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A study on the behavior of Cold-formed Steelsections beam column connections

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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 welded joints and their failure modes are analysed. The study covers the following elements*

- *Behaviour of Welded joint subject to non-linear load on I section beam connected to flange and web of I section Column*
- *Behaviour of Welded joint subject to nonlinear load on channel section beam connected to flange and webof channel section Column*

KEYWORDS: cold-formed steel, welded joints, non-linear analysis, load behaviour.

I. INTRODUCTION

Cold -formed steel is that common term for product created by rolling or pressing steel into semi-finished or finished merchandise at comparatively low temperatures (cold working). Cold formed steel merchandise square measure created by the operating of steel billets, bar, or sheet exploitation stamping, rolling (including roll forming), or presses to deform it into a usable product. Cold- worked steel product, like cold-rolled steel bar stock and sheet, square measure unremarkably employed in all areas of producing of consumer durables, like appliances or vehicles, however the phrase cold-formed steel is most prevalently accustomed delineated construction materials. The fabric thickness for such thin-walled steel members sometimes varies from 0.0147 in. (0.373 mm) to concerning ¼ in. (6.35mm).Cold formed steel members are built up sections from the products of steel plate, sheet or strip material at an ambient Steel sections are the bread and butter of steel fabrication. Designers, architects and engineers choose different sections for their aesthetics and structural qualities-their choices determined by size, weight and profile. Steel is extremely versatile and can be moulded to many different shapes. This means fabricators like steel fabrication services can fashion steel into to almost any shape or size, however this caries a premium. On the other hand there are many common steel section that you will see used throughout steel construction and fabrication, and would have come across in structures every day. Cold-formed steel starts with the production of raw steel, which is made by combining iron ore or steel scrap with small amounts of carbon in a Basic Oxygen Furnace (BOF) or Electric Arc Furnace (EAF) In the steel finishing process, the hot band is reduced once again into “cold rolled steel.” A protective coating of zinc is then added through the galvanization process. The final product is called a “coil.” To convert coils into cold-formed steel framing members, they are first slit into widths that match the intended dimensions of the final product. The slit coils of cold-formed steel are formed into C-sections and other shapes usually by roll forming the steel through a series of dies. No heat is required to form the shapes (unlike hot-rolled steel), and thus the name cold-formed steel. A variety of steel thickness is available to meet a wide range of structural and non-structural applications. The cold-formed steel framing materials are then either used to build wall and floor panels, and roof trusses, or delivered to the job site in bundles. The system bestowed here in is wide used, particularly in lightweight truss structures; but, there aren’t any normal style procedures specific for the planning of this structural part.

Cold forming steel framing is made from strips of structural quality sheet steel are fed through roll forming machines with a series of dies that progressively shape into C-shaped sections, or formed into a variety of other shapes, including ‘U’, ‘Z’ , and even hat shaped sections, to meet the requirements of specific applications. An I shaped section is also known as H shape section and it is known as an universal sections. These have two horizontal elements, the flanges, with vertical elements as a web. The web is capable of resisting shear forces, while the horizontal flanges resist most of the beam's bending movement. The I shape is very effective at carrying shear and bending loads in the web's plane. The construction industry widely uses I shaped sections in a variety of sizes both as a beam and column structural member. The Structural channel also known as C-sections, which as a C-shaped cross section. Channels have top and bottom flanges, with a web connecting them. C-shaped sections are cost effective solutions for short to medium span structures. Channel or C–beams are often used where the flat, back side of the web can be mounted to another flat surface for maximum contact area. These are sometimes welded together back-back to form a non-standard I- section shapes structural members. Channel sections were originally designed for bridges, but are popular for use in marine piers and other short span structures.

In general, cold formed structural members are used as secondary members in building constructions and they are connected to primary structural members through mechanical fasteners depending on the connection configuration. 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. Connections are structural elements used for joining different members of a structural steel frame work. Steel structure is an assemblage of different member such as "Beams, Columns" which are connected to one other, usually at member ends fasteners, so that it shows a single composite unit.

The structural behavior of cold formed steel sections construction with connection types 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. 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 weld joint configuration were tested. The experimental setup, procedures and failure modes of the joints are discussed in detail. As many researches have been carried out and significance of cold formed section is concerned. The aim of this paper is to collect data on the behavior of Cold Formed Beam Column Connections with weldtypes of Joints compared with experimental data's and analytical data's-by finite element modeling technique(ABAQUS CAE).

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 150mm, 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 weld 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 welding is the process of joining the metals by creating a strong metallurgical bond between them by heating pressure or both. Weld fasteners are ideal for applications which require a threaded fastener that is more sturdily attached to a sheet metal surfaces than a self-clinching fastener, rivet or rivet nut. Weld fasteners can be utilized in light, medium or heavy industrial manufacturing to produce everything from trailers and conveyors to sub-assemblies, framework, weldments, architectural components and more. Shop welding is preferred over field welding. Welded structures are lighter structure due to the absence of making holes for fasteners, connecting angles etc., and it makes the welding process quicker. This type joints is more adaptable than bolting or riveting. Welded connections are watertight and airtight .hence there is less danger of corrosion of steel structures. The weld connection testing for I-section and Channel section is shown in below Figure 1,2,3&4 respectively For both I Section and Channel section the beam is connected to the flange portion and Web portion of the column. 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 portion by the welded joints.

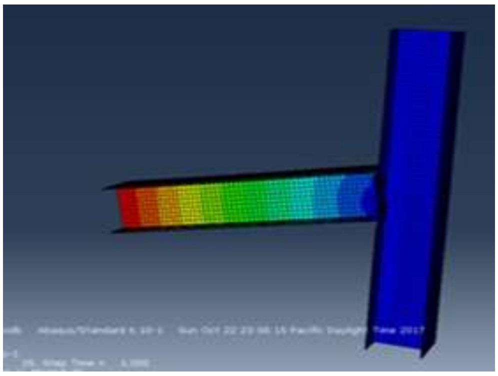

Fig 1 I section- Flange connection

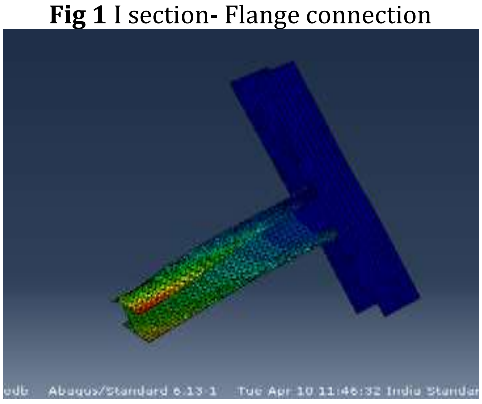

Fig 2 I section- Web connection

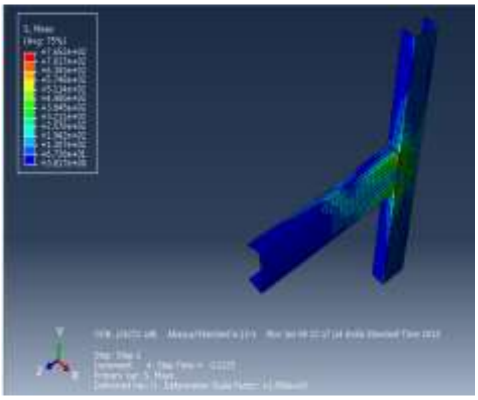

Fig 3 Channel section- Flange connection

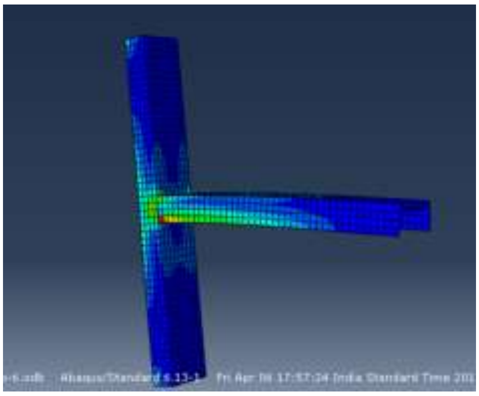

Fig 4 Channel section- Web connection

Table 1 Analytical Result values for beam column connection

Specimens- Bolted joints		**Ultimate load (kN)**
I section	*Flange connection*	18
	Web connection	23
CHANNEL section	*Flange connection*	8
	Web connection	15

IV EXPERIMENTAL INVESTIGATIONS

Connections are the glue that holds a steel structure together. Most major structure failures have been due to some sort of connection failure. Connectionsdepend on type of loading, strength and stiffness, economy, difficulty or ease of erection. Most connections have the connecting material (plates, angles,..) attached to one member in the fabrication shop and to the other members in the field. It is a common practice to Weld shop attachments and to Bolt field attachments. The cumulative rotational capacity of the moment connections is affected by welding procedures, steel materials, and details. The welding procedures have an important role for ductility.

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 Welded joint Beam column connections

SPECIMEN TYPES	Load (kN)	Deflection (mm)	Stress (N/mm^2)	Strain	Moment (kN.m)	Rotation (rad)
I section-Flange connection	18	44.23	1290.104	0.05529	15.2	0.00645
I section-Web connection	21	34.27	1358.0037	0.04284	16	0.00679
Channel section-Flange connection	7	13.5	7777.022	0.01687	5.6	0.00388
Channel section-Web connection	13	20.13	1443.04	0.02516	10.4	0.00721

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 8shows proportionaly linear load and deflection properties in all the specified sections. I-F-W and I-W-W withstand more load and inturn higher deflection. But C-F-W and C-W-W 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.Momen**t**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 Welded joints, the moment and rotation curve shows a linear pattern curve with an incremental loading as shown in figure 10.

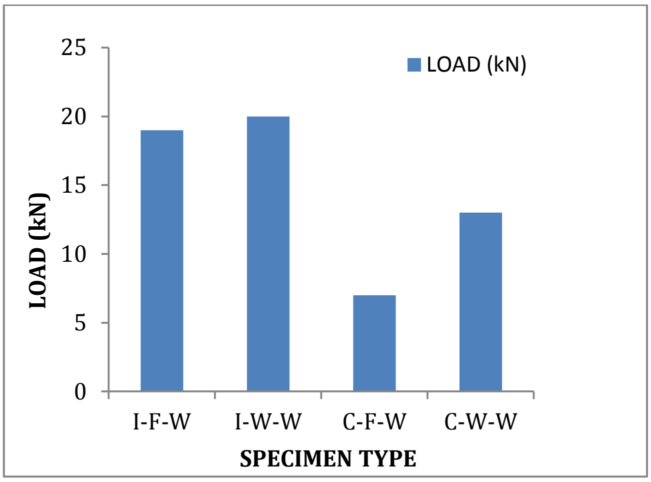

Fig 7 Load Carrying capacity

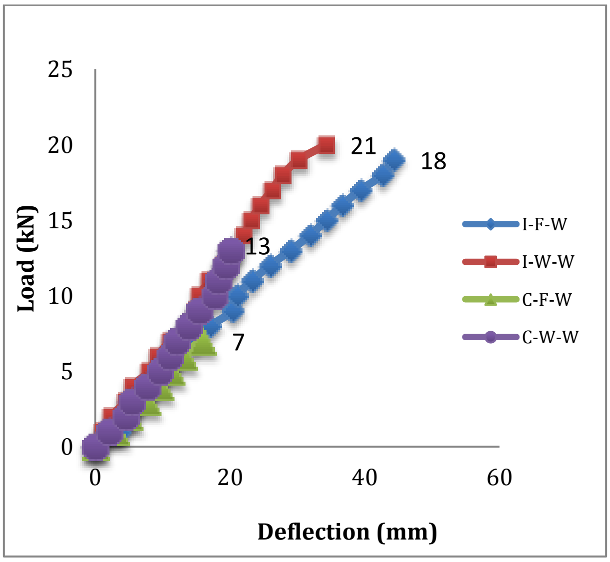

Fig 8 Load- Deflection curve

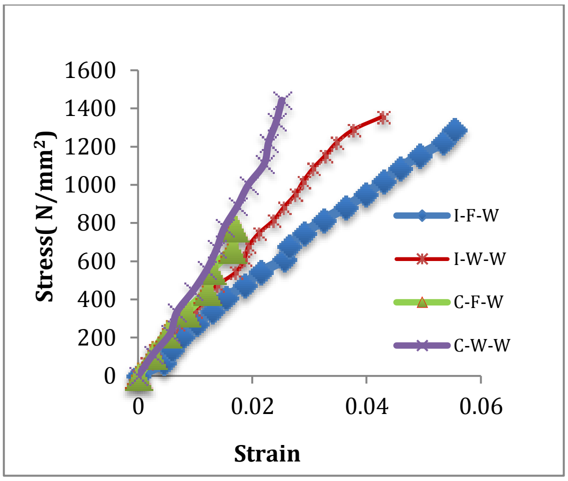

Fig 9 Stress- Strain curve

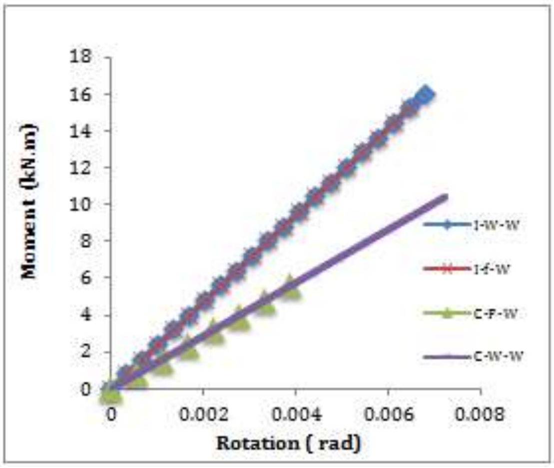

Fig 10 Moment- Rotation curve

Note:

I-F-B I section-Flange connection-welded joint

I-W-B I section- Web connection- welded joint

C-F-B Channel section-Flange connection-welded joint

C-W-W Channel section-Web connection-welded joint

CONCLUSION

An analytical and experimental study was conductedto 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 thatI-section is behaving dominantly in withstanding axial load over CHANNEL section. There has been a 34.78 percentage rise for I section than of Channel section by means of the analytical result values.

And there has been a 50 percentage rise for I section than of Channel section by means of the Experimental test result values. This percentage value proves that I sections are economical for the light weight cold-formed steel structures and also it shows web connection provides better results than of flange portion connections of beam.

Further, this implies the advantage of having welded 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 present study shows the futuristic technology application in terms of cold formed steel in steel structures and also to increase the usage of cold roll steel as primary structural member in light weight structures. And the further study on the cold form steel with types of configuration and connection would provide to the various beneficial properties.

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