Analytical Study of MERO Connector in Double Layer Grid Structure

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Abstract- The performance of structural connections of all types has been the subject of intensive research during last some decades. A double layer grid structure is considered and the MERO connector is modeled in ANSYS 14.0 software and analyzed for given loading and support conditions.

Keywords - MERO connector, ANSYS 14.0

I. INTRODUCTION

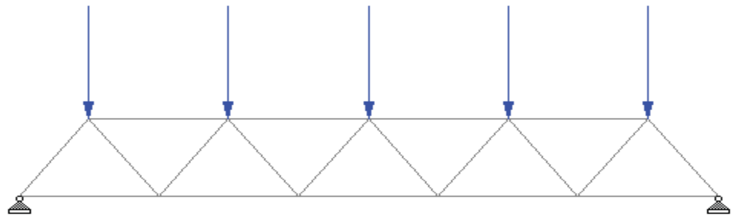
A grid is one of the popular type of space trusses. Members of space trusses connected to each other with numerous types of nodal connections are assumed to carry only axial loads.[1] A Double Layer Grid consists of two plane grids forming the top and bottom layers, parallel to each other and interconnected by vertical and/or diagonal members. A double layer grid is combination of prefabricated tetrahedral, octahedral or skeleton pyramids or inverted pyramids having triangular, square or hexagonal basis with top and bottom members normally not lying in the same vertical plane.

The connector is an extremely important part of a grid design. The type of connector depends primarily on the connecting technique, whether it is bolting, welding, or applying special mechanical connectors. It is also affected by the shape of the members [2]. One of the most popular types of connectors that are widely used in the construction of double layer grids is the MERO system. The name MERO derives from an abbreviation of the original German name MEngeringhausen ROhrbauweise, i.e. MEngeringhausen’s tubular construction [3]. The MERO system is multidirectional system allowing up to fourteen tubular members together at various angles. The system consists of tubular elements that are connected together by means of a MERO connector. The ball is located at the intersection of the longitudinal axes of tubular elements. The longitudinal axis of tabular element and all the constituent parts of its end connectors are along together. This axis is referred to as axis of member. The MERO system had only one type of standard joint, a sphere with 18 threaded holes and machined bearing surfaces at angles of 45, 60 and 90° to each other.

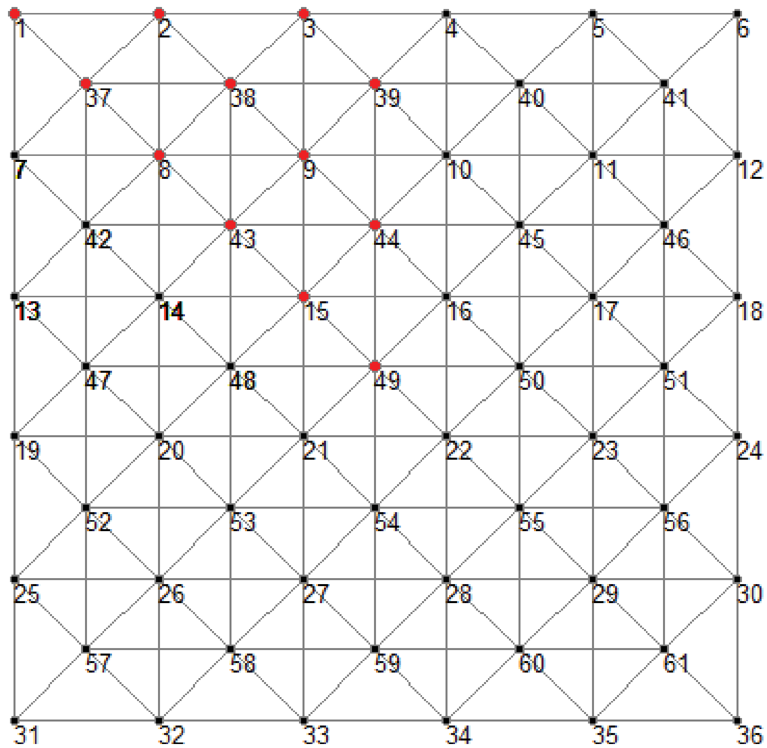
A model of MERO connector is presented in this paper for double layer grid structure. The internal forces in the members of double layer grid are found using STAAD Pro software. These forces are applied as pressures on the MERO connector. The stress pattern and deflection pattern of the connector are studied under different loading conditions using the ANSYS software.

II. ANALYSIS OF DOUBLE LAYER GRID

A double layer grid of size 12 m x 12 m having module size 2.4 m x 2.4 m (5 panels) shown in the fig. 1 was considered for analysis. Supports are at lower corner nodes. The material properties of the members were $E = 2.06 \times 10^5$ N/mm^2 and $F_y = 440$ N/mm^2. The structure was subjected to concentrated load P applied vertically downward to each node of the upper layer. The analysis of 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.



(A) Elevation



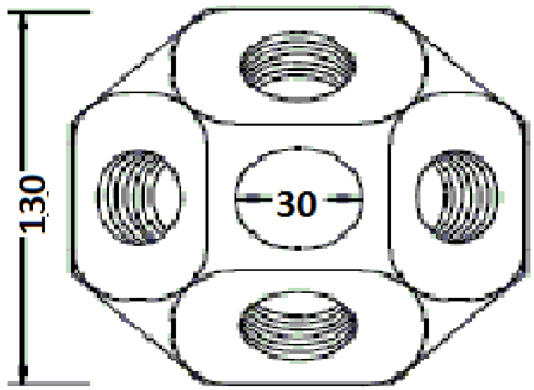
(B) Plan

Fig. 1. Model of Double Layer Grid Structure

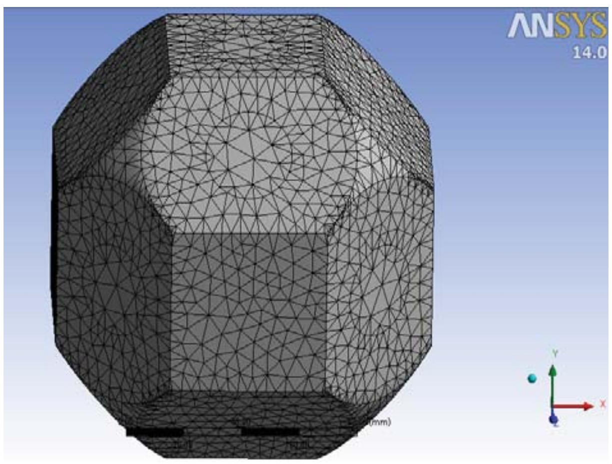
III. ANALYSIS OF MERO CONNECTOR IN ANSYS

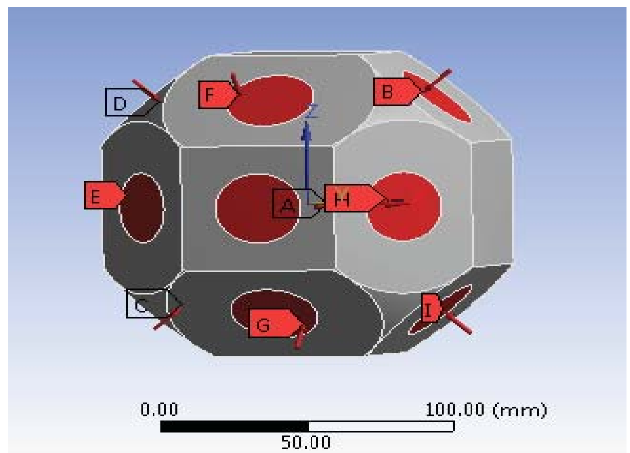
The pressures to be applied on the connector are calculated from the forces found from the STAAD Pro analysis. The applied pressures are different for different node connectors. In the present double layer grid, there are total 61 nodes, out of which only 12 nodes are considered for analysis because of symmetry. These considered nodes are shown in fig. 1.

MERO connector was modeled in ANSYS 14.0. 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) and fig. 2(c).



(a)



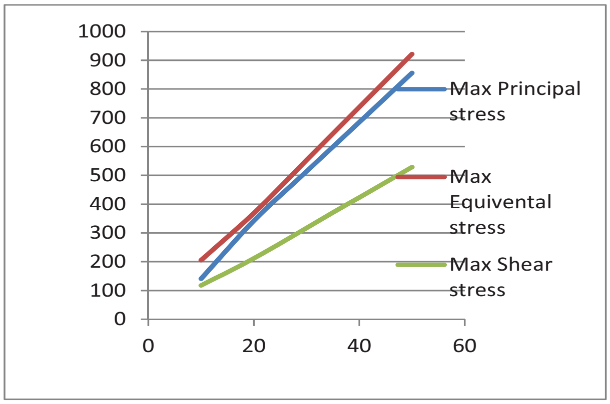


(b) (c)

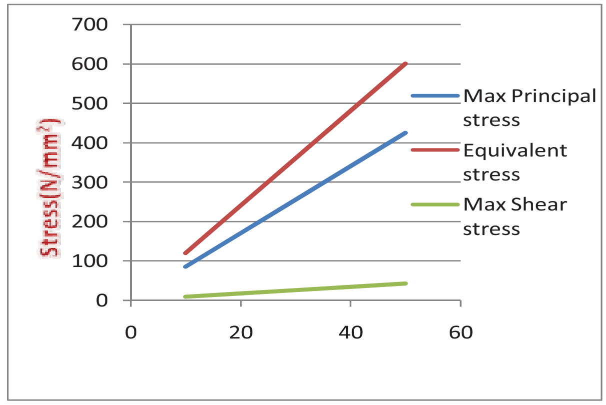
Fig. 2. (a) Dimensions (b) Meshing Pattern (c) Typical view of MERO connector model under loading condition

IV. RESULTS

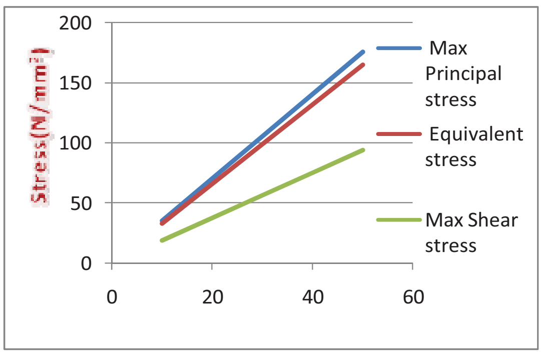
The MERO connectors are analyzed in ANSYS 14.0. Maximum Principle stress, Equivalent (Von Misses) Stress, Maximum Shear Stress and Total Deflection are found. The results for different node connectors are shown in fig. 3 and fig. 4.



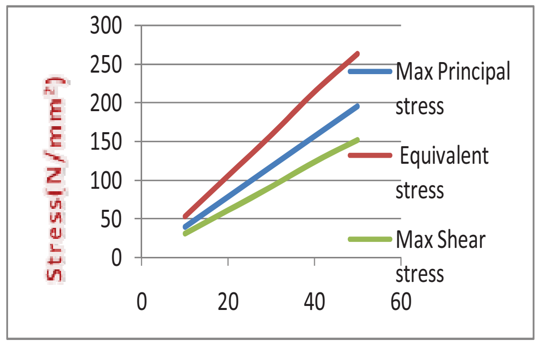
(A) Node 1



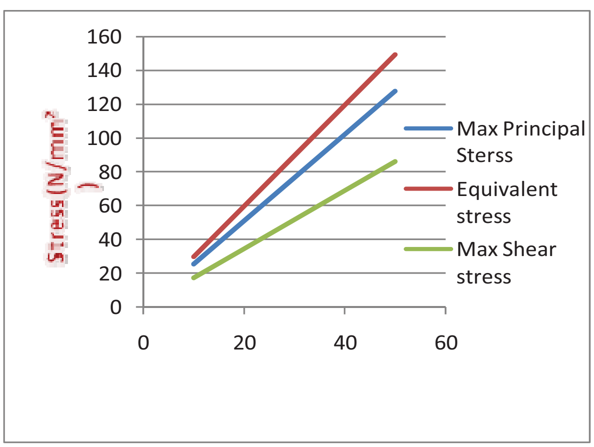
(B) Node 2



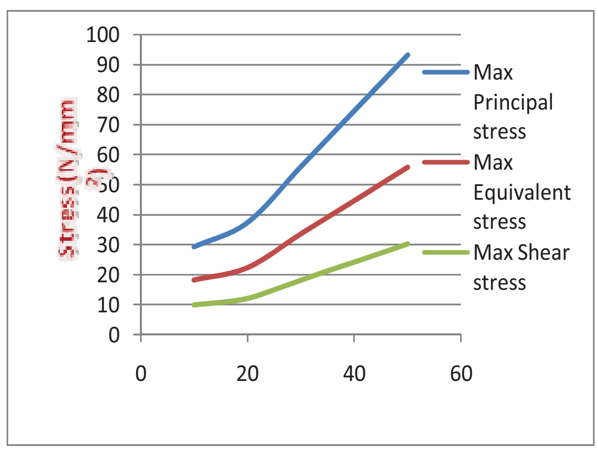
(C) Node 3



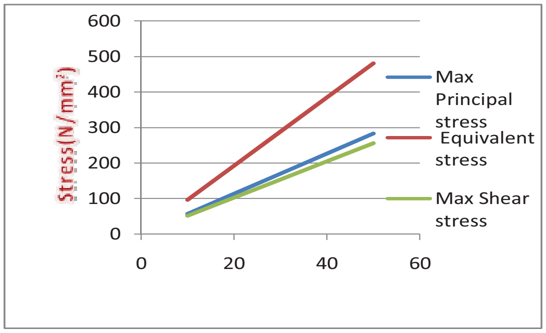
(D) Node 8



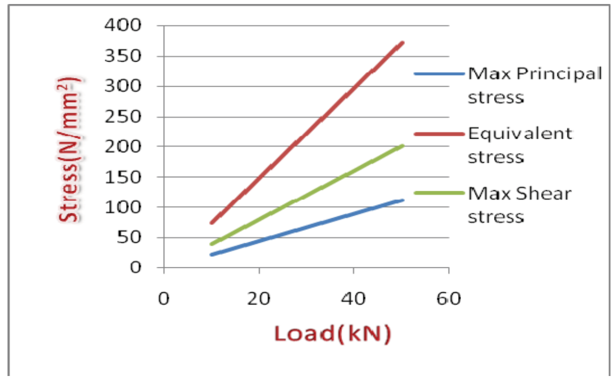
(E) Node9



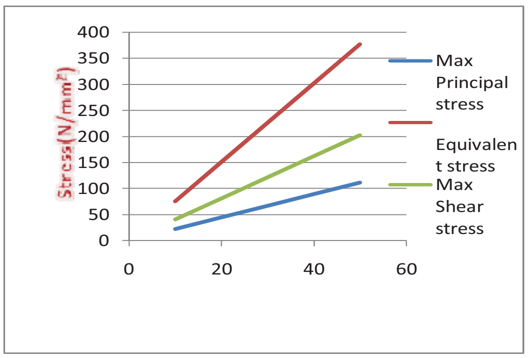
(F) Node15



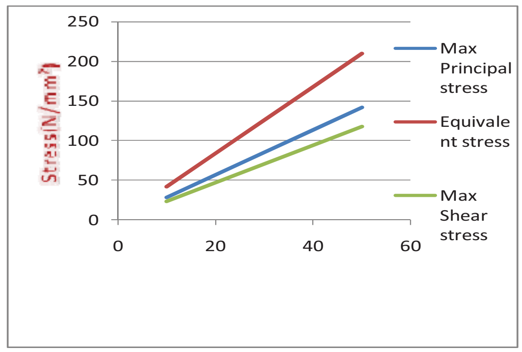
(G) Node37



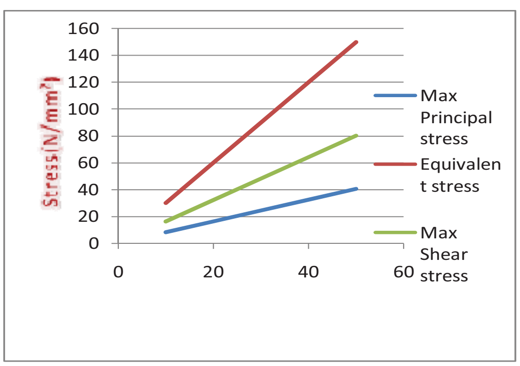
(H) Node38



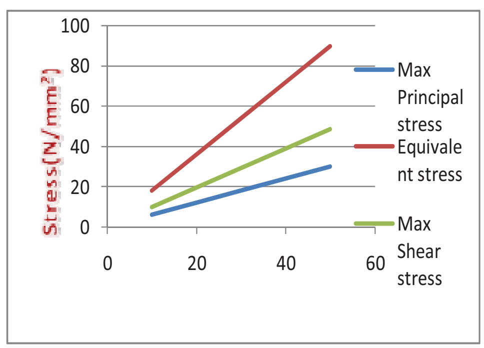
(I) Node39



(J) Node43

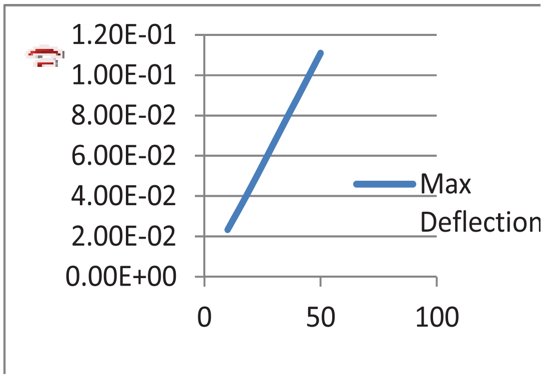


(K) Node44

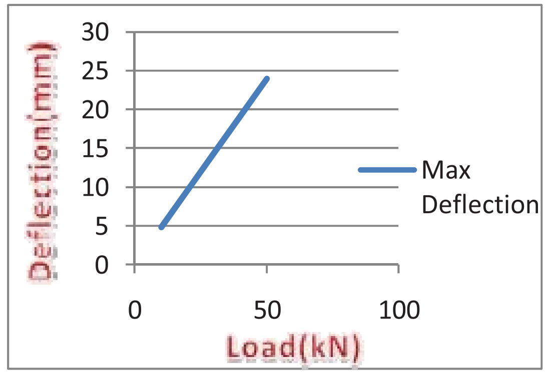


(L) Node49

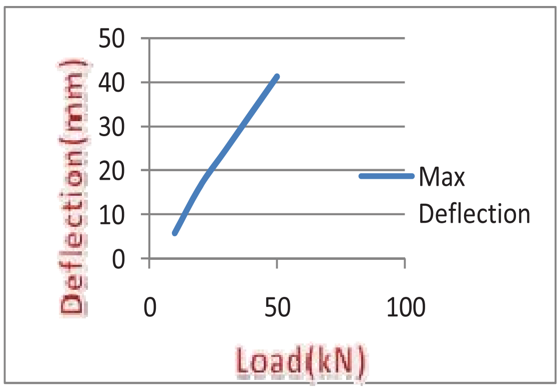
Fig. 3. Load v/s Stresses



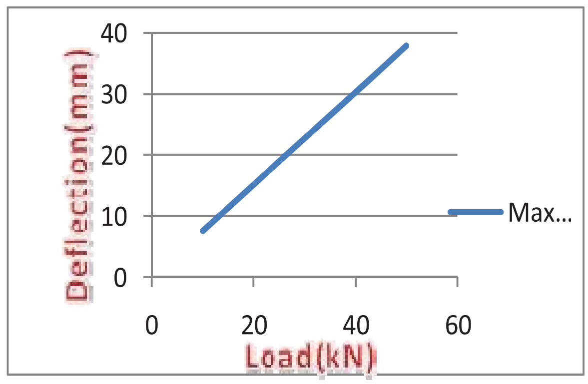
(A) Node1



(B) Node2



(C) Node3



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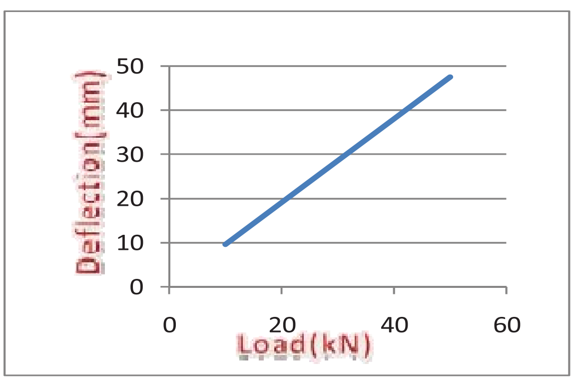
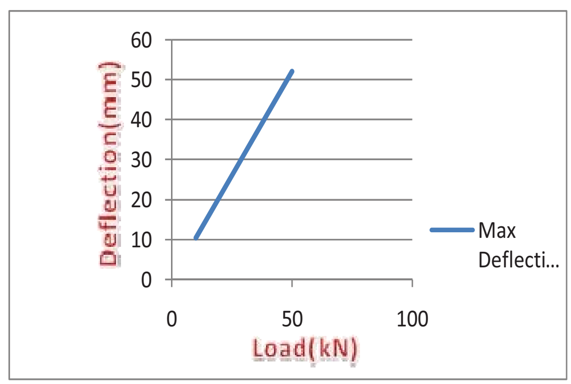
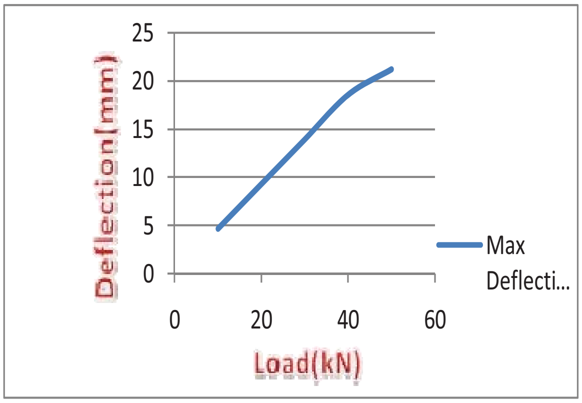


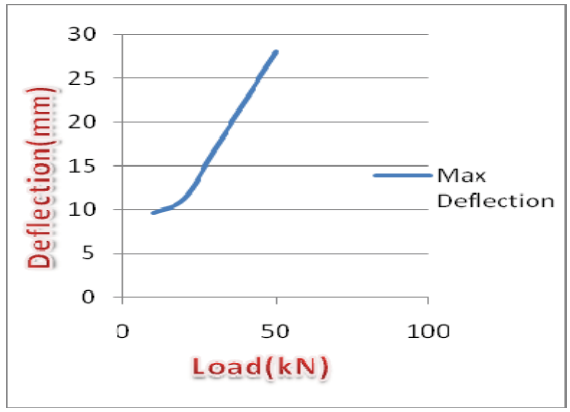
(E) Node9



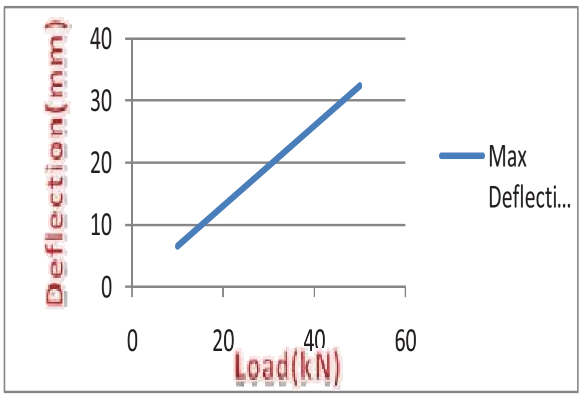
(F) Node15



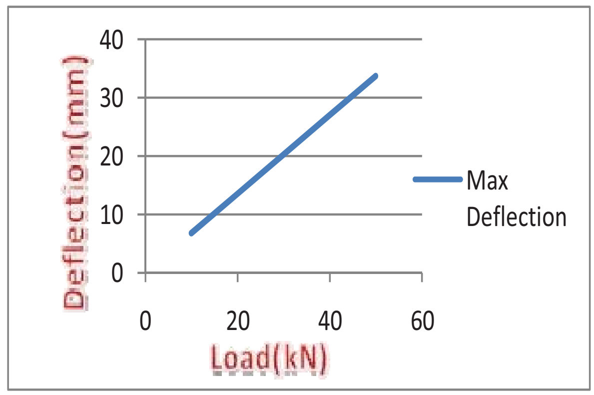
(G) Node37



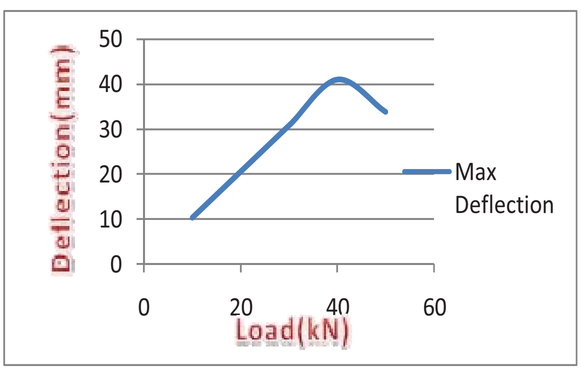
(H) Node38



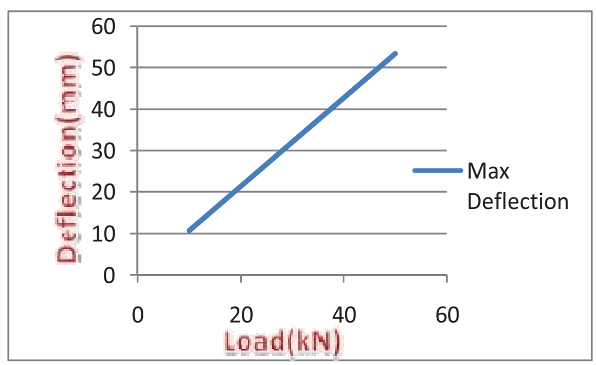
(I) Node39



(J) Node43



(K) Node44



(L) Node49

Fig. 4. Load v/s Deflection

V. CONCLUSION

In the present paper, a double layer grid is analyzed using STAAD Pro software. It is 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. The models of MERO connector are analyzed in ANSYS 14.0 software for all the loading conditions and the values of Maximum Principal stress, Equivalent (Von-Mises) stress, Maximum Shear stress are found. These values vary linearly as load increases linearly and are found quite high near all corner supports and reducing towards central region for all the nodes. The deflections of all the nodes are found increasing linearly in most of cases as load increases.

REFERENCES

[1] A.L Koushky, G. Dehdashti and A. Fiouz, "Nonlinear Analysis of Double-Layer Grids with Composite Nodes under Symmetric and Unsymmetrical Gravity Loads", International Journal of space structure, Vol. 22, No. 2, 2007.

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

[3] Subramanian N., "Principles of space structures", Wheeler Publishing, Berlin, 1981.

[4] Ahmed El-Sheikh, "Development of a New Space Truss System", J. Construct. Steel Res. Vol. 37, No. 3, pp. 205-227, 1996.

[5] J. J. Chen, Y.N. Shih, "A study of the helical effect on the thread connection by three dimensional finite element analysis" Department of Mechanical Engineering, Chung-Yuan Christian Uni6ersity, Chung-Li, 32023 Taiwan, ROC 27 April 1999.

[6] K N Lakshmikandhan, R Senthil, S Arul Jayachandran, P Sivakumar and Ravichandran R, "Parametric studies on the behaviour of steel and composite space structures", International Journal of space structure, 2010.

[7] L.M. Gupta and P.R. Harde, "Nonlinear analysis of double layer grid structures", Journal of civil engineering, 2010.

[8] M. Ebadi, M Davoodi., "Evaluate Axial Stiffness of the MERO Connection, Under the Effect of Hardening the Screw", Department of Civil Engineering, Babo University of Technology, Iran, 2012.

[9] Caglayan., E Yuksel., "Experimental and finite element investigations on the collapse of a Mero space truss roof structure – A case study", 2008.

[10] Salajegheh E, Salajegheh J., Seyedpoor S.M. and M. Khatibinia , "Optimal Design of Geometrically Nonlinear Space Trusses Using an Adaptive Neuro-Fuzzy Inference System", Sharif University of Technology, 2009.

[11] Vacev T, Kisin S. Rankovic S., "Experimental Analysis Of An Original Type Of Steel Space Truss Node Joint", Architecture and Civil Engineering, Vol. 7, pp.43 – 55, 2009.

[12] Xu Xudong, Tetsuro Ono and Guan Fulin, "FE Modelling of Tension Pin-End Connections", International Journal of space structure, October 2007.

[13] John Chilton, "Space Grid Structures" Architectural Press.

[14] Lan T. T., "Handbook of Structural Engineering", Institute of Building Structures, Chinese Academy of Building Research.