Experimental and Analytical Investigation on Space Truss

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Abstract— This project describes about the experimental and analytical investigations on space truss with different types of configurations for double layer grid structures such as square on diagonal, square on square offset, square on square offset diagonally, diagonal on square. The Profile stability analyses were done for the above listed configurations for the double layer grid structures using STAAD Pro Version8i software. From the analyses the best among configurations of double layer grid structures space truss were determined and the deflection, axial forces, weight of the truss and pipe section were recorded. The deflection and vibration results of different types of configurations for double layer grid structures space truss were investigated experimentally using Fast Fourier Transform vibration analyzer. From the effective outcome of the results, the structure was designed economically by adjusting the configuration of double layer grid structures with suitable distance. The result exhibits the obvious effect of the load carrying capacity and ductility of DLG space structures.

Keywords: Space Truss, STAAD Pro, DLG Space Structures

I. Introduction

Space structure is relatively lightweight, easy to fabricate and transport, flexible in workability, and requires short period for construction. Steel space trusses are frequently used as roof structures in industrial and commercial buildings to cover large areas with no internal supports. The complexity of the different types of connections is the main factor for the cost difference between the various truss systems. Bolted connections are preferred instead of welded connections due to easy transportation, fast assemblage, reduced cost, uncomplicated dismantling and expansion, availability of workforce, among other advantages. For many practitioner, manufacturing cost and fast assemblage are the main factors in the decision making process to choose the type of connection to use. For that reasons one of the most common connection used for steel space truss is the connection obtained by staking end-flattened tube and joining them with a single bolt. The staking end-flattened node is the simplest and therefore cheaper connection to manufacture for 3D trusses, but it has two main disadvantages like the generated eccentricity bending moment and the reduction of stiffness in the tubes due to the end-flattening process. The investigations focus on modifications required to the present end-flattened connection with the aim to improve the load carrying capacity of space trusses and, therefore, make it more economical. The proposed modifications are simulated numerically and tested in laboratory. Analytical investigations on space truss with different types of configurations for double layer grid structures such as square on diagonal, square on square offset, square on square offset diagonally, diagonal on square. The Profile stability analyses were done for the above listed configurations for the double layer grid structures using STAAD Pro Version8i software.

A. *Materials Used In Space Frames*

- Timber
- Steel
- Aluminium
- Concrete
- Plastics

B. *Advantages of Double Layer Grids*

- Double layer grids are usually built from simple prefabricated units, in many cases of standard size and shape. Such units, mass produced in factory, can be easily and rapidly assembled at site by semi-skilled labour.
- The small size of the units greatly simplifies handling, transportation and erection, as no heavy hoisting equipment is needed at the site.
- The high rigidity of double layer grids reduces the deflection of the structure.
- Due to the high indeterminacy, buckling of any member under any concentrated load may not lead to the collapse of the structure.
- The roofs can be extended at a later date by simply adding additional pyramidal units.

C. *Types of Configuration of Space Truss*

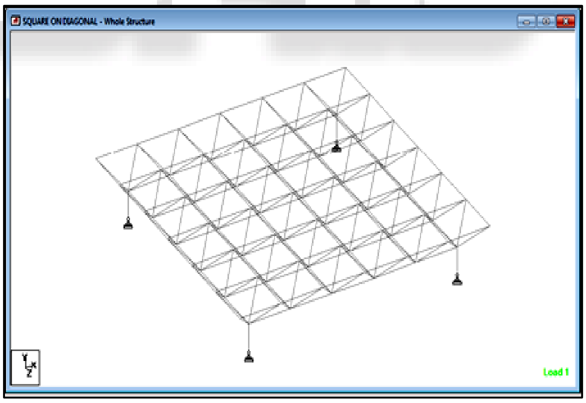

Fig. 1: Square on diagonal

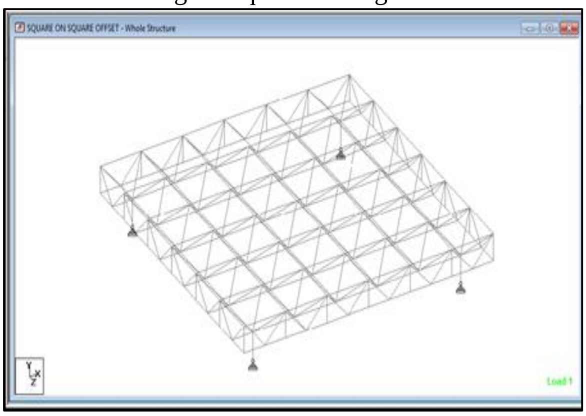

Fig. 2: Square on square offset

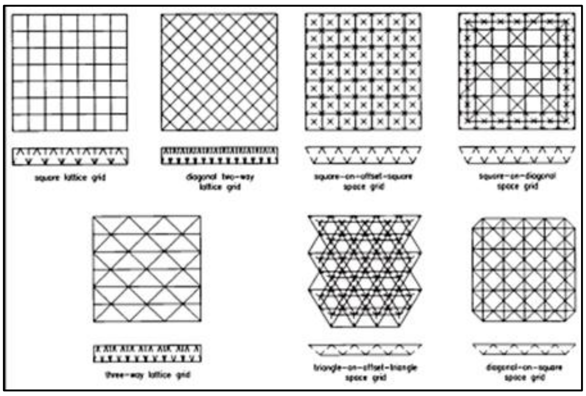

Fig. 3: Different types of configuration of space truss

II. TYPES OF SUPPORT CONDITIONS IN SPACE TRUSS

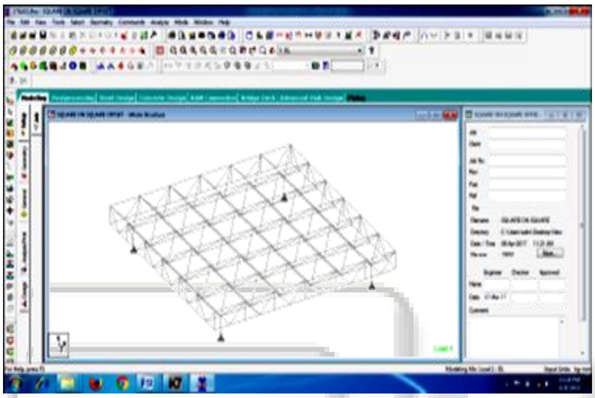

Fig. 4: Cornice support of square on square offset

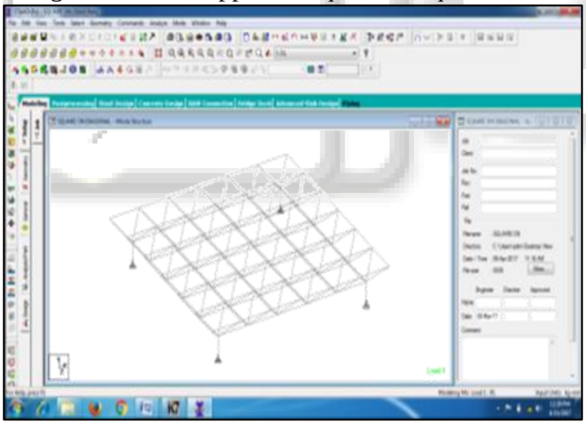

Fig. 5: Cornice support of square on diagonal

III. ANALYTICAL INPUT DATA

A. *Software Used:*

Design any type of structure and share your synchronized model data with confidence among your entire design team, using STAAD Pro. Ensure on time and on budget completion of your steel, concrete, timber, aluminum, and cold-formed steel projects, regardless of complexity.

– Lower total cost of ownership: Design any type of structure including culverts, petrochemical plants, tunnels, bridges, and piles.
– Increase design productivity: Streamline your workflows to reduce duplication of effort and eliminate errors.
– Reduce project costs and delays: Provide accurate and economical designs to your clients and quickly turnaround change requests.
– To determine the deflection, axial force, pipe section and weight of the truss by analytically.
– STAAD Pro is done by stiffness matrix method.

1) Analytical Work Using Staad Pro And Experimental Work

a) Analytical work for square on diagonal:

The size of the structure model is 1mx1m for both square on diagonal and square on square offset. It consists of 5 bays and each bays spacing is 200mm. The height of the model is 100mm for each grid. 6mm rod is used and welded connection is provided for all joints in the structure. Using staad pro software the pipe section is solid circular and also the space truss having 49 nodes each node having 15kg of weight applied all the pipe section passed. It will increase the weight of truss at each node and then all section failed.

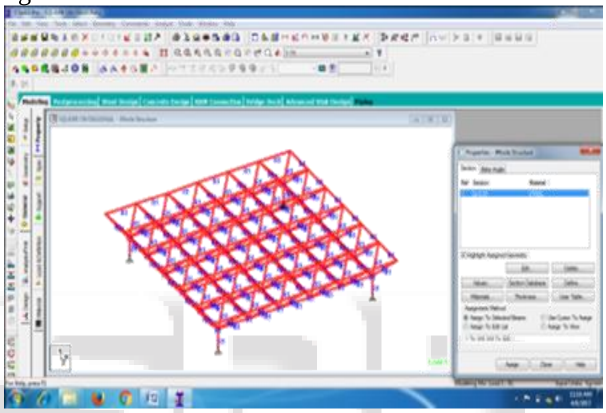

Fig. 5: Assigning the property

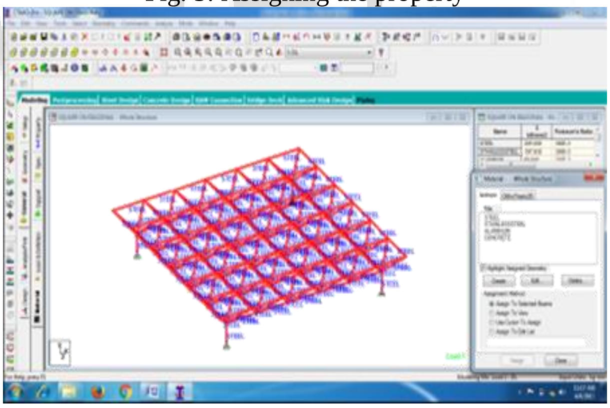

Fig. 6: Assigning the material property

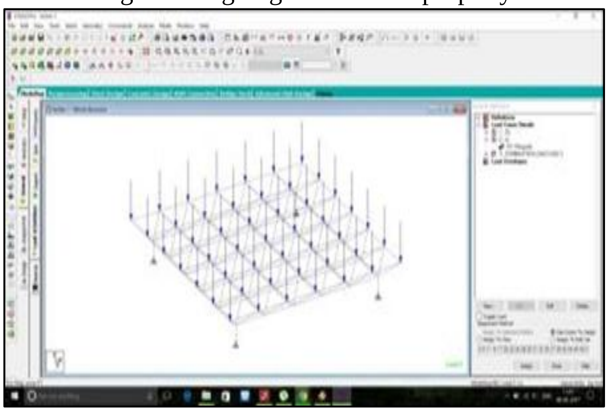

Fig. 7: Assigning the load at each node

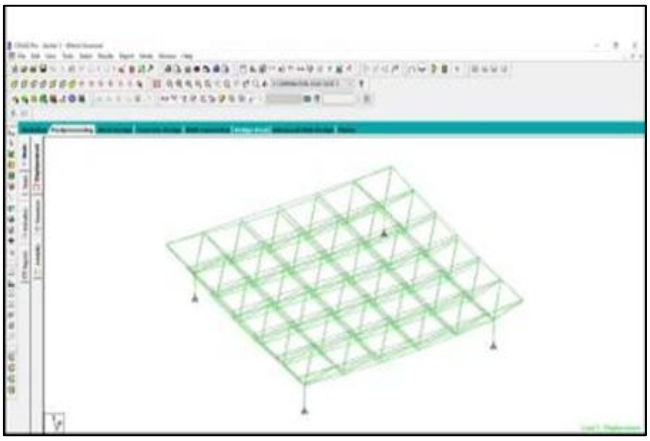

Fig. 8: Displacement

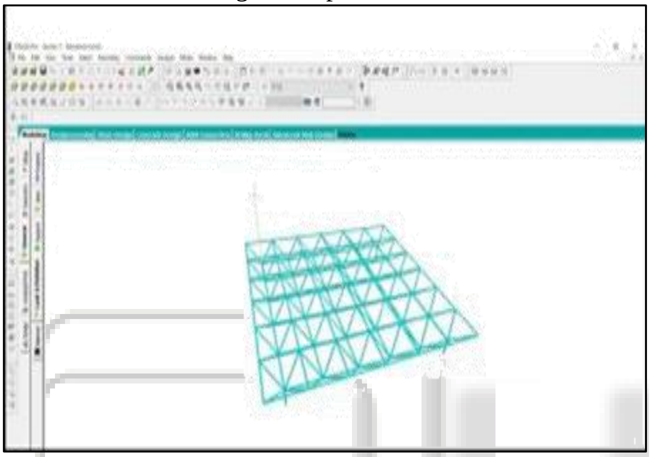

Fig. 9: Rendering view

IV. EXPERIMENTAL WORK

The Experimental Work is done in the second Phase of the Project. The size of the structure model is 1mx1m for both square on diagonal and square on square offset. It consists of 5 bays and each bays spacing is 200mm. The height of the model is 100mm for each grid. 6mm rod is used and welded connection is provided for all joints in the structure. This model is done near KCT college workshop and duration of the project is 3 to 4 days. The cost for making the model is Rs.5000. Then it is brought to the laboratory for testing and to obtain the result.

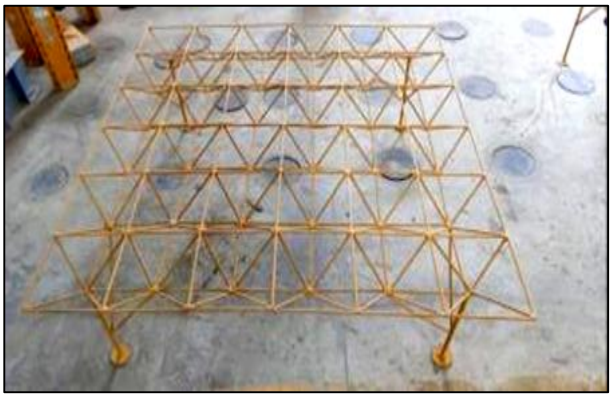

Fig. 10: Square on diagonal before loading

Fig. 11: Square on diagonal at loading

Fig. 12: Failure of joints

Fig. 13: Failure of joints

A. Fast Fourier Transform Vibration Analyzer:

FFT plug-in is used to compute the input signal FFT. We can also compute time signals in post analysis mode with the player module. FFT takes a block of time domain data and returns the frequency spectrum of the data. The FFT is a digital implementation of the fourier transform. Instead, the FFT returns a discrete spectrum, in which the frequency content of the waveform is resolved into a finite number of frequency lines or bins. Test results of Fast Fourier Transform Vibration Analysis of square on diagonal and square on square offset as shown in graph. Using FFT Vibration analyzer to determine the maximum frequency of the both space trusses.

Fig. 14: FFT vibration analyzer testing

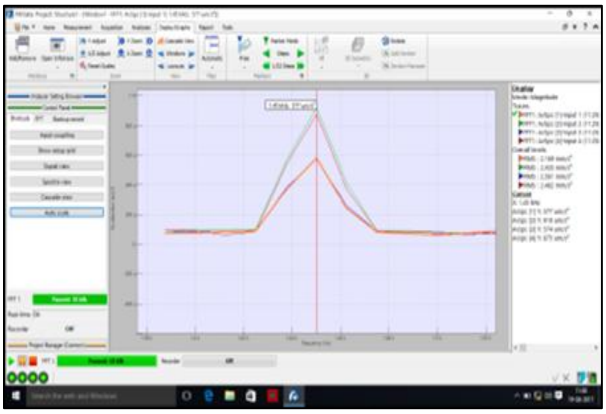

Fig. 15: Maximum frequency of square on diagonal

V. Result and Graphs

Configuration	Deflection(mm)	Weight of the truss(kn)
Square on	1.55	0.1545
Diagonal		
Square on square	1.63	0.1765
Offset		

Table 1: Test results of analytical work

Configuration	Deflection(mm)	Weight of the truss(kn)
Square on	1.59	0.1565
Diagonal		
Square on square	1.65	0.1785
Offset		

Table 2: test results of experimental work

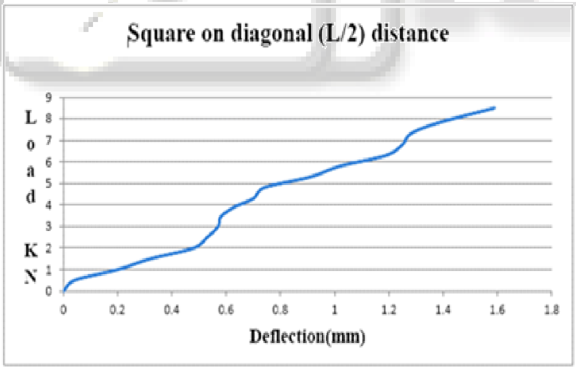

Fig. 16: Square on diagonal load versus deflection at L/2 distance

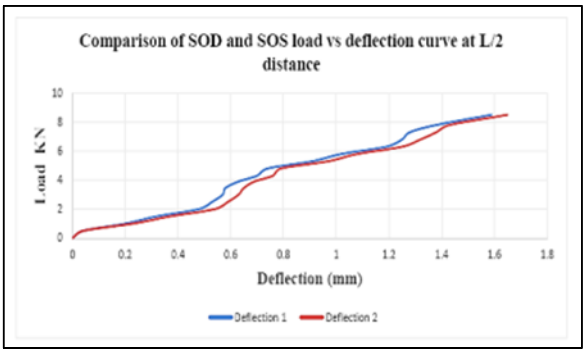

Fig. 17: Comparison of SOD and SOS load vs deflection curve at L/2 distance

VI. Conclusion

Different types of configurations such as square on diagonal, square on square offset. Analysis the different types of configuration of double layer grid space truss using STAAD Pro software in above mentioned configurations which one is the best configuration of double layer grid structure in space truss it is based on the deflection, axial forces, weight of the truss and pipe section and also comparison of the results of different types of configuration of double layer grids of space truss. The structure was designed economically with adjusting different configuration of double layer grid structures with suitable distance. After the analyses results and compared with experimental results of different types of configuration of space truss of the square on diagonal configuration space truss is suitable and also economical. The study concluded the square on diagonal space truss shows the good load carrying capacity of DLG structures and also reduction in deflection.

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