Investigation on Moment Connections in Cold Formed Steel Sections

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ABSTRACT

Now a day's cold formed structural steel tubular sections are being used in many developing countries like Canada, India Hong Kong and Australia. Tubular sections are offering light weight to high strength and width to thickness ratio is very less so as to reduce inertia forces and transport costs. In this paper presents, a brief in investigation on moment connections for typical cold formed steel tubular sections. Beam and column members comprise of hollow rectangular sections. A different moment connections by using stiffener plates and angle sections in different positions of beam-column joint. The safe connection details of frame for single frame are analyzed through FEM software ANSYS. the models are analyzed under 2 point load with different stiffness of welded moment connections. The performance of moment connection frame is evaluated in terms of deformation, Von-Mises stresses and shear stresses.

Keywords: ANSYS, cold formed steel, moment connection, tubular sections, thickness, strength.

1. INTRODUCTION

In steel construction basically two types of structural steel members are used. There are hot-rolled steel and cold formed steel (Fig. 1). Cold formed steel is made by pressing or rolling gauges of sheet steel under room temperature. Cold formed steel members are widely used in bridges, buildings, storage racks, car bodies, railway coaches and agricultural equipments. Cold formed steel is thinner than hot rolled steel. Its thin walled material thickness is 0.37mm to6.35 mm and steel plates and bars thickness is 25 mm.

Fig. 1, hot rolled steel and cold formed steel.

Cold formed steel members have strength -to- weight ratio more compared to hot-rolled steel. Cold formed steel members are easily fabricated in pre engineered buildings, because of economically transportation and easily handling of cold –formed steel (CFS) members. Cold-formed steel members are often has wide structural applications. this sections are reduce dead load compared to constructions. cold formed steel is not susceptible to shrinkage .this material reduce site management cost and storage costs. cold formed steel members are offering durable and sustainable material. Generally in construction industry cold formed structural members are joists, studs, floor decking and built-up sections. In past two decade cold formed steel framed sections like Z and C shapes, roof purlins are practice in steel building industry.

In recent construction industry cold formed steel hollow sections simply called tubular sections (Fig .2) are practiced in all major structural steel design standards like British standard(BS 5950), Australian standard (AS), Canadian standard (CSA). cold formed tubular sections are widely used as columns, beams, truss members and scaffoldings in construction industry. cold formed steel tubular members used in transport industry, agricultural equipments and highway equipments (hand rails and pedestrian bridges). tubular sections were offering structural efficiency and aesthetic solutions.

Fig. 2, tubular sections

Connections are devices which are used to join the elements of structure together at a point such that forces can be transferred between them safely. the majority of fabrication costs are observed by the connections and choice of connection also significant influence on the speed, ease and cost of erection(1). in generally structural connections are two types i.e. shear connections and moment connections.

Moment connections are also called rigid connections. this connections carry a portion or the full moment capacity of the supported member thus preventing any end-rotation of the member. Moment connections are typically designed to also carry the shear component of the load. this connections provide continuity between the supported and supporting members. moment connections are offering Relative rotation between the supporting and supported members is negligible. The flanges of the supported member are attached to either a connection element or directly to the supporting member.

So many Literatures are available for design of moment connections in hot rolled steel sections. However less discussion about the moment connections on cold formed steel tubular sections. tubular section connections are so difficult and uneconomic compare to traditional steel connections. This paper shows better solutions for cold formed steel tubular section with moment connections.

2. REVIEW OF LITERATURE

J.M. Goggins et al.[2]are examines the cyclic performance of axially loaded tubular members used as bracing elements to provide lateral seismic resistance in steel framed structures. An experimental study into the response of members with square and rectangular hollow sections, made from cold-formed steel, is described. Three cross-sectional geometries were employed to represent a range of local and overall slenderness. This specimens are tested out the tensile capacity, initial and post-buckling compressive resistance, ductility capacity, energy dissipation, and mid-length lateral deformations of bracing members. Alireza Bagheri Sabbagh et al[3].are presented the Cyclic behavior of bolted cold-formed steel moment connections. In this paper a Finite Element (FE) procedure is described for simulating hysteretic moment–rotation behavior and failure deformations of bolted cold-formed steel (CFS) moment connections. One of the main challenges in modeling the response of bolted connections is the presence of bolt slip. A series of six beam–column assemblies comprising CFS curved flange beams, a support column and a through plate were tested under cyclic loading. The moment–rotation behavior of the connections was dominated either by flexure in the beams or by bolt slip in the connections.

Ying Qin et al[4]. are presented the experimental seismic behavior of through-diaphragm connections to concrete filled rectangular steel tubular columns. In this paper, four full-scale specimens of existing and proposed through-diaphragm connections to concrete filled rectangular steel tubular columns were tested under cyclic lateral load. The variables in the experiments include the geometry of the through-diaphragm, the configuration of the weld access hole, horizontal stiffeners, and the methods of connecting beam webs to columns. Three failure modes were observed in the test. The strength, stiffness, ductility and energy dissipation capacity were evaluated at different load cycles. It is found that the moment-rotation hysteresis curves are all stable and plentiful and exhibit no obvious strength deterioration or stiffness degradation.

K.F. Chung and K.H. Ip[5] are presented the Finite element investigation on the structural behavior of cold formed steel bolted connections. A finite element model with three-dimensional solid elements established to investigate the bearing failure of cold-formed steel bolted connections under shear. There are demonstrated that the design rule is applicable for bolted connections of both low strength and high strength steels with different ductility limits.

Yeong huei lee et al[6]. are aims to review the previous research on cold-formed steel connections, namely screwed connections, storage rack connections, welded connections and bolted connections. The suitability of these connections in applying into cold-formed steel sections is studied.

3. MODELING

For this modeling, a beam and column members are formed from cold formed tubular rectangular sections. The thickness of each section is 2.5mm. the beam and column dimensions are 100x50x900mm. The member capacity was calculated according to the British Standard BS 5950: Part 1: 2000[7].the regular frame model is shown in below figure. 3. the frames are modeled using ANSYS software. four different models were studied with different types of beam- column end moment connections. for this analysis purposes the frame is assumed to be fixed at the base and two point loading applied on beam of frame (Fig.7). These sections assumed as C-350 grade of cold formed steel .

- Model 1- beam and columns are connected by direct welding as shown in Fig.3 .
- Model 2 - beam and columns are connected by gusset plate as shown in Fig.4.
- Model 3- beam and columns are connected by gusset plate and equal angle sections as shown in Fig.5 .
- Model 4-beam and columns are connected by gusset plate and flange supported haunch plate as shown Fig.6 .

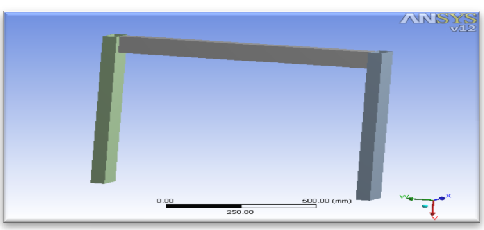


Fig. 3, model-1 `

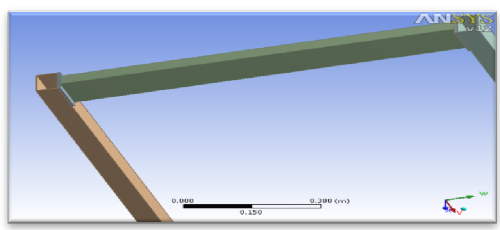


Fig. 4, model-2

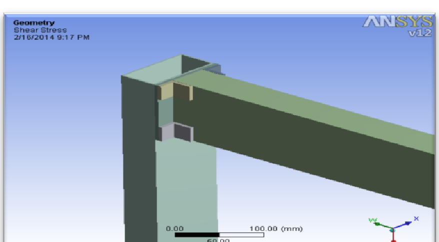


Fig. 5, model-3

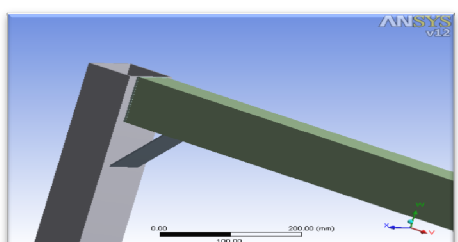


Fig. 6, model-4

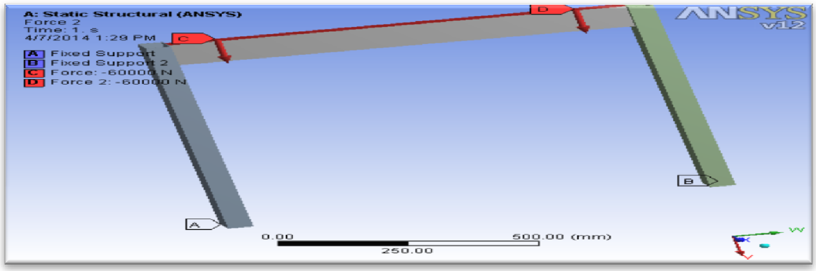


Fig. 7, loading and support conditions.

4. RESULTS AND DISCUSSIONS

Analysis of bare frame model and different types of stiffeners of frame model is done using ANSYS software, from the finite element analysis results obtained, four model results are compared. Deformation and Von- mises stress of all four models are shown in below graphs.

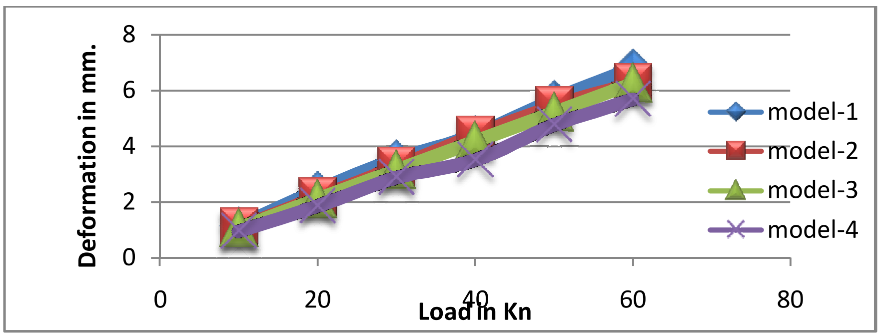


Fig. 8, deformation of all models.

The deformation of bare frame is more at the design load compare to model4. as per code allowable deflection is 3mm .model 4 is allowable range is more than the design load.

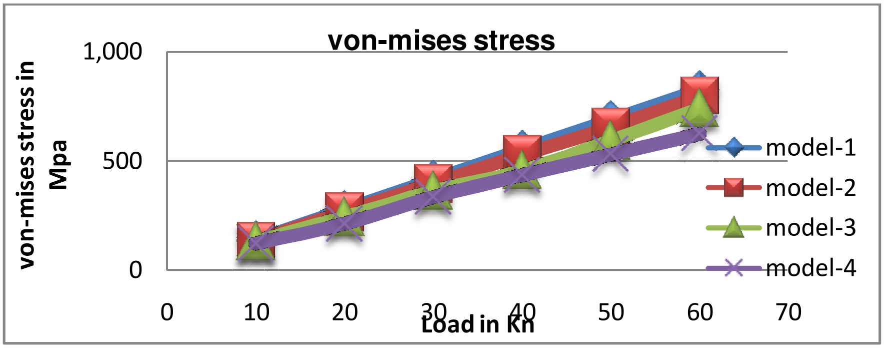
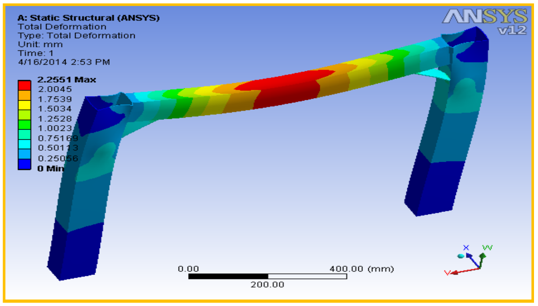


Fig. 9, von- mises stress of all models

the von- mises stress is more important in the design of structural members. this stress should be keep below the yield stress.model3 and model 4 are allowable range at the design loads.

ANSYS results are shown in below figures.



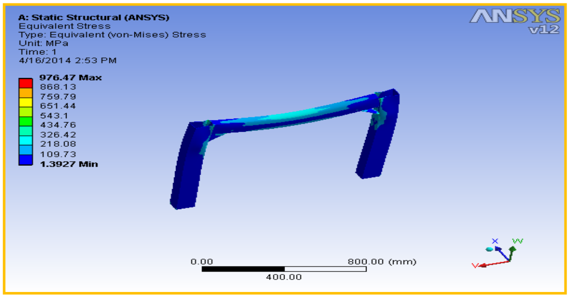


Fig. 10, deformation of model4   **Fig. 11, von-mises stress of model 4**

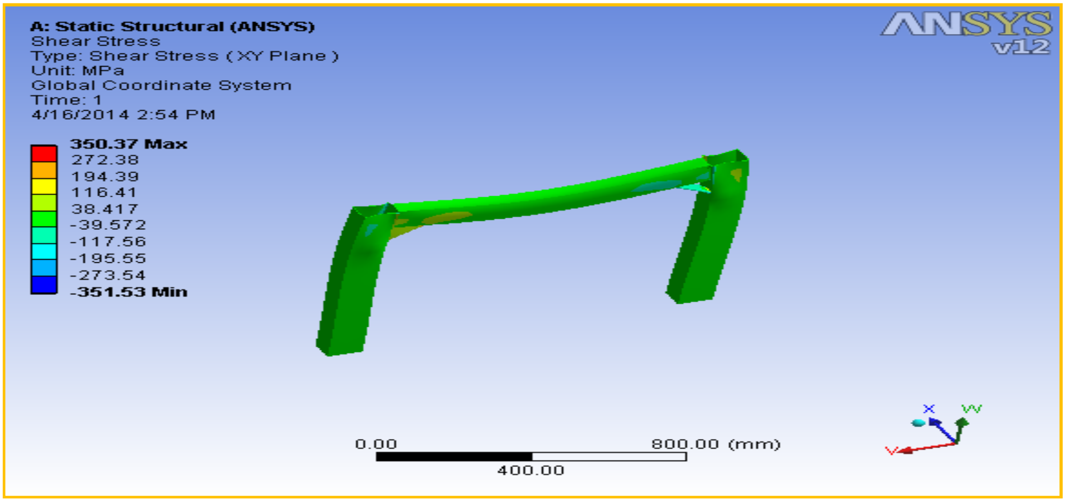


Fig. 12, shear stress of model 4

5. CONCLUSION

- From the above FEM analysis it is observed that the flange supported haunch stiffener type moment connection (model4) has less deformation compare to all other models.
- flange supported haunch stiffener type moment connection safely transfer moment and shear forces, this model controls the von-mises stress.
- By using the suitable connections in beam column joint to utilize the full strength of member capacity, like increase the flexural capacity in beams and compression capacity in columns.

- Engineers are encouraged to build light - weight low to medium rise moment frames build with cold formed steel tubular sections.

REFERENCES

[1] Buick Davison, Graham W.Owens."Steel designers manual".7th edition, Wiley-blackwell, 2012.

[2] J.M. Goggins et al. "*Behaviour of tubular steel members under cyclic axial loading*", Journal of Constructional Steel Research, *Issue 6* April 2005.

[3] Alireza Bagheri Sabbagh et al. " *Cyclic behaviour of bolted cold-formed steel moment connections : FE modelling including slip”* . Journal of Constructional Steel Research, *Issue 2013*.

[4] Ying Qin et al. " *Experimental seismic behavior of through-diaphragm connections to concrete-filled rectangular steel tubular columns"*, Journal of Constructional Steel Research, *Issue 2014.*

[5] K.F. Chung and K.H. Ip " *Finite element investigation on the structural behaviour of coldformedsteel bolted connections*", journal of Engineering Structures, *Issue* 2001.

[6] Yeong Huei Lee et al. " *Review on Cold-formed steel Connections*", UTM Construction Research Centre, Issue 2010.

[7] BS 5950, Structural use of steelwork in buildings, Part 1: Code of practice for design —Rolled and welded sections, London: British Standards Institution, 2000.