force limiting devices are more costly, so it is limited to use in the one or few members of the space structures. El-Sheikh (1999), has studied the effect of force limiting devices on space truss. He used the force limiting device to alter the post-buckling characteristics of truss compression members and introduce the overall truss ductility. These devices were fitted to critical compression members. He found that Force limiting device in rectangular space trusses is more economically feasible than square trusses. It also improves the truss strength and behavior. Sebastian and McConnell (2000) tested the composite truss consisting of RC slab on profile steel sheeting for the highway loading which is proposed for the fast erecting schemes of bridges. As observed from literature, the composite performs better than non-composite truss for normal and abnormal loading conditions. The composite space truss is recommended as the best suitable for the implementation, in which the tension carried by the steel and the compression carried by concrete.

2. MATERIALS AND METHODS

The steel space truss was a double layer grid type connected by Mero node connector over which concrete slab of thickness 40mm (M30 grade) was placed over the space truss. The span of the truss was 4m x 4m with three different module arrangements. The following are the three module arrangements

1. Truss A, of span 4m x 4m with five modules each of six 800mm(El-Sheikh)
2. Truss B, of span 4m x 4m with four modules each of size 1000mm.
3. Truss C, of span 4m x 4m with three modules each of size 1333mm.

   Figure 1 shows the dimension of the space truss.

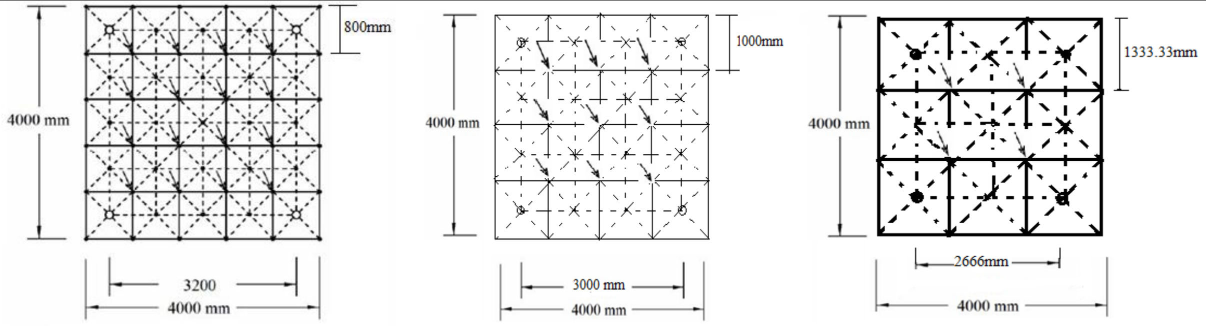

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Figure 1 Layout of the Space Truss A B & C

The Finite-Element Analysis of Composite Truss was carried out using ABAQUS against published experimental data ie Truss A (Ahmed El-Sheikh). Steel truss were modelled using Truss elements (T3D2) are one-dimensional bars or rods that are assumed to deform by axial stretching only. They are pin jointed at their nodes, and so only translational displacements and the initial position vector at each node are used in the discretization. Concrete slab were modelled using solid element (C3D8) .They are two-dimensional and three-dimensional. The two-dimensional elements allow modelling of plane and axisymmetric problems and include extensions to generalized plane strain. Solid elements are two-dimensional and three-dimensional applications. The two-dimensional elements allow modelling of plane and axisymmetric problems and include extensions to generalized plane strain. The solid element library includes isoparametric elements: quadrilaterals in two dimensions and "bricks" (hexahedra) in three dimensions. All the intermediate node of the top chord members were been subjected to a maximum load of 400kN at equal interval of 50kN and in bottom chord, four corner nodes were supported. Figure 2 shows the loading and boundary condition of the truss A, B and C.

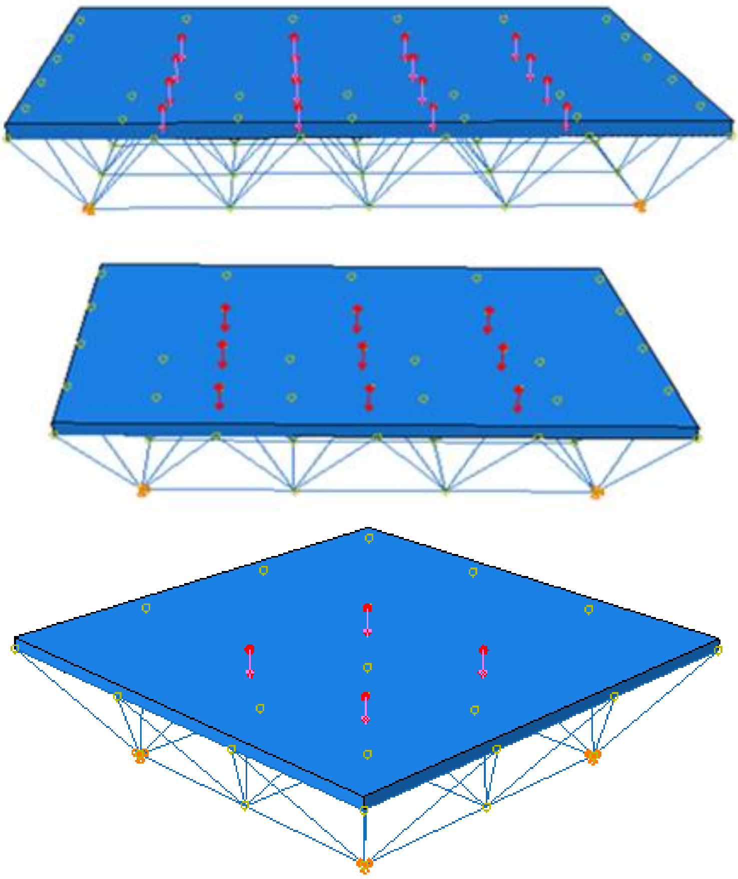


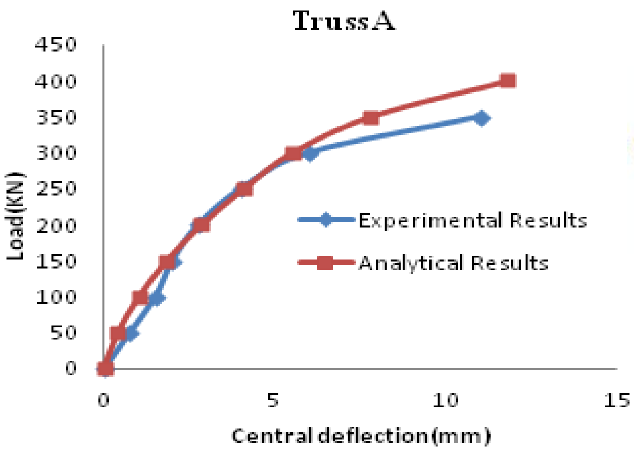
Figure 2 Loading and Boundary condition of the Truss A, B and C

The Truss A were analysed further by varying concrete strength (M25, M30 and M35) of the slab and by varying slab thickness (50, 80, 100 and 125mm) .

3. RESULT AND DISSCUSSION

3.1 Effect of Module Size

The analytical behavior of the truss A was compared against published experimental results (Ahmed El-Sheikh). Figure 3 shows the load verse deflection curve and deformed shape of the truss A. The percentage decrease in deflection is 17% for change from experimental to analytical results of Truss A. Figure 4 shows the deformed shape of the Truss B and C from that the inference made was the stress distribution is varying due to the point of application of loads at the nodes. Table 1 gives the Maximum deflection for the composite trusses by codal provision, Experimental and Analytical.



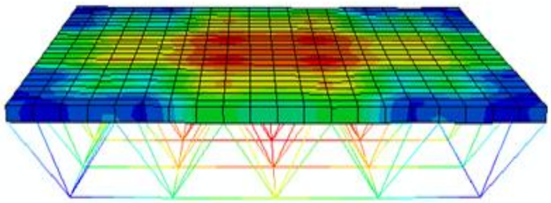


Figure 3 Load verse Deflection curve and deformed shape of the Truss A

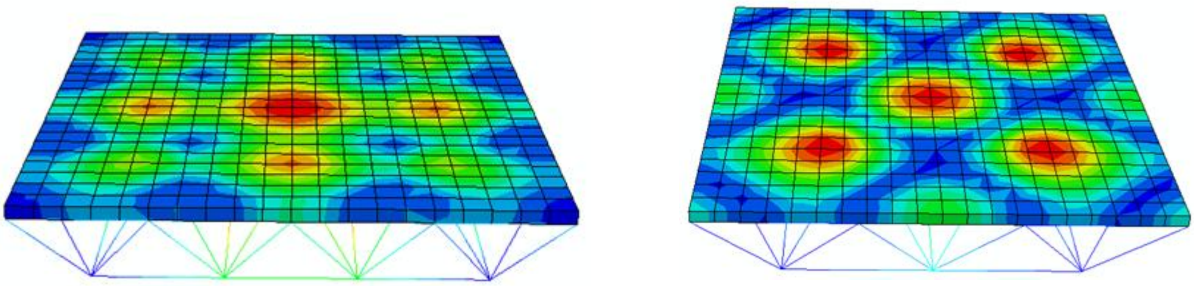


Figure 4 Deformed Shape of the Truss B and C

Table 1 Space Truss Series

Space Truss	Module Size (mm)	Maximum Deflection (mm) (Code) (L/360)	Maximum Deflection (mm) (Experimental)	Maximum Deflection (mm) (ABAQUS)
TRUSS A	800 x 800	11.11	11	7.8
TRUSS B	1000 x 1000	11.11	-	8.2
TRUSS C	1333 x 1333	11.11	-	8.5

The percentage increase in the central deflection of the Composite space truss of 4m x 4m span with slab thickness of 50mm is 9.4 % for change of Truss A to Truss B and 16% for change from Truss B to Truss C. The overall increase in deflection is 24% for change in Truss type from A to C. Figure 5 shows the Load verse central deflection curve for the all composite truss (Truss A, B and C).

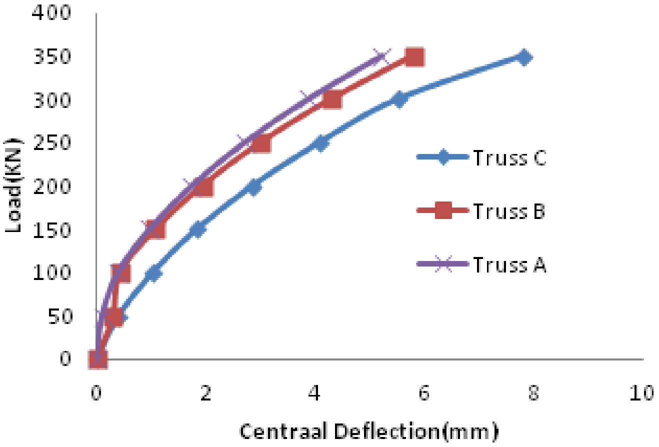


Figure 5 Load Vs Deflection Curve of all Composite Trusses

3.2 Effect of Concrete Strength

The percentage decrease in the central deflection of the composite space truss with the slab thickness 50 to 125mm is 5% to 10% for the change in the concrete strength from M25 to M35. Figure 6 shows the Load verse central deflection curve for the composite space truss with slab thickness 50mm.

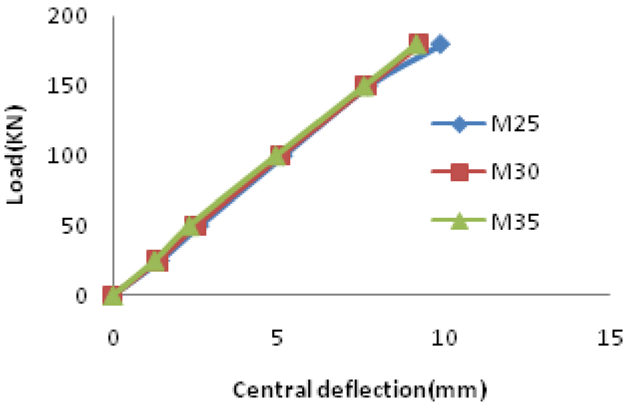


Figure 6 Load Vs Central Deflection of composite Space Truss (D=50mm)

3.3 Effect of Slab Thickness

The percentage decrease in the central deflection of the Composite space truss of 4m x 4m span with concrete strength M30 is 33 % for change in slab thickness from 50 to 80mm, 6.2% for change from 80 to 100mm and 4% for change from 100 to 125mm. The overall decrease in the central deflection of the composite space truss is 40% for change in slab thickness from 50 to 125mm. Figure 7 shows the Load verse central deflection curve for the composite truss with concrete Strength M30(El-Shiekh).

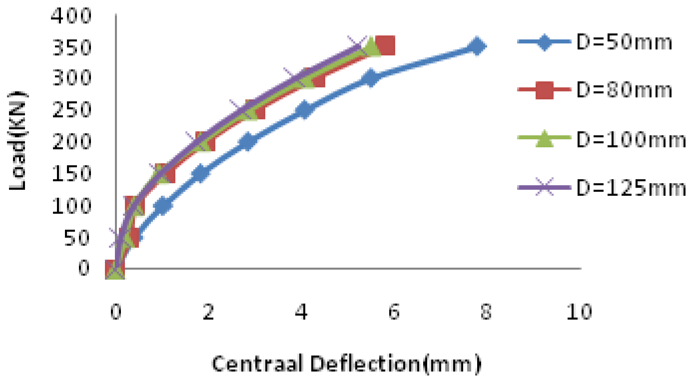


Figure 7 Load Vs central deflection curve for the composite truss (El-Sheikh-M30)

4 CONCLUSION

The Finite-Element Analysis of Composite Truss without profile decking sheet were carried out using ABAQUS against published experimental data. The following conclusions were made from the Analytical study.

1. The space truss with concrete slab without decking sheet at the top increases the stiffness of the truss and reduces the overall deflection of the structure.
2. The overall percentage decrease in the deflection is 17% for change from Experimental to analytical results (Truss A).
3. The deflections are within the permissible limit for the Truss A to Truss C by varying the module size.
4. The overall percentage decrease in the central deflection of the composite space truss with slab thickness between 50 to 125mm is only 5 to 10% for the change in the concrete strength from M25 to M35.
5. The overall decrease in the central deflection of the composite space truss of 4m x 4m span is 40% for change in slab thickness from 50mm to 125mm.

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