IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 5, Issue 4, April 2018

Analytical and Experimental study on the behavior of Cold-formed Steel beam column connections

Ranjitha S[1*], Sattainathan Sharma A[2]

Post Graduate Student, Civil Engineering, Valliammai Engineering College, Chennai, India[1]

Assistant Professor, Civil Engineering, Valliammai Engineering College, Chennai, India[2]

Abstract: Steel is one of the most widely used construction material for structural systems in modern construction. In recent years, Cold Formed Steel (CFS) sections- which is being an another major type of steel sections and found to be an alternative to the familiar Hot rolled steel sections. Cold formed steel sections are used more and more as primary framing components and as secondary structural components that connects the primary structural frames. Higher strength materials and a wider range of structural applications have caused a most important development in cold formed steel relative to the common heavier hot rolled steel structural member section. This paper deals with the study of properties and behaviour of the cold formed steel sections as a primary structural member which has scope for futuristic technology applications. This paper presents the non-linear finite element analysis of steel beam column connections (cold formed section). Hereby it also provides the experimental results of behaviour of the beam-column connections with the bolted joints. Load behaviour on Cold formed structural steel members with different configurations of bolted joints and their failure modes are analysed. The study covers the following elements

- Behaviour of Bolted joint subject to non linear load on I section beam connected to flange and web of I section Column
- Behaviour of Bolted joint subject to non linear load on channel section beam connected to flange and web of channel section Column

Keywords: Cold-formed steel, bolted joints, non-linear analysis, load behaviour.

I. INTRODUCTION

Cold formed steel members are built up sections from the products of steel plate, sheet or strip material at an ambient temperature in order to achieve the desired shapes, so that it can be used to convince the structural and functional requirements. Cold formed steel sections have been extensively used in recent trends due to its varied applications and advantages. Also, these sections are found to be an alternate to hard rolled steel section since it is more effective in high strength to weight ratio. Literature studies reveal that properties of Hot rolled steel sections were more frequently analysed, unlike cold forms.

Cold formed steel sections are light weight material, formed during the process of cold roll, where the sheet stock plate or strip material is fed longitudinally through a series of rolls, each of which works the steel progressively until it reaches the desired shape. Thickness of material that can be formed generally ranges from 0.16mm to 19mm thick and sections with yield strength from 250 to 450 N/mm^2 which are commonly available. Cold formed steel structures has its benefits like build ability, strong and light weight, design flexibility, safety, speed, quality and recyclable etc., Thin sheet steel products are extensively used in building industry, and range from purlins to roof sheeting and floor decking. Generally these are available for use as basic building elements for assembly at site or as prefabricated frames or panels. These thin steel sections are cold-formed, the manufacturing process of these thin sheets involves forming steel sections in cold state at room temperature (i.e. without application of heat) from steel sheets of uniform thickness. These are given the generic title **Cold Formed Steel Sections.** Sometimes these sheets are also referred as **Light Gauge Steel Sections** or **Cold Rolled Steel Sections**. The steel sheet used in cold formed construction is usually varies from 1 to 3 mm thick. For some particular application much thicker material i.e.,up to 8mm can be formed if pre-galvanised material is not required for the particular application. It must be noted that the method of manufacturing as it differentiates these products from hot rolled steel sections. Normally, the yield strength of steel sheets used in cold formed sections is at least 230 to 280N/mm^2.

During the First World War, the cold rolled products manufactured by cold-forming or press braking were developed and their extensive use worldwide has grown only during the recent 20 years because of their versatility and suitability for a range of lighter load bearing applications and also these sections give cheer for the strength, sustainability and cost efficiency. The wide range of available cold-formed steel products has extended their use to primary beams, floor units, rooftrusses and building frames. Indeed it is difficult to think of any industry in which Cold Rolled Steel products do not exist in one form or the other. More than building industry, they are manipulated in motor vehicles, railways,

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 5, Issue 4, April 2018

aircrafts, ships, agricultural machinery, electrical equipment, storage racks, house hold appliances and so on. In recent years, with the progression of attractive coatings and the distinctive profiles that can be manufactured, cold formed steel construction has been used for highly pleasing designs in practically every sector of building construction.

In general, cold formed structural members are used as secondary members as they connect the primary structural members in building constructions through mechanical fasteners. Connections are the physical components which mechanically fasten the structural elements and these fasteners are important in transferring force and moment from structural top member to the supporting element. Structural joints can be classified into several categories by referring to its strength and stiffness. Cold formed steel fasteners has a variety of joint elements used either by screws or bolted connection or welded connections or storage rack connection etc., The contribution of each component from the developed joints should be identified to achieve more reliable structural behavior.In steel structures, moment resisting steel frames are highly regarded for their seismic performance. This regard is based on their ductility and inelastic performance, since inelastic deformation is used to dissipate energy during major earthquakes. This dissipation of energy is predominantly required in the connections like beam column joints. The internal forces and moments produced in these connections influence the behaviour of the overall structures. Cold formed steel structures are tend to be very slender on compared with the hot rolled steel, it is expected that deformation and stiffness will often be significant in this type of steel sections.

In early 90s, detailed design standards and procedures for hot-rolled steel were incorporated but these standards were not applicable to cold formed sections due of their relatively thin steel walls which were susceptible to buckling and guidelines for connections are limited to their fundamental behaviour. Unlike, hot rolled steel sections précised design procedures are not common for cold formed section joint due to their wide variance and specific purpose and most design are made based on testing results Cold formed steel members uphold a constant thickness around their cross section, where tapering or fillets are hot-rolled shapes typically exhibited by hot-rolled shapes since, the material has ease practicable and it could be deformed into many possible shapes Cold formed steel allows for shapes which differed greatly from the classical hot rolled shapes. The strength characteristics of the section has created a significant changes by even a small variation appears in the geometry created and there is need to establish some minimum requirements and laws to control the buckling and strength characteristics. The application of cold-formed steel in light steel framing design can serve as an alternative for industrialized building system, by extending steelwork construction into residential housing. There is a lack of in-depth study on the joints behaviour in cold-formed steel frames, particularly the beam-to column connection. Four specimens with isolated bolt joint configuration and steel angle were tested. The experimental setup, procedures and failure modes of the joints are discussed in detail. As many research have been carried out and significance of cold formed section is concerned. The aim of this paper is to collect data on the behaviour of **Cold Formed Beam Column Connections** with different **Types of Joints** compared with experimental datas and analytical datas-by finite element modeling technique.

II. SECTIONAL AND MATERIAL SPECIFICATIONS

The section are selected from is 811-1987 specification for cold formed light gauge steel sections. Beam and Column are in symmetrical in both **I** section and **CHANNEL** section. Width of top and bottom flange is 150mm, depth of web is 150 mm, length of beam is 800mm and length of column is 1000mm and thickness is 2.5mm.

Similarly, both the beam and columns are of symmetrical channel sections with width of top and bottom flange is 75mm, depth of web is 150mm, length of beam and column are 800mm & 1000mm respectively.

The thickness is of 2.5mm.
Yield strength of steel sections is $f_y = 230N/mm^2$
Poisson ratio is 0.3
Four models was created using bolt joint connections for analytical model where one set of I section and CHANNEL section are connected to the flange portion of the column and the other set of models are connected to the web portion of the column.

III. NUMERICAL ANALYSIS

The numerical analysis has been carried out by a software namely ABAQUS -suite for finite element modelling and computer aided engineering. *Abaqus/CAE*(Computer Aided Engineering*)* is a software application used for both the modeling and analysis of mechanical components and assemblies (pre-processing) and visualizing the finite element analysis result. A subset of Abaqus/CAE also includes the post-processing module comes after the solver module. The software post processed module Visualization is shown in the below figures for both the I section and Channel section Beam connected to the Column of the similar sections with the variation in the connection (i.e.,) in the Flange and Web

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 5, Issue 4, April 2018

portion by the bolted joints. The figures 1,2,3&4 respectively shows the deformed pattern of the model specimen under loaded condition

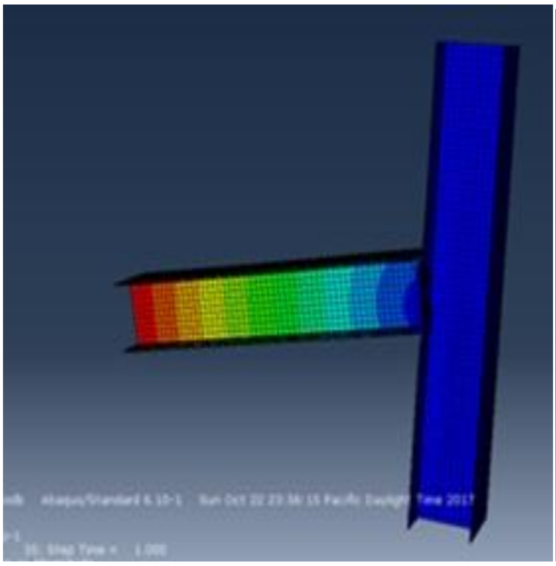

Fig 1 I section- Flange connection

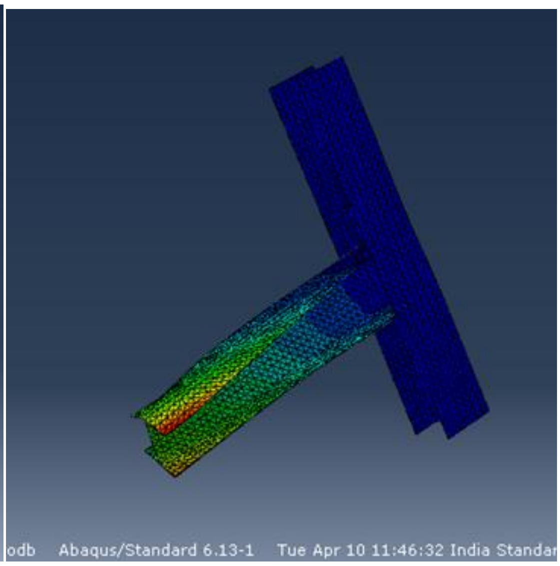

Fig 2 I section- Web connection

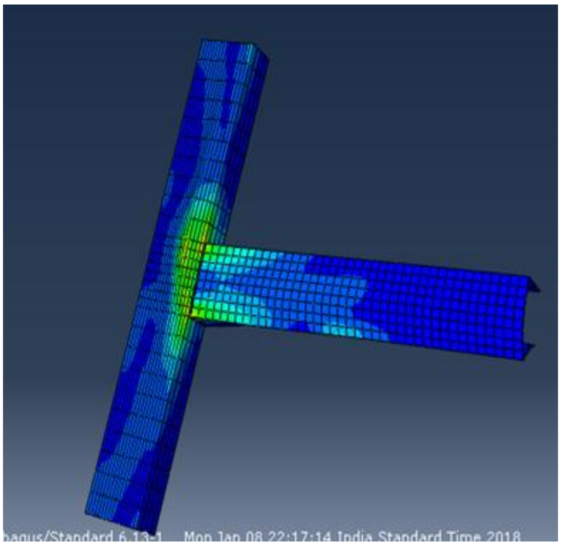

Fig 3 Channel section- Flange connection

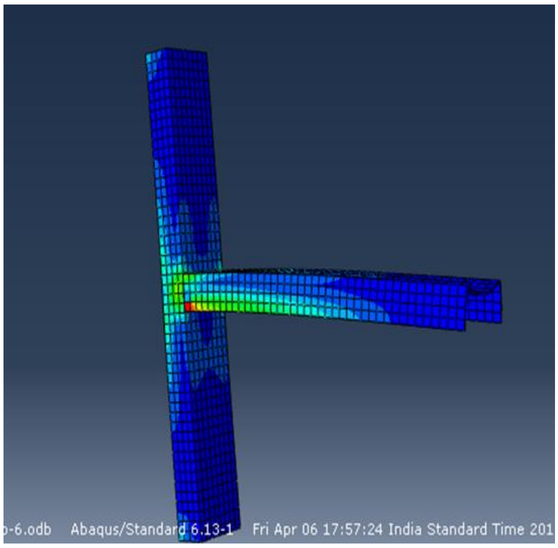

Fig 4 Channel section- Web connection

Table 1 Analytical Result values for beam column connection

Specimens- Bolted joints		**Ultimate load (kN)**
I section	*Flange connection*	15
	Web connection	18
CHANNEL section	*Flange connection*	11
	Web connection	14

IV. EXPERIMENTAL INVESTIGATIONS

The structural behaviour of cold formed steel sections construction with bolted connections is somewhat different from that in hot rolled steel construction. This is mainly due to the thinness of the connected parts of the cold form steel sections and this thinness may dictate the strength of joints assembly. The bolted connections are referred to as Concentric connections,(force transfer in tension and compression member), Eccentric connections, (in reaction transferring brackets) or Moment resisting connection,(in beam to column connection in frames). The use of bolts and

Copyright to IARJSET
DOI 10.17148/IARJSET.2018.5420

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 5, Issue 4, April 2018

angles can eliminate the dependence on welding works in production of joints for steel structures. The bolted connection can be formed into three types, namely Web-cleat Connection (WC), Flange-cleat Connection (FC) and combined Flange-Web-cleat Connection (FWC).

The Beam Column connection act as a Cantilever section where the loading is being at some specified distant from the end of beam. Here in all the cases, combined Flange Web-cleat connection are provided. The figures 5&6 shows the I section and Channel section specimens being tested. And the tested result values are shown in the table 2.

(a) (b)

Fig 5 Experimental test setup Beam-Column specimens- I section (a) Web connection, (b) Flange connection.

(a) (b)

Fig 6 Experimental test setup Beam-Column specimens- Channel section (a) Web connection, (b) Flange connection.

Table 2 Experimental results for Bolted joint Beam column connections

SPECIMEN TYPES	Load (kN)	Deflection (mm)	Stress (N/mm^2)	Strain	Moment (kN.m)	Rotation (rad)
I section-Flange connection	16	34.75	1086.2	0.0343	12.8	0.00396
I section-Web connection	23	54.85	1493.80	0.0685	17.6	0.0074
Channel section-Flange connection	14	35.47	1554.044	0.0443	11.2	0.0077
Channel section-Web connection	19	48.42	2220.64	0.06252	16	0.0110

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 5, Issue 4, April 2018

V. RESULT AND DISCUSSION

The load carrying capacity of beam-column connection of both I section and Channel section in web portion shows higher result values than of connection in flange portion. The figure 7 shows load carrying capacity of all the specified combination of sections and connections. The figure 8 shows proportionaly linear load and deflection properties in all the specified sections. I-F-B and I-W-B withstand more load and inturn higher deflection. But C-F-B and C-W-B attain failure with lesser load and deflection. The figure 9 shows directly proportional stress and strain values in all the specified section under transverse loading. The stress and strain behaviour is similar in all the combinations. Moment refers to the tendency of a force to move or rotate an object at an axis through a point. It is the perpendicular distance from the point of rotation to the force's line of action. In all the combination of Bolted joints, the moment and rotation curve shows a linear pattern curve with an incremental loading as shown in figure 10.

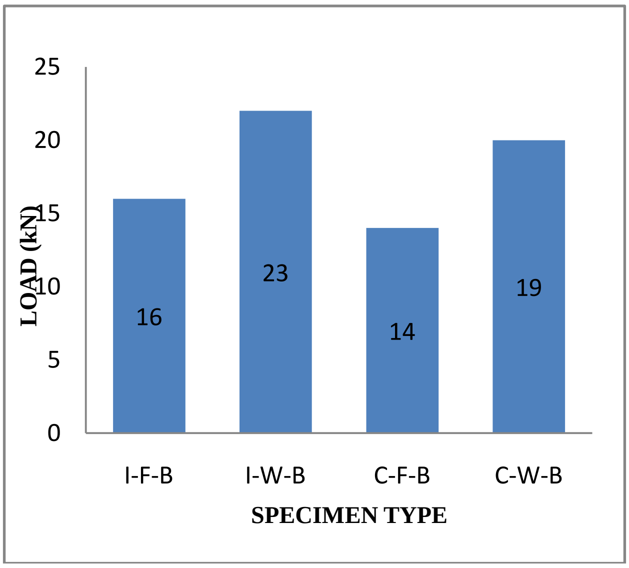

Fig 7 Load Carrying capacity

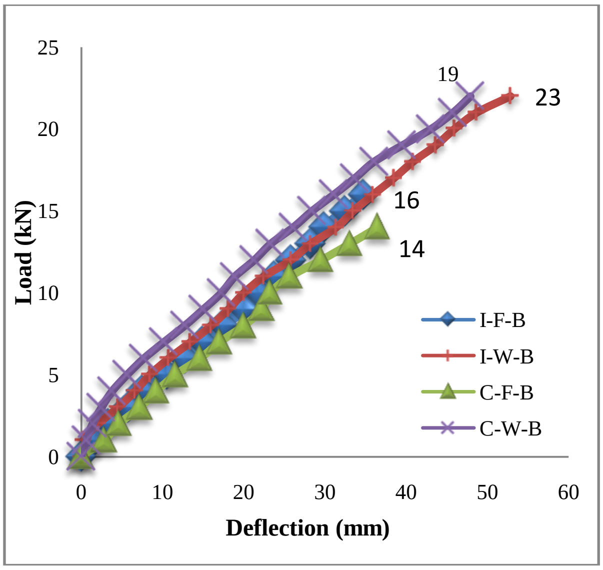

Fig 8 Load- Deflection curve

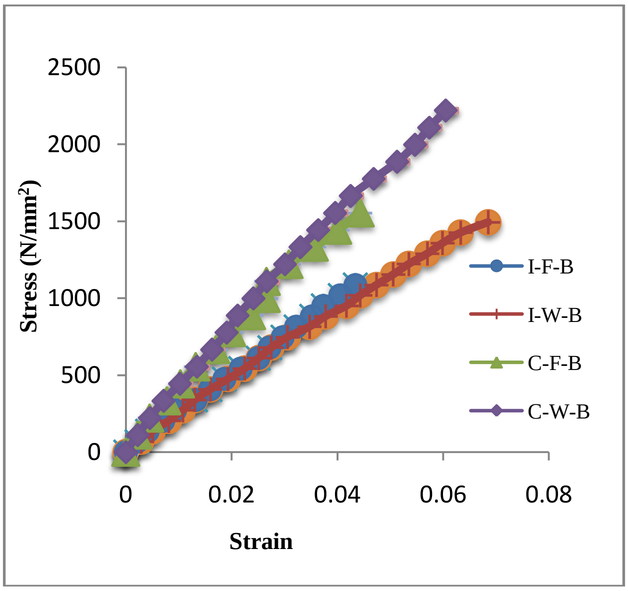

Fig 9 Stress- Strain curve

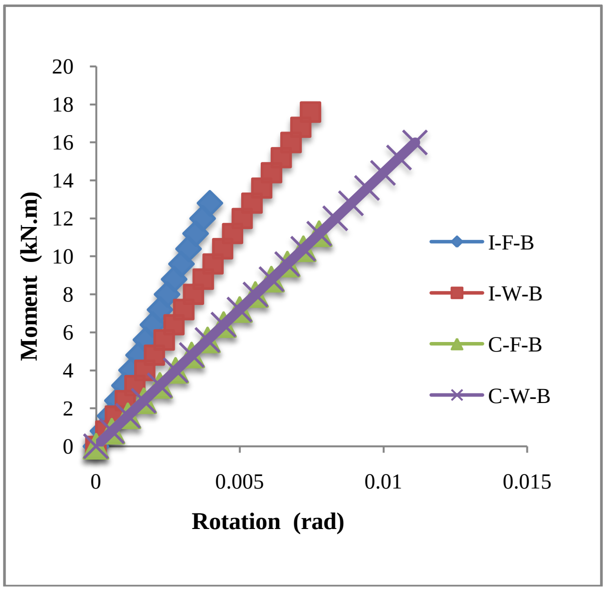

Fig 10 Moment- Rotation curve

Note:

I-F-B I section-Flange connection-Bolted joint
I-W-B I section- Web connection- Bolted joint
C-F-B Channel section-Flange connection- Bolted joint
C-W-W Channel section-Web connection-Bolted joint

There has been a 16.66 and 21.42 percentage rise for I section and Channel section respectively for the beam that has been connected to the Web portion of the column than of Beam connected to the Flange portion of the column. And there has been a 22.22 percentage rise for I section than of Channel section by means of the analytical result values.
There has been a 30.43 and 26.31 percentage rise for I section and Channel section respectively for the beam that has been connected to the Web portion of the column than of Beam connected to the Flange portion of the column. And there has been a 17.39 percentage rise for I section than of Channel section by means of the Experimental test result values.

VI. CONCLUSION

An analytical and experimental study was conducted to investigate the structural performance of cold formed steel beam column connections with the bolted joints for the two types sections i.e., I section and Channel section and the connection id done at the flange and web portion of the column for type of sections. From the analysis it is evident that I-section is behaving dominantly in withstanding axial load over CHANNEL section. further, this implies the advantage of having bolted joint in light weight steel structures. Furthermore, the experimental study also proves that I section is behaving dominantly in withstanding axial load over Channel section and also implies the advantage of having bolted joint in light weight structure.

The study also shows that flexural member being connected by the joints at the web portion of the compression member has a greater impact in the structural behavior under loaded condition. The percentage rise values for both the sections show the deviated percentage values under the loaded condition that the specimens withstands. Further, the stiffness and ductility factor values can also be derived and the results for the best sections can be adopted.

REFERENCES

1. Anna green Antony, Journal of *"Cold formed steel sigma section joints"* International journal of innovative research in technology, volume *3-2*016.
2. Bayan Anwar ali, sariffudin said, Mondhanim Osman, Journal of *"Cold formed steel frame with bolted moment connections"* International journal of civil and structural engineering, volume 1 - 2010.
3. Cher Siang Tan, Mohamood Md Tahir, Muhammad Lawan, Journal of *" Experimental Investigation of Bolted Angle Joints for Cold-formed Steel with Double Channel sections"* International Journal of Structural Analysis &Design- IJSAD - 2015
4. K.F. Chung, L. Lau, Journal of *"Experimental investigation on bolted moment connections among cold formed steel members"* Engineering structures – 1999.
5. M. Dundu, Journal of *"Base connections of single cold-formed steel portal frames"* Journal of construction steel research - 2012.
6. Ibrahim Elkersh, Journal of *" Experimental investigation of bolted cold formed steel frame apex connections under pure moment"* Ain shams engineering journal – 2010.
7. M.F.Wong, K.F.Chung, *"structural behaviour of bolted moment connections in cold-formed steel beam-column sub-frames"*
8. Xian zhong Zhao, Tuo Wang, Yiyi Chen, K.S. Sivakumaran, Journal of *"Flexural behaviour of steel storage rack beam-to-upright connections"* the scientific world journal- 2014.
9. W.K. Yu, K.F.Chung, M.F.Wong, Journal of *"Analysis of bolted moment connections in cold formed steel beam-column sub-frames"* Journal of constructional steel research - 2005.
10. Yeong Huei Lee, Cher Siang Tan, Shahrin Mohammad, Mahmood Md Tahir, and Poi Ngian Shek, Journal of *"Review on Cold-Formed Steel Connections"* The scientific world journal – 2014.
11. F. Zadanfarrokh, E. R. Bryan, Journal of *"Testing and Design of Bolted Connections in Cold formed Steel Sections"* International speciality conference on cold-formed steel structures – 1992.
12. Zilvinas Bucmysa, Alfonsas Daniunasb, Journal of *"Component method in the strength evaluation of cold-formed steel joints"*Modern building materials,structures and techniques – 2017.