ISSN: 2455 – 4200
International Journal of Engineering Research and Modern Education
Impact Factor 6.525, Special Issue, April - 2017
6th National Conference on Innovative Practices in Construction and Waste Management
On 25th April 2017 Organized By
Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore, Tamilnadu

INVESTIGATION ON THE BEHAVIOUR OF COLD-FORMED STEEL BEAM-COLUMN CONNECTIONS

T. Srinath*, B. Abinaya & M. Ravichandran*****

* Assistant Professor, Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamilnadu

** PG Student, Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamilnadu

*** Associate Professor, Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamilnadu

Cite This Article: T. Srinath, B. Abinaya & M. Ravichandran, "Investigation on the Behaviour of Cold-Formed Steel Beam-Column Connections", Special Issue, April, Page Number 280-283, 2017.

Abstract:

Cold-formed steel (CFS) members are an economic solution for many construction applications in buildings. The sections are formed by usingroll-forming, press brake, or bending machines. In general, CFS members are thin; the width-to-thickness ratios are large, compared to hot-rolled steel sections. Local buckling is a major consideration in design of CFS members; which provides a good safety margin local instabilities. For framed buildings, construction of cold-formed steel sections by using screw connections and evaluation of connection stiffness is an essential requirement. In view of this, a review has been conducted on the guidelines available in various codes of practice for screw connections and also a comparative study on the strength of lap joint fastened with screws has been conducted. Limited studies are available on the performance of connection between CFS beams and columns by using screws. Hence, analysis of a single storey residential CFS frame and an experimental investigation has been conducted to predict the exact M-θ behavior of screw connections.

Key Words: CFS,Self-Drilling,Beam-Column Connection,Gusset Plate & Moment-Rotation

1. Introduction:

In steel construction hot-rolled members and cold formed members are the two main families of structural members. Even though cold formed structural members are less familiar it has a growing importance relative to the traditional heavier hot-rolled steel structural members. Cold-Formed Steel (CFS) structural members are made by bending the flat thin steel sheet of thickness 0.4mm to 0.7mm at a room temperature by press braking operations to get a desired shape that will support more load than the flat sheet itself. Their unique feature of having large strength to weight ratio, versatility, very small thickness, non-combustibility with appropriate measures and ease of production makes the CFS useful in many situations where higher strength is required with low member weight. Unlike hot rolled steel, variety of cross sections can be produced in CFS

2. Stadd Analysis:

In the present study, a STADD model of a G+1 storey residential building having width of bay and height of storey as 3m has been developed. Dead load, live load, wind load, earthquake load and their combinations are the different loading conditions used in the analysis. Lipped channel section has been considered for the design of beams and columns. The dad load is calculated considering the thickness of slab as 100mm. Live load, wind load and the seismic load are taken from IS:875- parts. The design forces of the interior joint are the focus of the present study. The frame is provided with in-plane moment connection in the direction of the lateral loads application and the moment is released in the other direction. The member force for the design of beams and columns of the interior joint are obtained by conducting frame analysis which is presented in Tables 1 and 2.

Table 1: Member forces of the interior joint for zone II, III and IV

Zone II,III,IV					
Member	**F_x,KN**	**F_y,KN**	**M_z,KNm**		**Load combination**
			Top	Bottom	
Beam L	7.65	23.07	-	18.54	DL+LL+WL
Beam R	2.88	19.16	-	16.27	
Column T	62.29	3.03	4.44	4.64	
Column B	124.7	7.81	11.45	11.96	

Table 2: Member forces of the interior joint for zone V

Zone V					
Member	**F_x,KN**	**F_y,KN**	**M_z,KNm**		**Load combination**
			Top	Bottom	
Beam L	7.65	23.07	-	18.54	DL+LL+EL
Beam R	2.88	19.16	-	16.27	
Column T	62.29	10.06	14.81	15.36	
Column B	125.76	11.34	16.47	17.54	

3. Design of Beam ND Column Sections:

CFS sections are an assembly of stiffened and unstiffened thin sections. Both beams and columns are designed by using lipped channel sections. Different codes of practices have been used for the design of beams, columns and beam-columns. The

ISSN: 2455 – 4200
International Journal of Engineering Research and Modern Education
Impact Factor 6.525, Special Issue, April - 2017
6th National Conference on Innovative Practices in Construction and Waste Management
On 25th April 2017 Organized By
Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore, Tamilnadu

design of beam and bem-columns is done by using BS-Eurocode-3. From the design, the following geometrical dimensions are adopted for lipped channel beams and beam-column for seismic zones II and III.

Beams : 200 x 150 x 50 x 2mm

Column : 250 x 150 x 50 x 2.5mm

Five codes of practices, AISI, AS/NZS, CSA, BS-Eurocode and IS:801 – draft are compared for their guidelines for the prediction of ultimate capacity of self-drilling screw joints between CFS components loaded under shear. The number of screws required for the beam-gusset and column-gusset connections are calculated based on the design equations available in BS-Eurocode-3. The number of screws adopted for beam and column connections for varying gusset plate thickness is listed in table 3.

Table 3: Number of screws for beam and column

Gusset plate thickness (mm)	Screw dia. (mm)	No. of screw for beam	No. of screw for column
2	6.3	30	30
2.5	6.3	30	22
3	6.3	30	22

4. Experimental Investigation:

The analysis of steel frame is neededfor the exact moment-rotation behavior of connection is difficult. It can be predicted only through experimental investigations. In the present study, an experimental programme is conducted to predict the moment-rotation behavior for the beam to column self-drilling screw connection for zone II and III. The present set up consists of two beams connected to a stub column and forms a beam-column assembly. The self-drilling screw connection model is tested under simply supported conditions and subjected to central point load. Each beam is of length 1.2m and an air gap of 10mm is adopted between the beam and column. The stub column height is 500mm for all the test cases. The test cases considered for the experimental investigation is shown in Table 4. View of the connection assembly is shown in fig 1.

Table 4: Test Cases

ID	Beam	Column	Gusset thickness (mm)	Screw dia (mm)
Sp. 1	200x150x50x2	250x150x50x2.5	2.0	6.3
Sp. 2	200x150x50x2	250x150x50x2.5	2.5	6.3
Sp. 3	200x150x50x2	250x150x50x2.5	3.0	6.3

Figure 1: View of the Connection Assembly

5. Result and Discussions:

Initially Sp.2 with 2.5mm gusset plate has been tested. It has been provided with additional plate strips over the support points as shown in Fig.2. this specimen withstood ultimate moment as 11.66kNm. The stiffness of the initial linear portion is 1800kNm/radian and the reduced stiffness due to beam distortion is 320kNm/radian, which is nearly 82% reduction in stiffness. The initial linear stiffness represents the connection stiffness. The stiffness has been reduced due to the initiation of beam distortion. The reason for such a low value of capacity is that, the beam is not restrained for distortional mode of buckling. In addition to the beam failure, it is observed that the gusset plate has buckled on the compression side. Fig.3 shows failure mode and Fig.4 shows the moment-rotation curve for the first specimen.

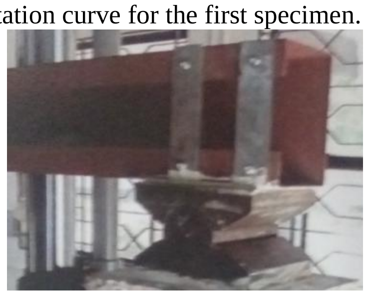

Figure 2: View of the Additional Strip

Figure 3: Failure Mode

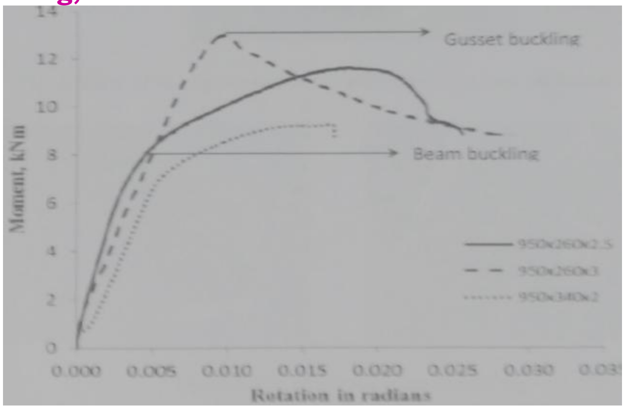

Figure 4: Moment Rotation Behaviour

In the second test, the specimen with 3mm gusset plate has been investigated. With the observation of failure modes in the first test, two additional strips have been screwed in beam between the gusset plate and the support for avoiding the twisting/distortional mode of beam failure. Also, this specimen has been provided with end restraints in the support points as a torsional and shear buckling restraints. Fig.5 shows the specimen with additional strips and end restraints. Now, the load has been transferred without beam distortion and twisting. Initially, the stiffness of this specimen is equal to the specimen, which is a reduction in the stiffness. The stiffness of this connection is calculated as 1500 kNm/radian. After the gusset plate bucklibg, the specimen lost its strength and started to yield. Then the connection became unsymmetrical and the gusset plate did not offer any resistant to beam slip. The beam slipped in the lateral direction. In this specimen, the strain guage locations are shifted and numbers also reduced. Fig.6 shows the buckled view of the specimen.

Figure 5: View of specimen with end restraints and additional strips

Figure 6: View of gusset plate buckling

In the third test for specimen with 2mm gusset thickness, steel strips are screwed to stiffen the haunching portion of the gusset plate. The stiffnened connection is shown in Fig.7. This specimen is also provided with beam distortion and shear buckling restraints as that of the Sp.2. This specimen had imperfection in the out of plane to the gusset plate. The thickness of the gusset plate is 2mm. Since, the haunched portion of the gusset is stiffnened, the weakest portion of thr connection becomes the portion of gusset between the screw on the column side. This portion of the gusset starts to buckle from the initial loading itself (Fig.8). the stiffness of this specimen is 1400kNm/radians. Later, at 608kNm, the specimen predominantly starts to deform laterally due to the initial imperfection and the stiffness reduced drastically to about 320kNm/radians. All the specimen have been instrumented with starin gauge also. The straingauge are pasted on the gusset plate and in beam. Most of the strain gauges showed strains below the yield strain.

Figure 7: Stiffened gusset plate

Figure 8: Buckled view

6. Summary and Conclusions:

In the present work, a two storey-teo bay frame has been analysed by using STADD Pro software for different load conditions. From the analysis, member end forces are extracted for designing the beam and column elements. The beam, column and connections are designed as per BS-Eurocode-3. For designing the self-drilling screw connections, an analytical study has been conducted by using different codes of practices and found that BS-Eurocode gives conservative results and it has been adopted for designing the connections. After arriving the size of beams, columns and connection components, fabrication drawings are prepared and given for fabrication. The fabricated specimens are assembled and transferred to do the testing in UTM. Three experiments have been conducted on cold-formed steel self-drilling screw beam-column connections. In the present study, the effect of gusset plate has been studied. The connection models are supported on simple supports and subjected to monotonic loading under displacement control mode. Behavior and failure modes are observed during the testing. From the present work, the following conclusions are arrived.

Analytical Study:

- ✓ All the codes vary with respect to the bearing factor in their guidelines for failure against bearing and tilting.
- ✓ AISI only addresses the block shear failure and staggered arrangement of bolts for calculation of net section strength.
- ✓ AISIm AS/NZS and CSA yield unconservative results with std. deviation of about 0.14.
- ✓ BS-Eurocode and IS:801-draft yield conservative results with an error of about 30% and std. deviation as 0.11.
- ✓ The failure modes predicted by all the codes match with the respective experimental failure mode.

Experimental Study:

- ✓ Local buckling in the beam lip portion and the compression side of gusset resulted in loss of stiffness which was not the expected mode of failure. In view of this, the correct connection behavior could not be observed and there was on screw bearing or tilting as predicted ny Eurocode-3
- ✓ The initial stiffness of the specimens drastically reduced to nearly 77% - 82% due to beam distortion.
- ✓ For specimens with lateral restraints, the twisting of beam is prevented, however, gusset plate buckling occurred, which resulted in yielding due to loss of stiffness.
- ✓ In the further investigations, the following should be taken care of:
    - The gusset plate buckling should be avoided by providing thicker gusset plate so that the common failure modes such as bearing, tilting and their combinations will occur.
    - Simple lap joints needs to be tested for evaluating the bearing and tilting capacity of the self drilling screw joint as per BS-Eurocode-3.

7. References:

1. Gregory J. Hancock, Thomas M. Murray, and Duane S. Ellifritt, "Cold-formed steel structures to the AISI specifications"
2. IS: 801-1975, "Code of practice for use of cold formed light gauge steel structural members in general building construction", dureau of Indian standards.
3. IS: 801-draft, "Code of practice for use of cold formed light gauge steel structural members in general building construction", bureau of Indian standards.
4. IS: 800-2007, "Code of practice for general construction in steel", bureau of Indian standards.
5. Australian/New Zealand std AS/NZS. 2005."Cold-formed steel structures." AS/NZ 4600, Standards Australia, Sydney, Australia.
6. CSA (1994), COLD formed Steel Structural Members, CSA-S136-94, Canadian Standards Association, Rexdale, Ontario, Canada, December 1994
7. BS En 1993-1-3:2006,"Design of steel structures, Part 1-3 General riles, Supplementary rules for cold-formed members and sheeting", Brussels.
8. NAS (2004) "Supplement to the North American specification for the design of cold-formed steel structural members." AISI std, 2001 Ed., American Iron and steel institute.
9. NAS (2001) "North American specification for the design of cold-formed steel structural members." AISI STD, 2001 Ed., American Iron and steel institute.
10. Dhalla, A.K., Errera, S.J. and Winter, G., "Connections in thin Low-Ductility Steel", journal of the structural division, ASCE, October, 1971
11. Rogers,C.A., Hancock, G.J.(1997). "Screwed connection tests of thin G550 and G300 Sheet Steels", Research Report No. R761, Centre for advanced structural engineering, University of Sydbey, Sydney, Nsw, Australia.
12. Yu, W. W. 1991.Cold-formed Steel Design, John Wiley & Sons, New York.
13. Nityadharan, M amd Kalyanaraman, V (2011), "Experimental study of screw connections in CFS-Calcium Silicate board wall panels".
14. Bambach, M. R. and Rasmussen, K. J. R. "Behaviour Of Screw Connections In Residential Construction", 10.1061/ (ASCE)0733-9445(2002)128:1(115)