OPEN ACCESS
International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-4 Issue-3, July 2015

Finite Element Analysis of Cold Formed Steel Bolted Connection

Sneha Khalate, Sumant Kulkarni

Abstract-The aim of this paper is to present a simple and accurate three dimensional finite element Model (FE) capable of predicting the actual behavior of beam-to-column joints in steel frame subjected to static loads. The software package ANSYS is used to model the joint. The beam- column type connection is used for study. This is chosen for its complexity in the analysis and their inheritable non-linear behavior. Two experimental tests in the literature were chooses to verify the finite element model. The results of model in literature were compared with analytical model. Two modes of failure were identified from the tests; 1) Mode: Bearing failure in section web around the bolt hole. 2) Flexural failure of connected section. The structural behaviour of the connection including the moment – rotation relation, Load- deflection curve, the yield strength, and ultimate moment capacity of the connections were studied. The main parameters considered in this study were the thickness of flange & web, span and number of bolts.

Keywords: finite element Model, Cold formed, ANSYS, Connection, Bolted, Bearing failure, Flexural failure, moment – rotation relation, Load- deflection curve

I. INTRODUCTION

One of the most exciting developments in structural steelwork during recent years has been the widespread and increasing use of cold-formed members as main structure in the construction of steel framing. Their strength, light weight, versatility, non-combustibility, and ease of production have encouraged architects, engineers, and contractors to use cold-formed steel products which can improve structural function and building performance, and provide aesthetic appeal at lower cost. Common shapes of cold formed steel sections used in structural framing are channels(C-sections), Z-sections, angles, hat sections. In general, the depth of cold-formed individual framing members ranges from 51-305 mm, and thickness of material ranges from 1.2 to about 6.4 mm.

II. APPLICATIONS OF COLD-FORMED STEEL

Cold-formed steel products find extensive application in modern construction in both low-rise and high rise steel buildings.

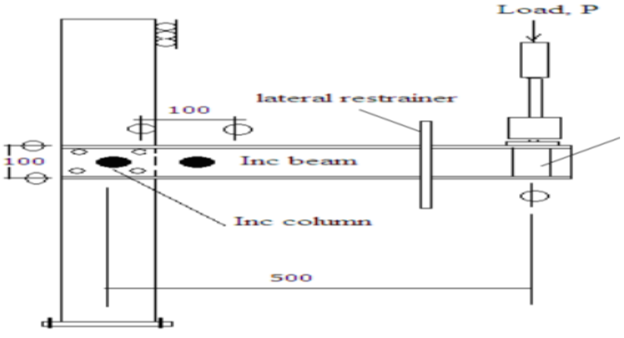
Primary as well as secondary framing members in low-rise construction are fabricated using cold-formed steel sections, while in tall buildings, roof and floor decks, steel joists, wall panels, door and window frames, and sandwich panel partitions built out of cold-formed steel sections have been successfully used.

The main attractions of cold-formed steel sections are their lightness, high strength and stiffness, ease of fabrication and mass production, fast and easy erection and installation, substantial elimination of delays due to weather, more accurate detailing, non-shrinking and non-creeping at ambient temperatures, absence of formwork, protection from termites and rot, uniform quality, economy in transportation and handling, and non-combustibility. The realistic modelling of a steel frame, therefore, requires the use of realistic connection modelling if an accurate response of the frame is to be obtained. The aim of this paper is to present a simple and accurate three dimensional finite element Model (FE) capable of predicting the actual behaviour of beam-to-column joints in steel frame subjected to static loads. The software package ANSYS is used to model the joint. Two experimental tests in the literature were chooses to verify the finite element model. The results of model in literature were compared with analytical model.The beam and column members are formed from single channel sections which are bolted back-to-back at the joint. It is expected that the proposed structure will offer efficient and economic connecting system and further insight on behaviour of single channel sections. *Case A:* The connection test specimens consisted of beam-column sub frame formed by single cold-formed channels with a member thickness of 1.6, 2 & 3.15 mm respectively. For all specimens, bolts grade 8.8 of 12mm & 16 mm diameter were used.Channel sections were connected back to back at the joint as simple and effective means to connect beam to columns in steel constructions as indicated in Figure 1. The applied loads at the loaded points,rotations and deflections of the test specimens were recorded during the tests. Loads are taken from the research work done on literature. With respect to available data, flange width thickness, no of bolts. Lipped and without lipped channel is used to study the structural behaviour.

Revised Manuscript Received on 30 July 2015.
***** Correspondence Author
Sneha Khalate*, P.G. Student, Trinity College of Engineering and Research, Pune, Maharashtra, India.
Sumant Kulkarni, Assistant Prof. of Trinity College of Engineering and Research, Pune, Maharashtra, Pune. India.

III. ACTUAL SPECIMEN LAYOUT FOR BEAM-COLUMN CONNECTIONS

The type of test arrangement employed for the isolated tests in this study was the cantilever arrangement



Modes of failure of the specimens

Mode **BFcsw**: Bearing failure in section web around bolt hole,

Mode **FFcs**: Flexural failure of connected section,

IV. FINITE ELEMENT MODELLING USING ANSYS

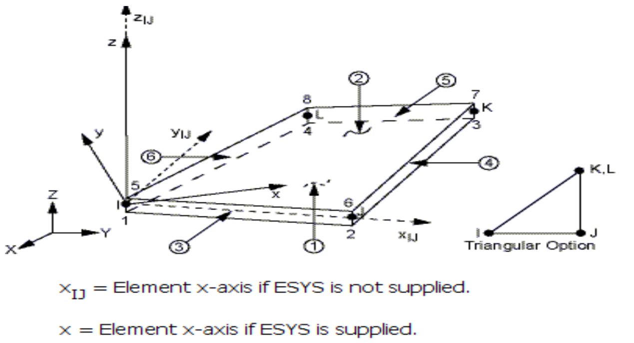
Create two blocks of desired size one vertical and another horizontal by using BLOCK Command. Assign proper element i.e. shell element shell63. SHELL63 has both bending and membrane capabilities. Both in-plane and normal loads are permitted. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes. Stress stiffening and large deflection capabilities are included. A consistent tangent stiffness matrix option is available for use in large deflection (finite rotation) analyses.

ANSYS input: - mp, ex, 1, 203

mp, nuxy,1,0.3

After giving the material properties it is necessary to create proper mesh members with a proper size. Meshing helps the element to break into smaller pieces which can be solved further by using finite element method and proper variation in meshing sizes gives accurate results of stresses, displacement, reactions, bucklingloads etc. Finer the meshing accurate is the result.

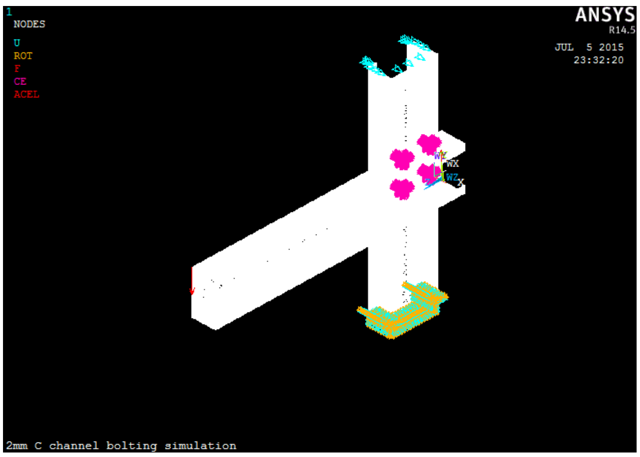
ANSYS input: - esize, 3 amesh, all.



V. 3-D 4-NODE SURFACE-TO-SURFACE CONTACT

CONTA173 Element: CONTA173 is used to represent contact and sliding between 3-D "target" surfaces (TARGE170) and a deformable surface, defined by this element. The element is applicable to 3-D structural and coupled field contact analyses. It has the same geometric characteristics as the solid or shell element face with which it is connected. Contact occurs when the element surface penetrates one of the target segment elements (TARGE170) on a specified target surface.

TARGE170 Element: TARGE170 is used to represent various 3-D "target" surfaces for the associated contact elements (CONTA173, CONTA174, CONTA175, CONTA176, and CONTA177). The contact elements themselves overlay the solid, shell, or line elements describing the boundary of a deformable body and are potentially in contact with the target surface, defined by TARGE170. This target surface is discretized by a set of target segment elements (TARGE170) and is paired with its associated contact surface via a shared real constant set. The target surface can either be rigid or deformable. For modelling rigid-flexible contact, the rigid surface must be represented by a target surface. For flexible-flexible contact, one of the deformable surfaces must be overlayed by a target surface. Proper supports are given using D command. Fixed support is given at bottom and top of column restrained in x direction.After modelling evaluation is done using solve command, and results are obtained.



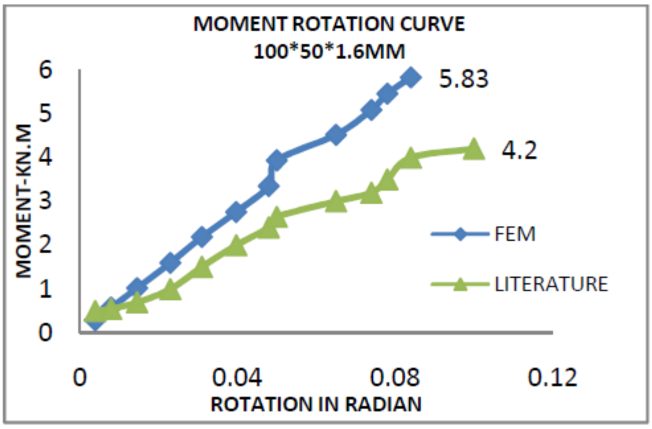
Boundary element model

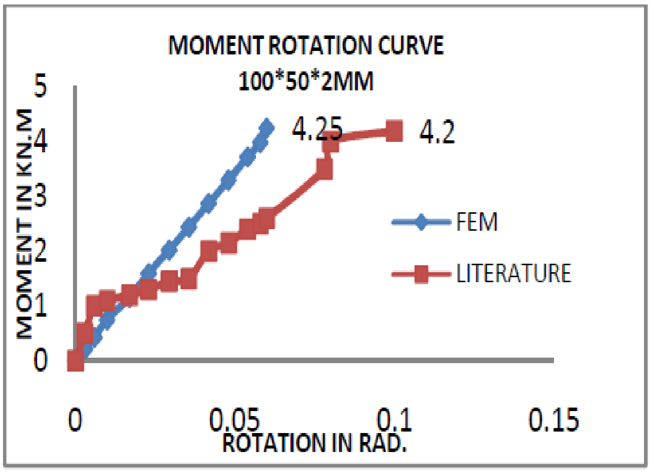
VI. ANALYTICAL RESULTS:

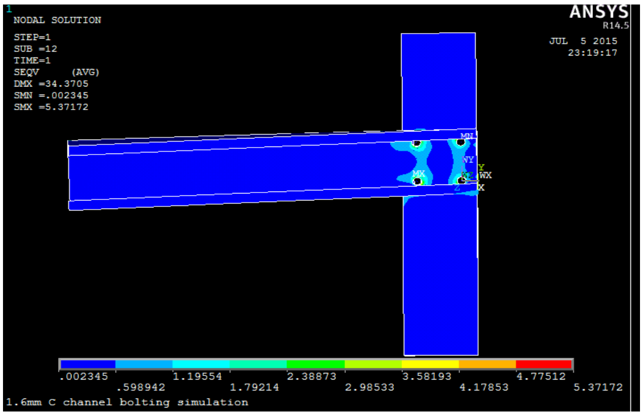
1) Validation of test Results: Experimental tests on beam column connection using single cold formed lipped channel sections with bolted moment connection were carried out by [3]Bayan Anwer Ali, SariffuddinSaad, MohdHanim Osman "Cold-Formed Steel Frame with Bolted Moment Connections." In their study they carried out tests on two specimens 100*50*1.6mm & 100*50*2mm with 15mm lipped sections.Edge distance, e=20mm, Bolts: M8.8

ø16 Pitch- 60 mm

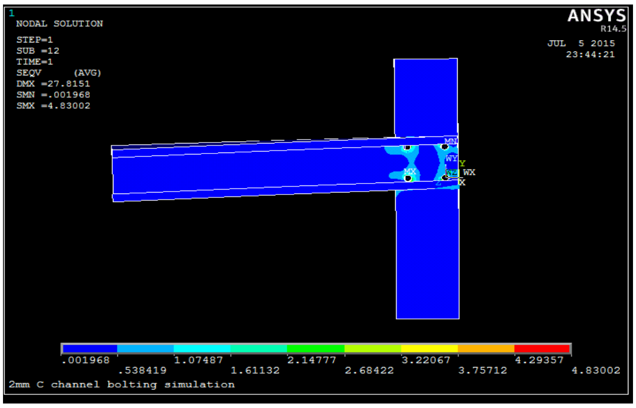
Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)







Von Mies stress diagram (100*50*1.6mm lipped)



Von Mies stress diagram (100*50*2mm lipped)

Moment Rotation curves obtained from the Analytical model. The above graph shows both experimental and analytical model test results along with that model

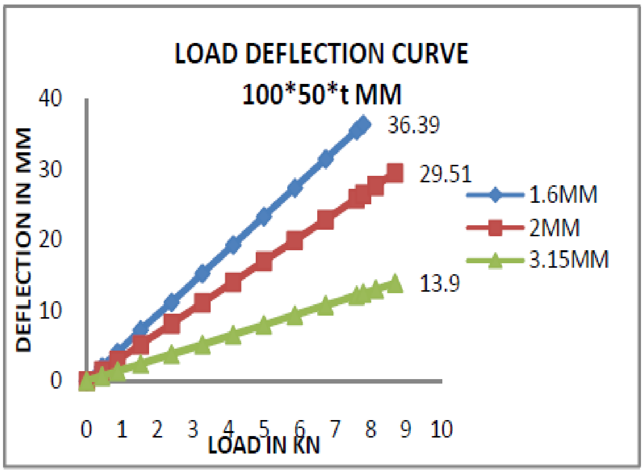
100*50*1.6mm & 2mmchannel Section results are plotted to compare the results.

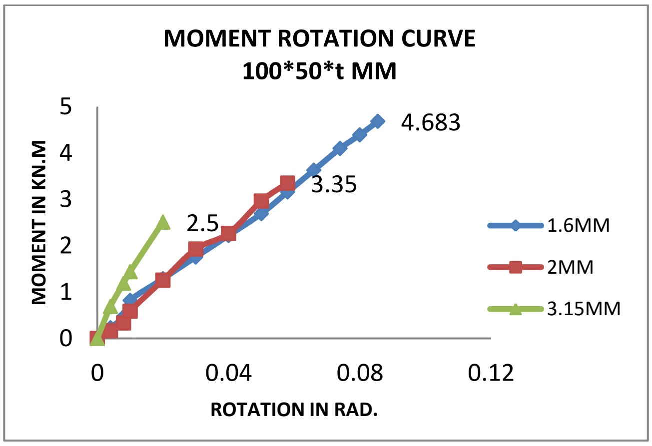
$$\text{Model factor} = \frac{\textit{moment resistance obtained from Finite Element Analysis}}{\textit{Moment Resistance By test}}$$

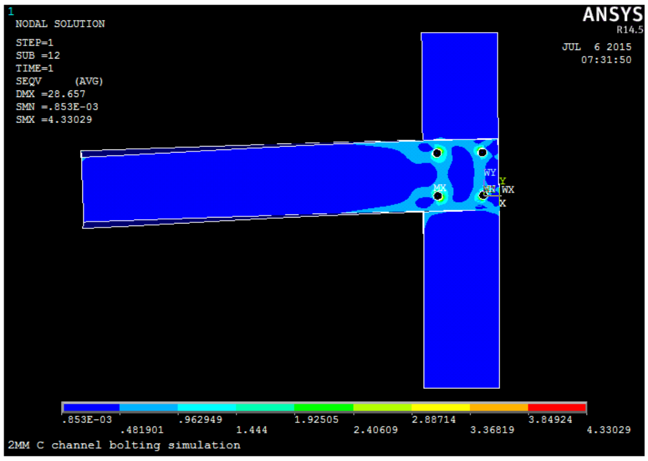
Summary of Test Result:

Section	MR_{exp} (Kn.m)	MR_{FEM} (Kn.m)	Model factor
100*50*1.6mm	4	5.83	1.457
100*50*2 mm	4.2	4.25	1.01

2) Change in thickness & without lipped Channel section







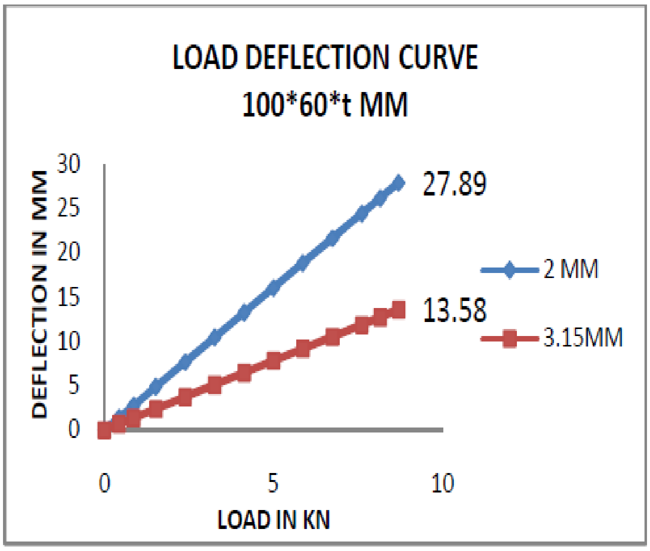
Von Mies stress diagram (100*50*3.15mm)

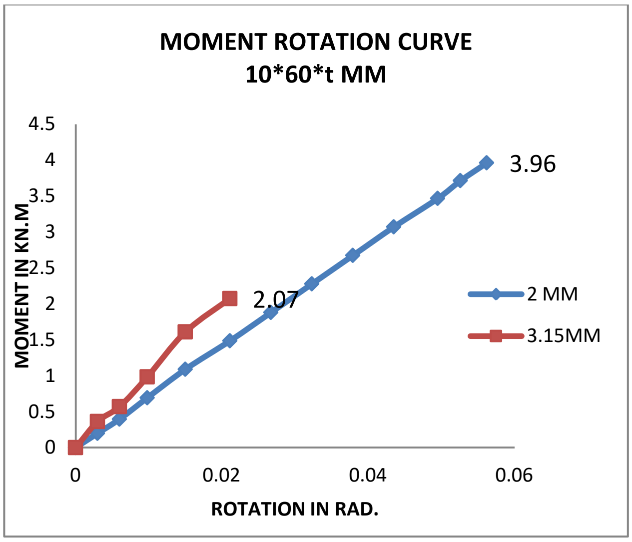
Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

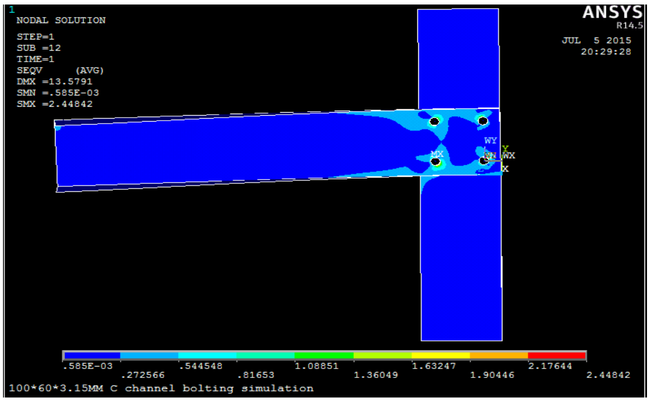
Section	Load kn	Deflection mm	MR_{FEM} Kn.m
100*50*1.6 mm	7.8	36	4.64
100*50*2 mm	8.7	30	2.64
100*50*3.15 mm	8.7	14	2.07

3) Change in Flange Channel section

100*60*2mm
100*60*3.15mm







Von Mies stress diagram(100*60*3.15mm)

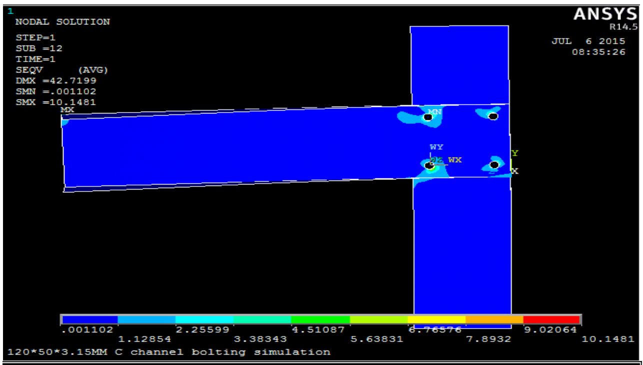
Section	Load kn	Deflection mm	MR_{FEM} Kn.m
100*50*2 mm	8.7	30	2.64
100*50*3.15 mm	8.7	14	2.07

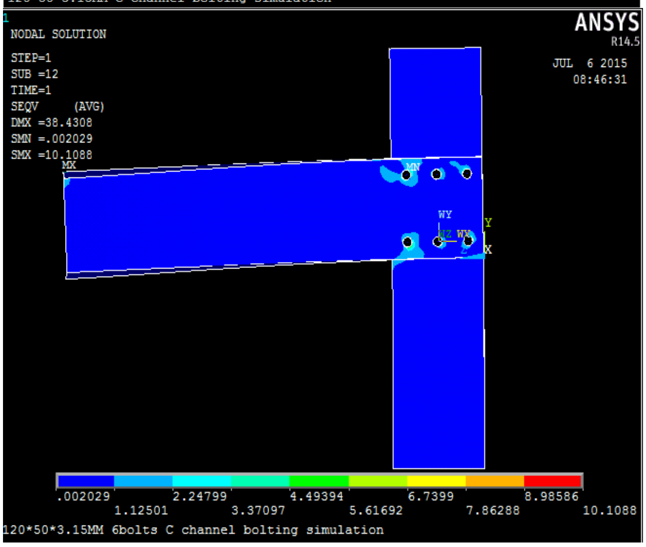
VII. PREDICTION OF ANALYTICAL RESULTS WITH DIFFERENT BOLT ARRANGEMENT

In this Analysis of connections with different bolting arrangement is carried out for particular section. Where numbers of bolts are changed for each case ultimately pitch of bolts are changed with 20mm edge distance. Load deflection and moment rotation curve is plotted.Bolts dia. M8.8 ø 12mm, Nos.

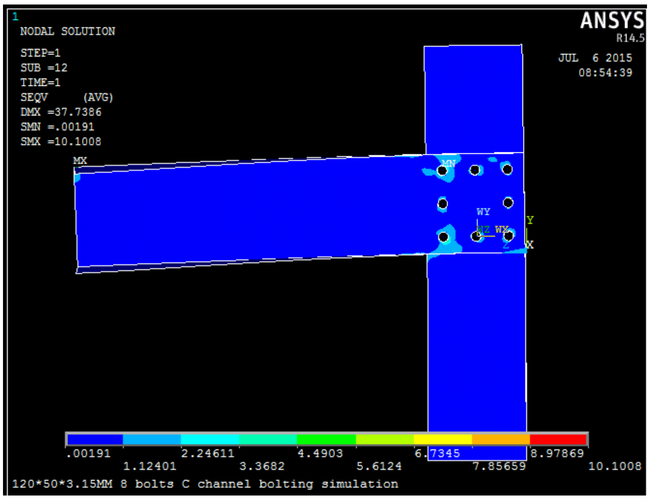
4 nos. – e= 20mm & pitch (p) = 80mm
6 nos. - e = 20mm & pitch (p) = 40 & 80mm
8 nos. – e = 20mm &pitch(p) = 40 mm

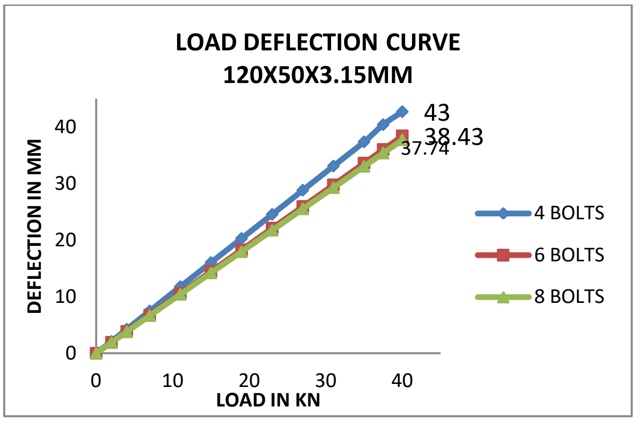
Von Mies stress diagram (120*50*3.15mm)

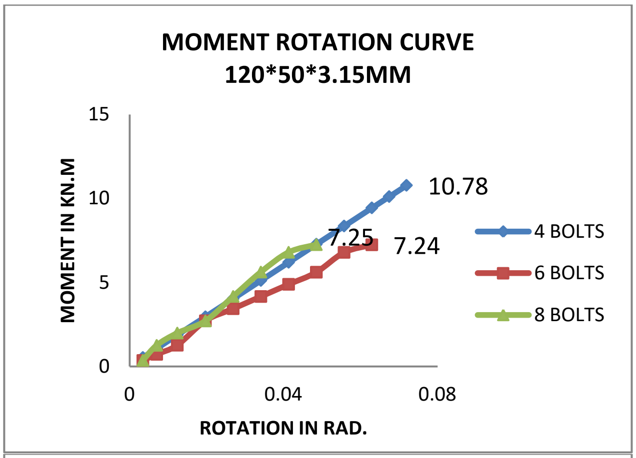


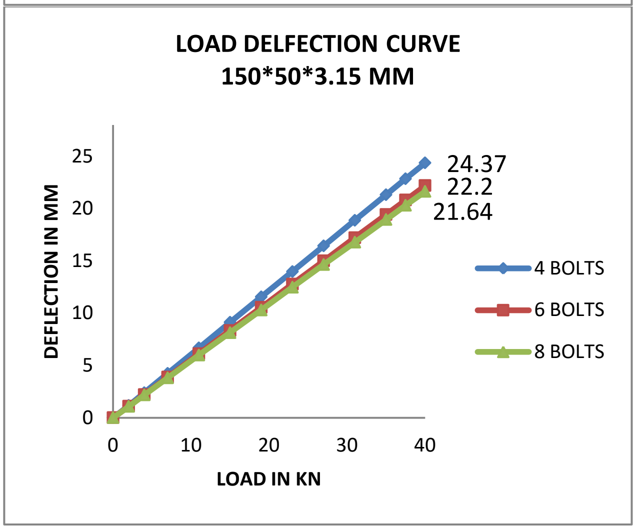


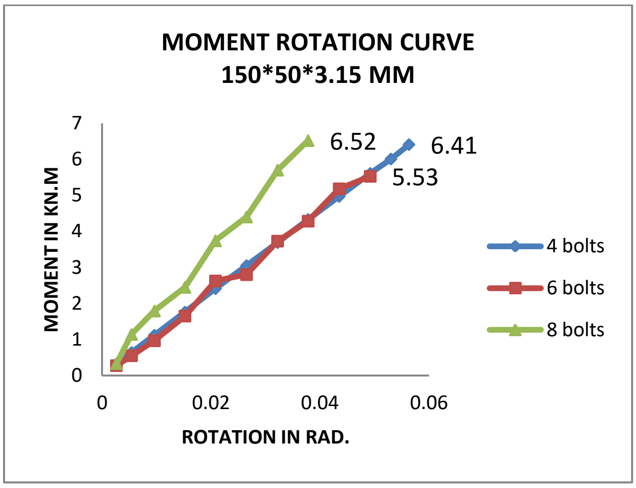
Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)











Summary of Analytical Test Result

Section	Load kn	Deflection mm	MR_{FEM} Kn.m
120*50*3.15 mm (4 bolts)	40	43	10.78
120*50*3.15mm (6 bolts)	40	38	7.24
120*50*3.15mm (8 bolts)	40	37.74	7.24
150*50*3.15mm (4 bolts)	40	24	6.41
150*50*3.15mm (6 bolts)	40	22	5.53
150*50*3.15mm (8 bolts)	40	22	6.52

VIII. CONCLUSION

An analytical study was conducted to investigate the structural performance of cold formed steel frame with bolted moment connection. No. of bolts are also affect the deflection of the system; with increase in nos. it will reduce the deflection of the member. The data of Analytical analysis presented in this paper. Channel Section was connected back to back at joints as simple and effective means to connect beam to column in steel construction. Finite element models developed using ADPL; all the geometrical properties were same as Experimental model from literature review papers. Total 7 nos. of models are prepared based on Experimental model from literature. And 2 model test results are compared with experimental results. Test done by [3]BayanAnwer Ali, SariffuddinSaad, MohdHanim Osman "Cold-Formed Steel Frame with Bolted Moment Connections." For 1.6mm & 2 mm lipped channel section connected back to back has Model factors as 1.457 and 1.01 respectively. From test results we can say that increase in thickness of member causes decrease in deflection. Bolted moment connection are shown to be effective in transmitting moment between the connected section, enabling effective moment framing among cold formed steel structure.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

REFERENCES

1. Bayan Anwer Ali, SariffuddinSaad, MohdHanim Osman, Yusof Ahmad "Finite Element Analysis of Cold-formed Steel Connections"- International Journal of Engineering (IJE), Volume(5),issue(2)2011.
2. Bayan Anwer, SariffuddinSaad and Hanim Osman "Structural Performance of Bolted Moment Connections among Single Cold-Formed Channel Sections"- International Journal of Engineering and Technology Volume 2. No. 4 April 2012.
3. Bayan Anwer Ali, SariffuddinSaad, MohdHanim Osman "Cold-Formed Steel Frame with Bolted Moment Connections"- 2010.
4. Bayan A, Sariffuddin S., Hanim O "Cold formed steel joints and structures" – International Journal of civil and Structural Engineering Volume. 2 No 2, 2011.
5. Tadaharu NAGAO, Tsuyoshi TANAKA, Hisashi NANBA "Performance of beam-column connections in steel structures" – 13th world conference on Earthquake Engineering Vancuver, B.C., Canada Agust1-6, 2004. Paper No. 1235.
6. YanchengCai, Ben young "Structural behaviour of cold formed stainless steel bolted Connections".
7. K.F. Chung, K.H. Ip "Finite element investigation on the structural behaviour of cold formed steel bolted connections" in 2000.
8. P. Manikandan, S. Sukumar and L. S. Naresh"Finite Element Modelling of Cold-formed Beams with Intermediate stiffeners".
9. D. Dubina, A. Stratan, A. Ciutina, L. Fulop, Z. Nagy, "Strength, stiffness and ductility of cold-formed steel bolted connections".
10. Tae Soo KIM, Hitoshi KUWAMURA and Taejun CHO**, "**Prediction of Ultimate Behaviours in Cold-formed Steel Bolted Connection by the Introduction of Initial Geometric Imperfection in FE Modelling"-(ISIJ International, Volume 48(2008). No. 5, pp. 671-680.
11. Syahril Taufik1**, "**Numerical Modelling of Semi-rigid Connection with High Strength Steel" – 2013.
12. Lixin Li, K.S.(Siva) Sivakumaran**, "**Beam – column behaviour of cold-formed steel lipped channel sections".
13. S. Taufik and S.Baharom "Finite Element Model for the Behaviour of Partially Restrained High Strength Web Angle Connections." – Research Journal of Applied Science, engineering & Technology 6(6).
14. M.F.Wong and K.F.Chung, "Experimental investigation of cold-formed steel beam-column sub frames: pilot study" – 15th International specialty Conference on cold-formed steel structures St. Louis, Misssouri U.S.A Oct. 19-20, 2000.
15. K.M.Bajoria, R.S.Talikoti "Determination of flexibility of beam to column connectors used in thin walled cold formed steel pallet racking System".
16. Y.B.Kwon, H.S.Chung, and G.D. Kim "Experiments of Cold Formed Steel Connections and Portal Frames" – Journal of Structural Engineering © ASCE/ April 2006(J. Struct. Eng.2006.132:600-607)
17. ZilvinasBucmys, Gintalšauciuvēnas "The behaviour of Cold Formed steel structure Connection". – Engineering Structures and technologies 5(3) : 113-122.
18. KuldeepKasushik, Avadeshkumar Sharma and Rishi kumar "Modelling and FE analysis of Column to beam endplate bolted connection"- Engineering Solid Mechanics 2 (2013)-51-66.
19. A.Pirmoz "Predicting of /moment rotation behaviour of Bolted Connection using neural Networks".
20. Fattouh M.F. Shaker and Waseem M. AbdElrahrnan "Analytical behaviour of steel Pre-tensioned Bolted connections with flushed and extended end plates under bending". – World Applied Science journal 30(6):673-684-2014(ISSN 1818-4952).
21. Shemys. Babu, S. Sreekumar "A study on ductility of Bolted Beam-Column Connection".- International Journal of Modern Engineering Research (IJMER) Volume 2, Issue 5, Sep. – oct. 2012, pp-3517-3521. ISSN: 2249-6646.
22. KuldeepKaushik, Avadesh k. Sharma, Rishikumar "A Review on finite element analysis of beam to column endplate bolted connection". – ISOR Journal of mechanical & civil Engineering (IOSR-JMCE) e-ISSN: 2320-334X, Volume 8, issue 1(July- Aug. 2013), pp 97-103.
23. Ye ongHueilee, Tahir, and Poi NgianShek – Hindawi Publishing Corporation the scientific World Journal Volume 2014, Article id 951216,11 pages.
24. R. A.laBoube and W.W. Yu "Additional design Considerations for bolted Connection". 13th International Speciality conference on Cold-formed steel Structures St. Louis, Missouri U.S.A, Oct 17-18,1996.
25. Benjamin W. Schafer, A. M.ASCE, Dinar Camotim, "Special issue on Cold formed Steel Structures". – Journal of structural Engineering © ASCE/May 2013/ 637.
26. Tatiana Nazmeeva "Methodology of Experimental research of cold Formed steel Members". – Proceedings of the International Conference 3,Inovative materials, Structures and technologies"
27. (doi: 10.7250/ issconstrs. 2014.18)
28. Jim Butterworth "Finite element Analysis of Structural Steel work beam to Column bolted Connections".
29. S.K. Duggal, " Design of steel structures" the mcgraw-hill companies, 3rd edition
30. Dr. B.C. Punmia, ashokkumarjain, arunkumarjain, "Design of steel structures" laxmi publications(p) ltd., 2nd edition
31. Ramchandra, "Design of steel structure- II"- Edition: 2011.
32. IS: 801-1975 Indian standard code of practice for use of cold-formed light gauge steel structural members in general building construction.
33. BS: 5950-Part 5 British standard institution.1987, structural use of steelwork in building. Part 5. Code of practice for design of cold formed sections.
34. IS 800: 2007 Indian Standard General Construction in Steel – Code of practice

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)