Kalpa Publications in Civil Engineering
Volume 1, 2017, Pages 456–461
ICRISET2017. International Conference on Research and Innovations in Science, Engineering &Technology. Selected papers in Civil Engineering

Effectiveness of Different Connectors Used in Double Layer Grid Structure: A Parametric Study

Mansi J. Mehta[1,2,3*], Dipali Patel[1†] and Vishal A. Arekar[1††]
[1]Civil and structural engineering, CHARUSAT, Changa, India
[2] Assistant Professor, CHARUSAT, Changa India
[3]Assistant Professor, BVM, Vidyanagar, India
mehtamansi85@gmail.com, Dipalipatel.cv@charusat.ac.in, Vaarekar@bvmengineering.ac.in

Abstract

Double-Layer Grid structures are three-dimensional pin-jointed structures, which are generally used for covering roofs having large span areas with the help of connectors. A Double Layer Grid structures are quite popular as the use of material can be reduced, easy to assemble and permits quicker construction. The weight of the structure depends on the member as well as connectors. The connectors contain 20-30% of total weight (by referring Lan, T.T. “Space frame structure”). In present study, two types of Connectors are used for analysis and for optimisation of structure. The aim of this study is to optimize the design and to get the effective connector. Solid connector and Hollow connector (with varying thickness) have been taken for parametric study, modelled in CREO and analysed using ANSYS 17.2. The results of stresses have been obtained under the static loads for comparison.

Keywords— ANSYS 17.2; CREO; Double layer Grid (DLG); Solid Connector; Hollow connector; Stresses

1 Introduction

Space frames were developed around 1900 and architectural appearance have been given in 1950. In space frame, members are attached to each other with several types of nodal connections to cover large span areas without interior supports. They are simple, lightweight, prefabricated, economical and easy to erect compare to other types of structure.

Zeinab and Ihab [1] worked on Double Layer Grid space steel frames with the modular angle 45^0 and 30^0 and concluded modular angle 45^0 is best angle because it gives highest and larger reduction factor in maximum displacement at different loading condition. M.R. Davoodi et.al [2] compared standard linear analysis with and without connector. It was shown connector gives much better agreement with the test result.

In this paper an attempt has been made to find the effective connector from solid connector and hollow connector. Both are modelled for Double Layer Grid structure to show the behaviour of joints. The axial forces found in STAAD.Pro on Double Layer Grid under static load and applied on connector in ANSYS to analyse for stresses.

2 Geometry and Property of Double Layer Grid and Connectors

2.1 Double Layer Grid

Square Area of Double Layer Grid structure is 144m^2 and area of panel is 5.76m^2 for each. E = 2.05 × 10^5 and F_y = 250 N/mm^2 are the material properties of the members. Fix Supports are provided at corner of the grid. Vertical downward Load (P) is applied on each node on the top layer of Grid. P ranging from 2kN to 10kN at an interval of 2kN.

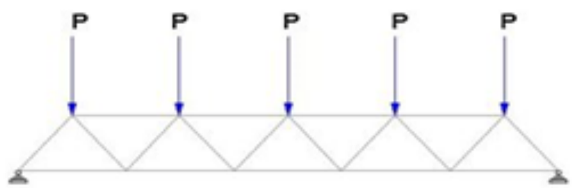

Figure 1: Elevation

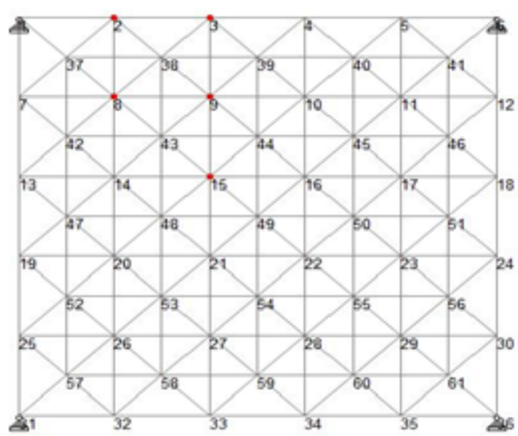

Figure 2: Plan

All the nodes of bottom layer grid, except support, have been considered for comparison of results. As the geometry is symmetric, it can be observed that the five nodes (2, 3, 8, 9, and 15) represent all the bottom layer nodes, these five nodes have been conserved for comparison.

2.2 Connector

Solid Connector

Solid connector of 150 mm diameter is modelled in CREO and analysed in ANSYS 17.2 to calculate the stresses. Smaller circles on solid sphere show the space for connection of bolts. Forces are applied on that small circle to calculate stresses.

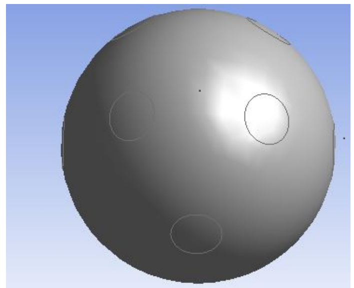

Figure 3: Solid sphere

Hollow connector with different thickness

Outer diameter of hollow sphere is same as solid sphere with varying thickness of 10mm to 30mm thickness at an interval of 5mm. Opening is provided in the connector to insert the bolt. Same method is used for calculation of stresses.

Figure 4: Hollow sphere

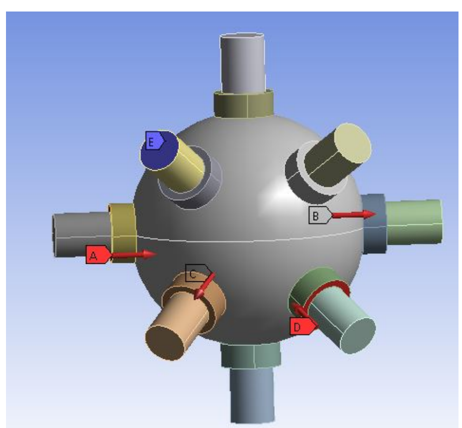

Figure 5: Loads on connector

The forces acting on connectors are in the direction of members, which are connected to them as shown in Fig. 5 The direction of arrows show the nature of member forces e.g. compressive or tensile.

3 Results

Solid connector and hollow connector are analysed for considered forces at nodes. The graph of incremental Load P vs Principal stress is plotted under the deliberation. Fig. 5 to 9 show the comparison graph of Solid Sphere and Hollow Sphere (with varying thickness) for nodes at 2, 3, 8, 9, and 15.

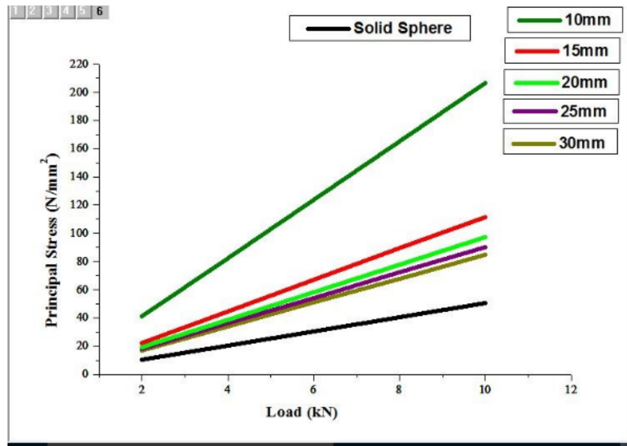

Figure 6: Principal stress at node 2

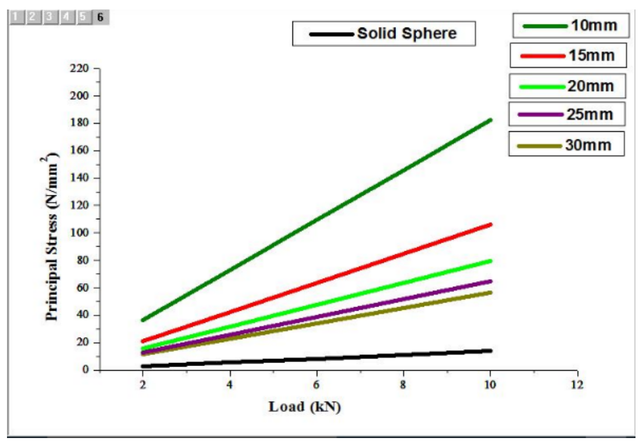

Figure 7: Principal stress at node 3

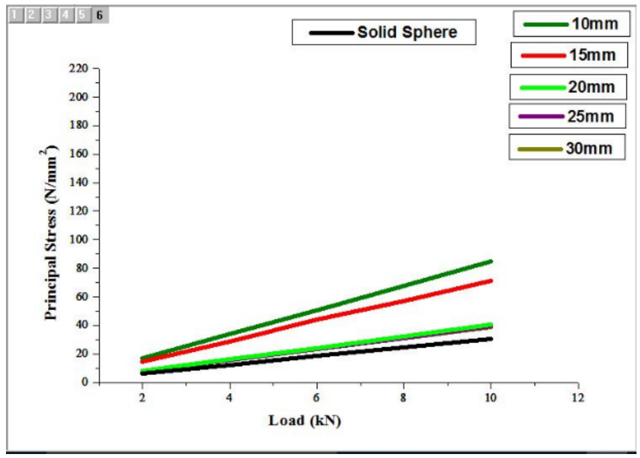

Figure 8: Principal stress at node 8

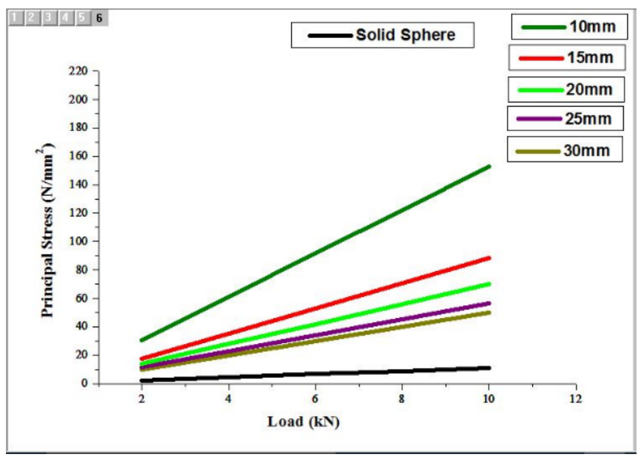

Figure 9: Principal stress at node 9

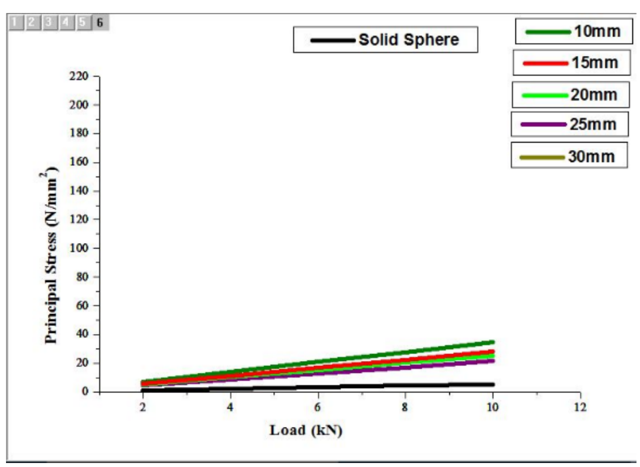

Figure 10: Principal stress at node 15

4 Conclusion

After the analysis of double layer grid structure in ANSYS 17.2, the following points have been concluded:

- As shown in graph, the value of principal stresses is linearly varying as the load is increased linearly.
- Max value of Principal stress in solid sphere is 50.768 N/mm^2 at node 2 for 10kN load. The same for hollow sphere is 206.36 N/mm^2 for 10mm thickness at node 2. The value of max stress is increase by 75.4 % in case of hollow sphere but it is within the permissible limit of 250 N/mm^2 (yield stress). So it can be used in place of solid connector.
- It is clearly seen that the use of Hollow Connector instead of Solid Connector is better to reduce overall weight which leads to the reduc (H)tion in cost of Double layer grid.
- In view of the above mention points, we can conclude that the hollow sphere gives better result at 10mm compared to solid sphere and other considered thicknesses of hollow sphere.

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