Comparison of Principal Stresses in Space Structure Connectors

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Abstract **—The present paper reveals the study of three dimensional finite element analysis of space structure connectors using ANSYS software. A new type of connector, named THH150 (Patent Pending – Application No. 1644/MUM/2014), has been developed and comparison has been carried out with the MERO connector, which is a well-known as well as commercially used connector. The maximum principal stresses of the MERO as well as THH150 connector are compared. This research opens up a possibility of availability of a very compatible connector which can be easily fabricated due to its simple geometry, unlike many others having a very complex geometry, making it comparatively cheaper.**

Keywords— MERO connector, THH150 connector, Double Layer Grid, ANSYS, STAAD Pro.

I. INTRODUCTION

Space trusses/frames are well-known for covering large open spaces with few or no internal supports. Their advantages include mass production, easy transportation, fast assembly, light weight and aesthetic view. A double layer grid is one of the most commonly used space trusses. It consists of two parallel plane grids forming the top and bottom layers and interconnected by vertical/diagonal web members with node connectors.

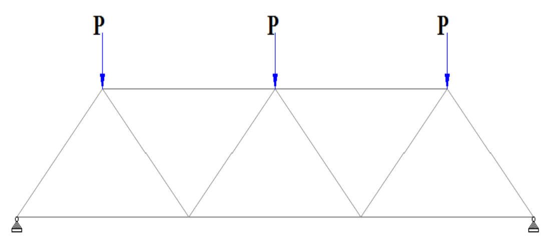
The connector is an integral part of a space grid. The type of connector depends mainly on its connecting technique, whether it is bolting, welding or applying special mechanical connectors.

T. Vacevet. al. [1]presented experimental analysis of an original type of node joint for a steel space truss. A connector has been developed which can be made in average technology conditions, without special tools and requirements. The connector was tested in ANSYS software for strain values till its elastic limit and compared with the experimental values.M. Ghasemiet. al. [2]presented the relationship of force-displacement of MERO jointing system. The experiments showed that the behaviour of connector was nonlinear and was affected by the degree of bolt tightness.V. Arekaret. al. [3]have presented a paper on the analytical study of MERO-connector in double layer grid structure using ANSYS software. They observed that in the bottom layer, tensile forces are predominant in the central region; where as in the top layer compressive forces are predominant in the central region.YANG Guoqinget. al. [4] modeled a parameterized 3D finite element model of bolted joints with real helical thread geometry and meshed with refined hexahedral elements. This research provides a simple and practical approach to constructing the 3D finite element model and predicting the mechanical properties of helical thread connection.

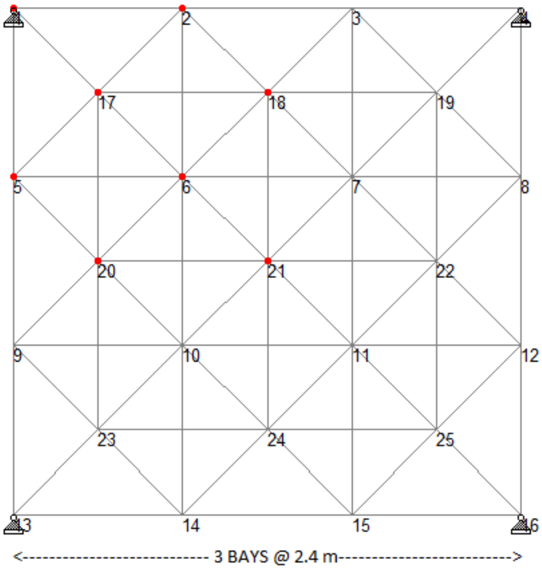
The MERO system, which is a commercially well-known connector, is a multidirectional system allowing up to fourteen tubular members to be connected at various angles and so is the newly developed 'THH150' connector system, except that the angles of connection varies in the latter.

II. ANALYSIS OF THE DOUBLE LAYER GRID

In the present paper, a double layer grid of size 7.2 m x 7.2 m having panel size 2.4 m x 2.4 m (3 panels) shown in fig. 1 is considered for analysis. Supports are at four lower corner nodes. The material properties of members were E = 2.05 x 10^5 N/mm^2 and F_y = 250 N/mm^2. The structure is subjected to concentrated load P, applied vertically downward to each top layer nodes. The analysis of the grid was carried out in the STAAD Pro software for different values of P ranging from 10 kN to 50 kN in increments of 10 kN[5].



(A) Elevation



(B) Plan

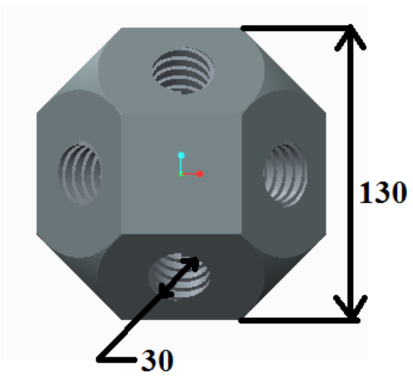
Fig.1 Details of double layer grid

III. Analysis Of The Connectors

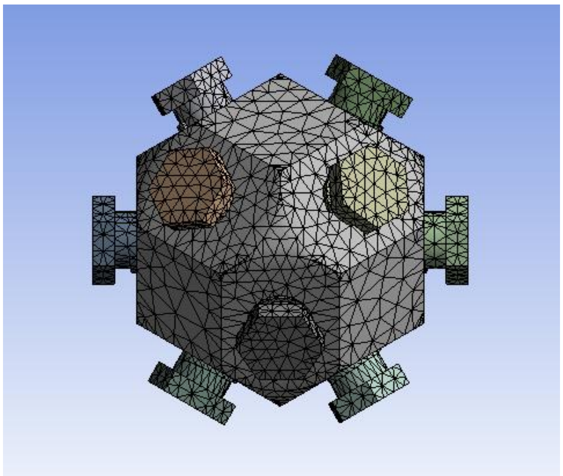
A. MERO connector

The forces to be applied on the connectors are calculated from the forces found from STAAD Pro analysis. The forces are different for different node connectors. In the present double layer grid, there are total 25 nodes, out of which only 8 nodes are considered for analysis because of symmetry. These nodes are shown in Fig.1 (b) with red colour.

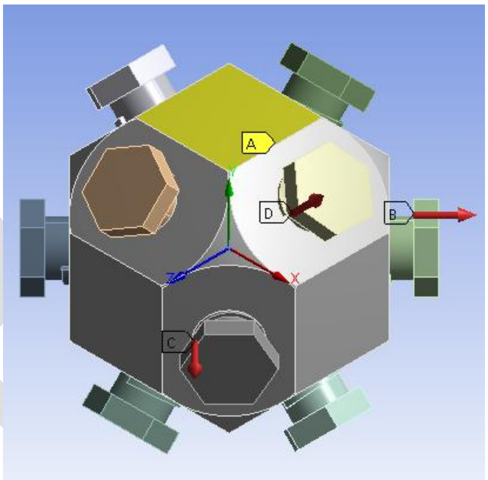
MERO connector is modeled in ANSYS 14.5 considering 10 noded tetrahedron elements for meshing and with square threading to match the actual field situation of application of the forces. The dimensions of the MERO connector and holes are shown in Fig.2 (a). A typical view of the meshing pattern of the model and the connector under loading condition are shown in Fig.2 (b) andFig.2 (c).



(A) Dimensions



(B) Meshing in ANSYS

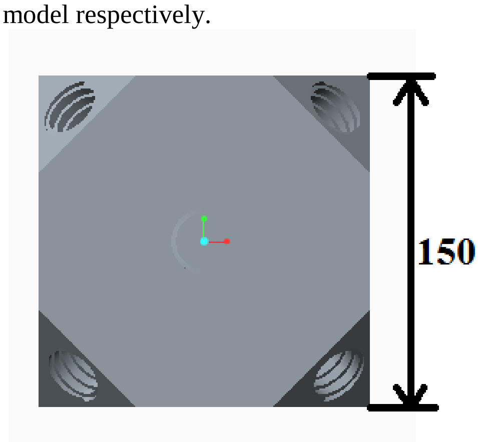


(C) Connector under loading

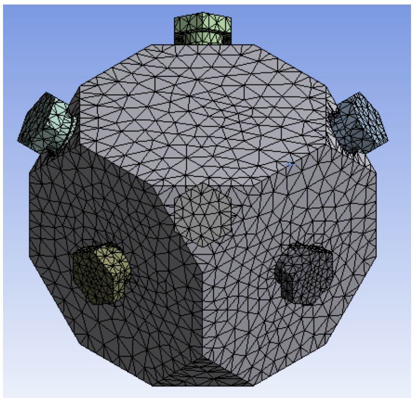
Fig.2 Model of MERO connector

B. THH150 connector

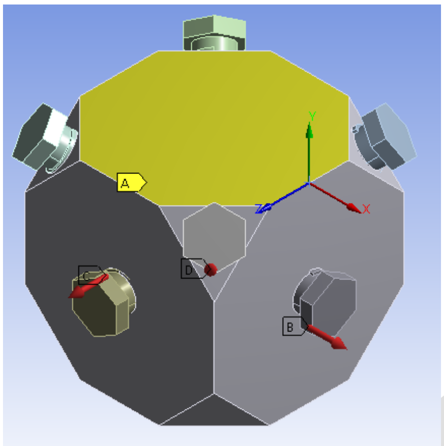
The THH150 connector is modeled in ANSYS 14.5 with similar threading and hole diameter as in MERO. Fig.3 (a) shows dimensions of THH150 connector while Fig.3 (b) and (c) shows the meshing pattern and loading condition of the model respectively.



(A) Dimensions



(B) Meshing in ANSYS

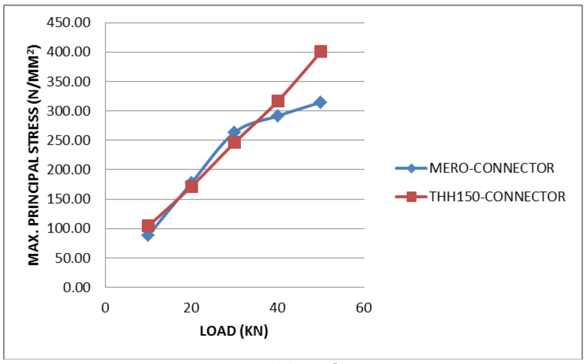


(C) Connector under loading

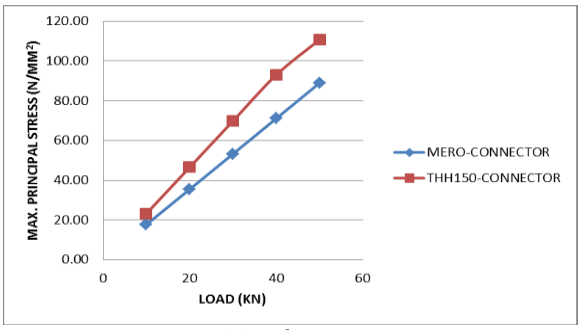
Fig.3 Model of THH150 connector

IV. RESULTS

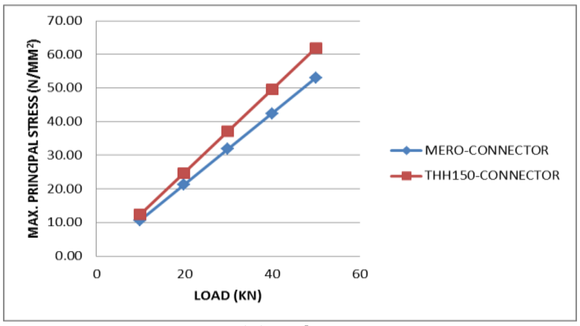
Both connectors are analysed in ANSYS 14.5 for their respective forces, and graphs of load increments v/s the maximum principal stresses for each node under consideration are plotted. The graphs show the comparison of Maximum Principal Stresses between both the connectors. The results for different nodes are shown in Fig.4.



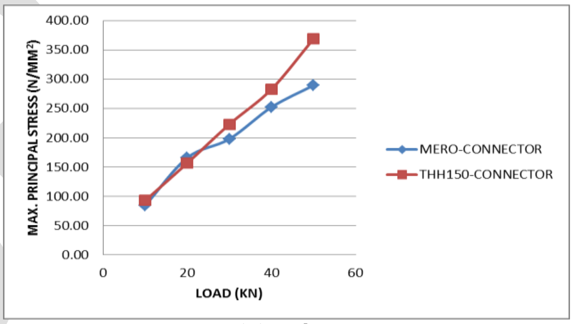
(A) Node-1



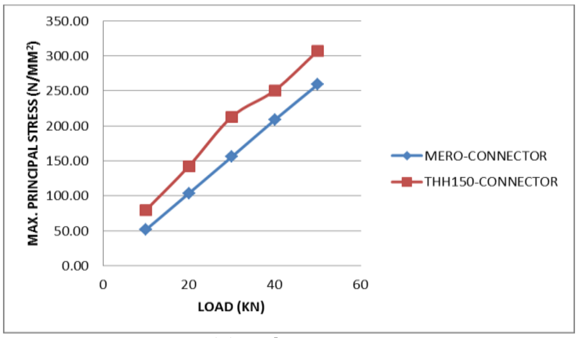
(B) Node-2 & 5



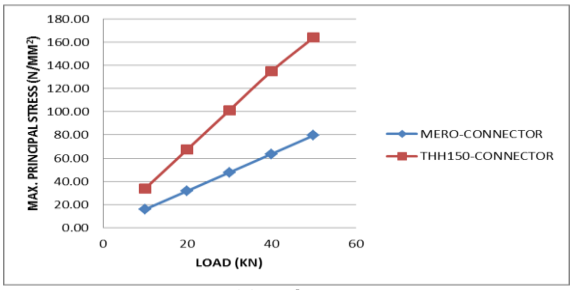
(C) Node-6



(D) Node-17



(E) Node-18& 20



(F) Node-21

Fig.4 Comparison of Max. Principal Stresses

CONCLUSIONS

Based on the analysis of the double layer grid in STAAD Pro software and that of the connectors in ANSYS software, following conclusions have been derived:

1. It is confirmed that in the bottom layer, tensile forces are predominant in the central region; where as in the top layer compressive forces are predominant in the central region.
2. It is found that principal stresses in both the connectors are of the nearer values so the newly developed connector can be considered as strong as the MERO connector.
3. It is also observed that for the loading of 28 kN in STAAD analysis, the connectors remain in its elastic limit.
4. The above conclusion also opens up the possibility of a new competent connector and also which can be made in average technology conditions making it comparatively cheaper.

REFERENCES

[1]Vacev, T.;Kisin, S.;Rankovic, S.; (2009). Experimental Analysis of an Original Type of Steel Space Truss Node Joint.Architecture and Civil Engineering, Vol. 7.

[2] Ghasemi, M.;Davoodi, M.R.; Mostafavian, S.A; (2010). Tensile Stiffness of MERO-Type Connector Regarding Bolt Tightness. Journal of Applied Sciences.

[3] Arekar, V.;Bhavsar, B.; (2013). Analytical Study of MERO Connector in double layer grid.International Journal of Latest Trends in Engineering and Technology.Vol. 2 Issue 2.

[4] YANG, G.; HONG, J.; ZHU, L.; LI B.; XIONG, M.;WANG, F.; (2013). Three Dimensional Finite Element Analysis of the Mechanical Properties of Helical Thread Connection. Chinese Journal Of Mechanical Engineering, Vol. 26, No. 3.

[5] Gupta, L.M.; Harde, P.R.; (2010). Nonlinear analysis of double layer grid structures.Journal of civil engineering.

[6] ANSYS - Software Manual.