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STRUCTURAL PERFORMANCE AND PARAMETRIC STUDY ON LIGHT WEIGHT CFS TRUSS FLOORS

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Abstract - *Cold-formed steel (CFS) is the familiar term for steel products formed by cold working processes carried out near room temperature such as rolling, pressing, stamping, bending, etc. Cold formed steel are entirely different to hot-formed steel and hot-rolled steel. Trusses made with cold formed steel known as cold formed steel trusses. Cold formed steel trusses can be together will form Multi span truss beam. Multi span steel truss beams are more effective than single truss beams. Structural performance of cold formed steel light weight composite floor slab possess good structural behavior. It can be used in any type of structures. They having high load carrying capacity and high ductility. They possess high flexural strength. Cold-formed steel members have been used also in bridges, storage racks, grain bins, car bodies, railway coaches, highway products, transmission towers, transmission poles, drainage facilities, firearms, various types of equipment and others. Other advantages of cold formed steel members are Lightness in weight, High strength and stiffness, Ease of prefabrication and mass production, Fast and easy erection and installation, Substantial elimination of delays due to weather, More accurate detailing.*

***Key Words*: Cold formed steel truss, Flexural strength, Punching shear, Ansys workbench 16.1, Multi span truss beam**

1. INTRODUCTION

Trusses are the structures in which single units of triangles together will form a whole structure and these types of structures are most commonly used in bridges, roofs, towers and floors. Trusses consist of triangular units constructed with straight members. Triangles are the strongest single unit because of its shape, i.e base at the bottom. Cold-formed steel (CFS) trusses, also known as light gauge steel trusses, are made from high-quality sheet steel that is fashioned into different shapes by roll forming, or the continuous bending of long strips of sheet metal. CFS can be formed into various steel thicknesses and are fabricated in a manufacturing plant using screws, bolts or welds. Cold-formed steel trusses are used in all fields of construction such as commercial, residential, educational, manufacturing and hospitality. Cold formed steel trusses are a viable option when building codes require the use of non-combustible materials. In a typical floor truss the top and bottom chord members are constructed from a continuous lipped channel section. Due to the ease in fabrication, sections with similar thickness are generally employed for both the top and the bottom chord. The diagonals and the vertical members are attached to the chords by making use of rivets or self-tapping screws. Fabricators usually prefer to use at least one rivet in each connection. The use of a single rivet enables to precisely position the members. The rivet holes in the chords and diagonals are punched during the roll forming operation. These holes are overlapped and a rivet is driven though during the assembly phase. Some of the main properties of cold formed steel are their lightness in weight. Because of its lightness it can be transport and handle easily. Low unit weight reduces the cost comparatively. Cold formed steels having high strength and stiffness. So it can be used in structures like bridges, towers, roofs, floors, drainage bins etc. Compared to hot rolled section cold formed sections having 20 % higher strength.

2. OBJECTIVES OF THE WORK

This work mainly carried out:

- Parametric study on multi span cold formed truss beams by varying Depth ratio, Breadth ratio and Alignment of truss members
- To study the structural performance of light weight CFS rectangular slab under flexural strength
- To study the structural performance of light weight CFS square slab under punching shear test

3. GEOMETRIC DETAILS

Truss members are modeled using Ansys workbench 16.1. Spacing between truss members taken as the width of the beam. Beam element 188 is used to model the truss element. Shear deformation effects are included. BEAM 188 is a linear (2-node) beam element in 3-D with six degrees of freedom at each node. The degrees of freedom at each node include translations in x, y, and z directions, and rotations about the x, y, and z directions.
In design, the members of these trusses are generally considered as pin-ended and their capacities are assessed

under pure compressive and tensile loads by making use of commonly accepted design specifications. A number of full-scale floor trusses were experimentally investigated through four-point bending tests. Here the specimen i.e., lipped channel section having thickness of 0.8 mm and span of 6 m. Steel properties are given in Table 1

Table -1: Properties of steel material

Yield strength	396 Mpa
Density	7850 kg/m3
Poisson's Ratio	0.3

4. FINITE ELEMENT ANALYSIS OF THE STUDY

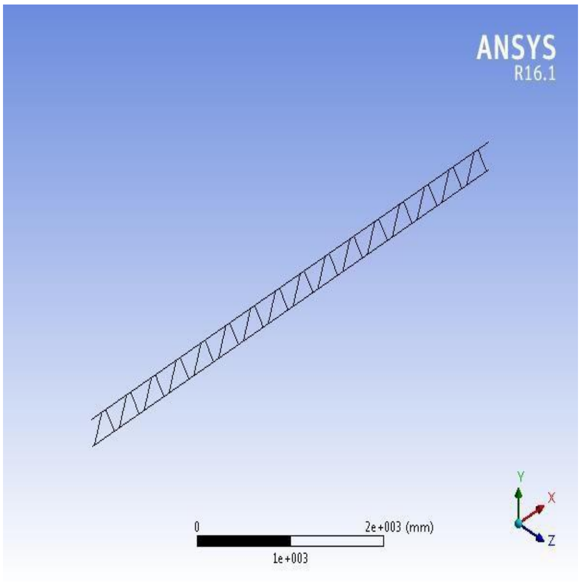

Fig-1 FEA model of truss

Truss specimens were subjected to four-point bending tests under monotonically increasing vertical displacement loading using the test setup shown in Fig.2. Loading was applied at two points 555mm spaced out from mid-span. A clear span between two roller supports of 5810mm was considered except for one of the specimens where the clear span was 3780 mm. Location of the loading points were selected to coincide with the joints where the diagonal members meet with the top chord. Similarly, the supports at two ends of trusses were located at the joints where the diagonal members meet with the bottom chord.

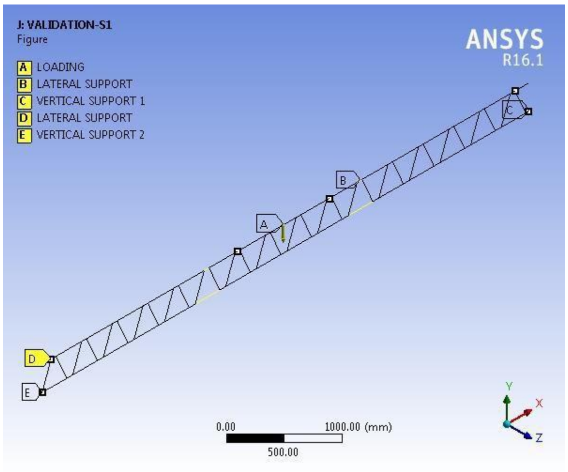

Fig-2: Loading condition of truss

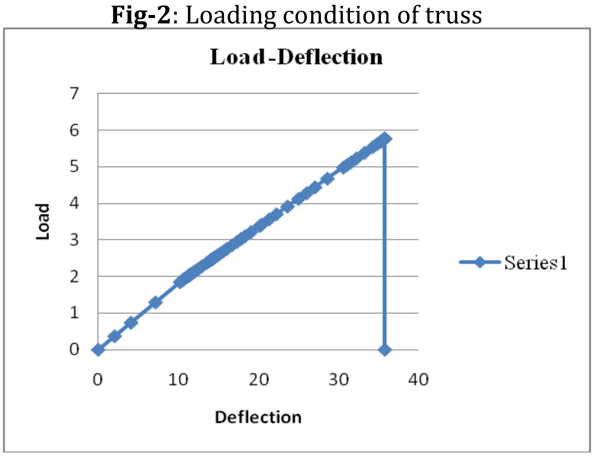

Fig-3 Load deflection curve

Fig-3 shows the load deflection curve.

5. PARAMETRIC STUDY ON TRUSS BEAM

Cold formed steel trusses can be used as beams by joining truss members known as multi span truss beam. Rows of truss together will form a beam. For effective performance of the beam we have to know about effective depth ratio, width ratio and alignment. To know effective depth, we analyze beams having same breadth of 200mm and varying depth from 300 mm to 600 mm. Similarly, for effective breadth depth of the beam kept constant as 300 mm and varying breadth from 200mm to 400 mm. In alignment study truss members are arranged in different manners. Lipped channels placed by back to back, face to face, face to back and back to side. These arrangements analyzed by applying four-point loading. Maximum load and deflection will obtain in each case. Loading conditions are same for all cases as shown in Fig-4.

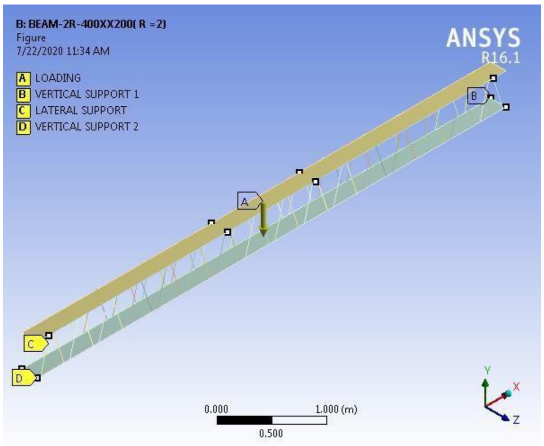

Fig-4 Load deflection curve

5.1 Depth ratio

Results obtained from the analysis for effective depth as shown in Table 2. Deformations, Maximum load and Percentage increase in load as shown in Table 2. Better performance shown by the beam having size 500X200 mm. Maximum load about 96.06 kN and deflection obtained as 80.58 mm. So the structure having sufficient ductility. Deformation of the same as shown in Fig-5. Load deflection chart for the beams as shown in Fig-6

Table -2: FEA results for effective depth

Models	R value	Deflection (mm)	Load (kN)	% increase in load
Beam-2R-300X200	1.5	51.75	39.07	1
Beam-2R-400X200	2	61.87	63.11	61.52
Beam-2R-500X200	2.5	80.58	96.06	145.87
Beam-2R-600X200	3	79.68	110.09	181.78

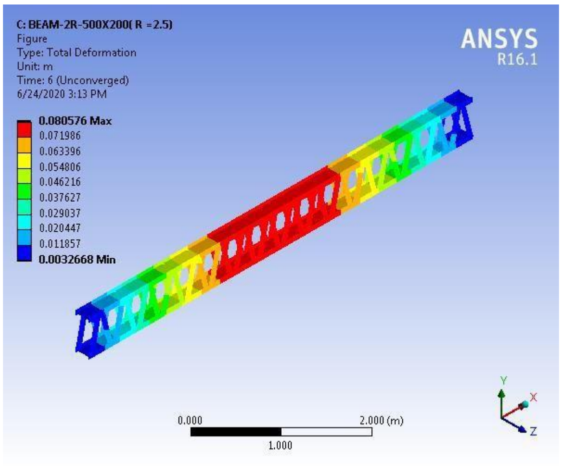

Fig-5 Deformation of beam 500X200 mm

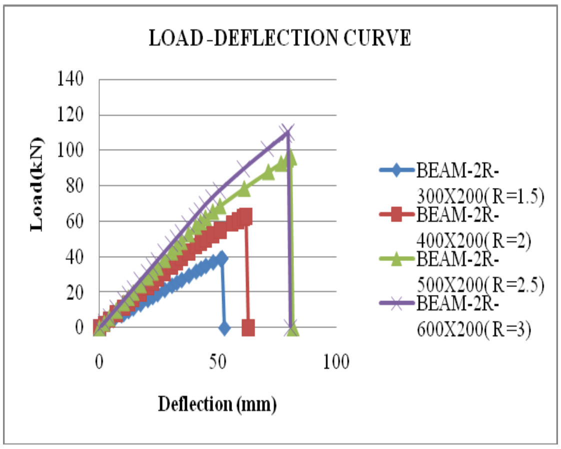

Fig-6 Load deflection curve

5.2 Breadth ratio

Results obtained from the analysis for effective breadth as shown in Table 3. Maximum deflection for the beam is 69.05 mm have R value 1, ie dimension of beam 300X300 mm also it having high ductility. Load carrying capacity is high for the beam 300X400 is about 59.27 kN. From these results the efficient section of the beam is 300X300 mm ie, R=1. Deformation of the beam 300X300 as shown in Fig-7. Load deflection curve as shown in Fig-8.

Table -3: FEA results for effective breadth

Models	R Value	Deflection	Load(kN)	% of increase in load
Beam-2R-300X200	1.5	52.75	39.07	1.0
Beam-2R-300X300	1	69.05	46.76	19.69
Beam-2R-300X400	0.75	57.39	59.27	51.72

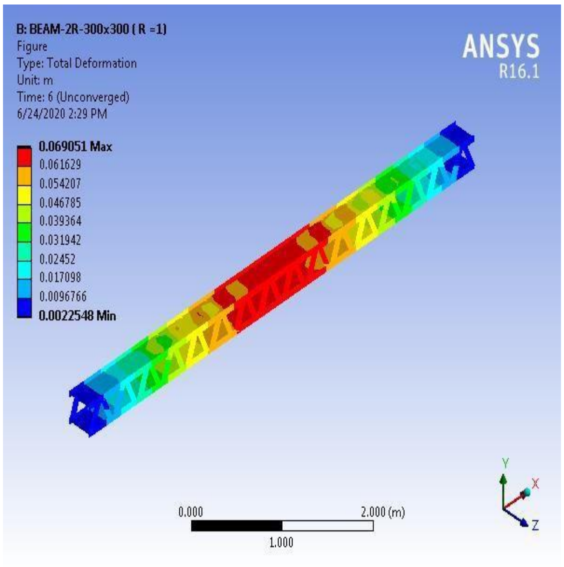

Fig-7 Deformation of beam 300X300 mm

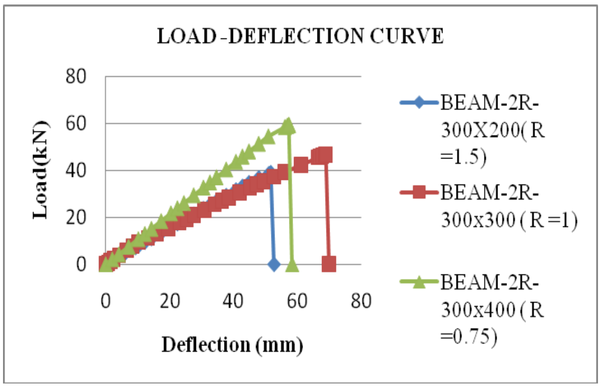

Fig-8 Load deflection curve

5.3 Alignment study

Results obtained from the finite element analysis for different arrangements of truss members as shown in Table 4. Four types of beams were tested to know about the efficiency of each arrangement. Back to back connection and face to face connection shows efficient load carrying capacity. In validation members are placed in face to face arrangement. Here the back to back connection shows better result than face to face to connection. Maximum load about 42.64 kN and possess high ductility i.e., deflection about 59.22 mm. Deformation of the B2B connected beam and load deflection for each beam as shown in Fig-9 and Fig-10 respectively.

Table -4: FEA results for different alignment of truss members

Models	Connection	Deflection	Load(kN)	% of increase in load
B-2R-300X200	F2F	52.75	39.07	1
B-2R-300X200	B2B	59.22	42.64	9.15
B-2R-300X200	F2B	49.75	37.69	3.54
B-2R-300X200	B2S	2.05	1.54	96.07

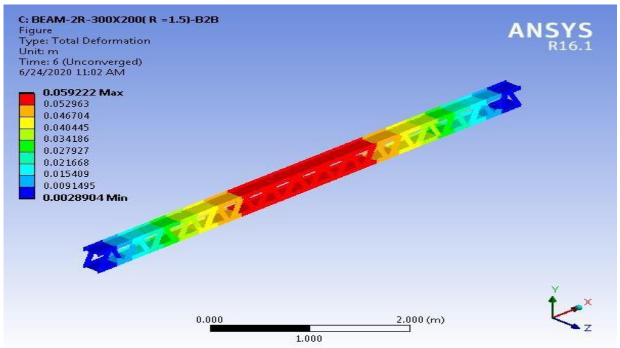

Fig-9 Deformation of beam-connection B2B

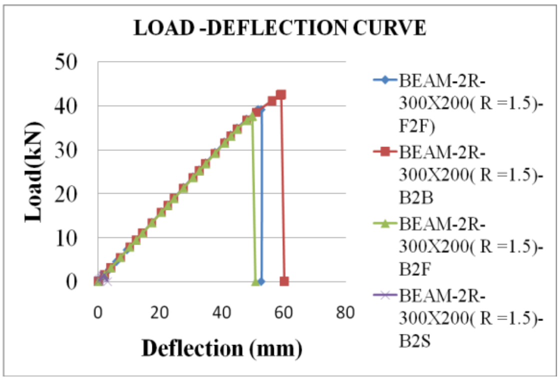

Fig-10 Load deflection curve

6. STRUCTURAL PERFORMANCE OF RECTANGULAR SLAB

Test conducted to study the structural performance of rectangular floor slab along with multi span truss beam. Here the one-way slab tested under flexural strength. Different sizes of slabs were tested for compare each other. The size of the beam taken as 300X200 mm. The truss members are connected back to back. Slabs of size 5X1 m, 5X2 m, 5X3 m, 6X1 m, 6X2 m and 6X3 m were tested. Finite element analysis results are as shown in Table 5. Flexural strength of slabs is tested under four-point loading. Flexural strength was high for all specimens. Ductility also increases. Load deflection curve as shown in Fig-11. Slabs of size 5X3 m and 6X3 m possess high load carrying capacity and ductility.

Table -5: FEA results for truss beam with rectangular floor slab

Model	Deflection(mm)	Load(kN)	% of increase in load

1S-6X1 mm	59.69	582.20	1
1S-6X2 mm	84.24	1411.20	142.39
1S-6X3 mm	82.79	2627.30	351.27
1S-5X1 mm	0	676.37	1
1S-5X2 mm	49.75	1571.40	132.33
1S-5X3 mm	61.48	3415.10	404.92

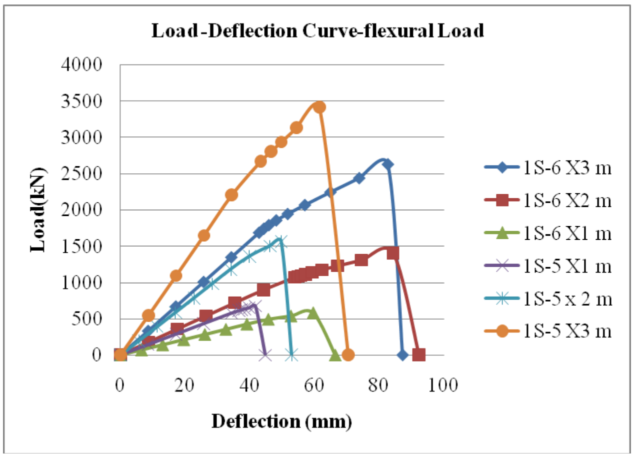

Fig-11 Load deflection curve

7. STRUCTURAL PERFORMANCE OF SQUARE SLAB

Test conducted to study the structural performance of square floor slab along with multi span truss beam. Punching load test is carried out to analyze the structure. In punching load test the slab were supported on four sides and load applied at centre. Total four number of slabs were tested. Test set up of the specimen as shown in Fig-12. Slabs of size 2X2 m, 3X3 m, 4X4 m and 5X5 m were tested. Results from finite element analysis listed in Table 6.

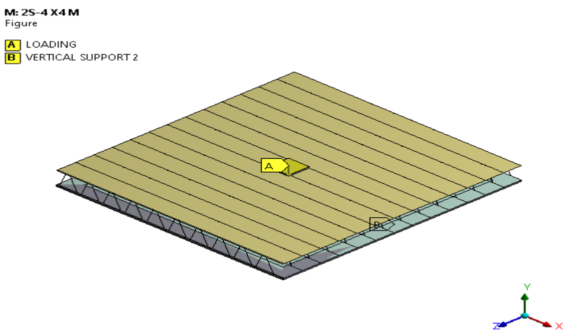

Fig-12 Test set up of the specimen

Table -6 FEA results for truss beam with square floor slab

Models	Deflection(mm)	Load(kN)	% of increase in load
2S-2X2 m	22.96	828.03	1
2S-3X3 m	27.55	1160.6	40.16
2S-4X4 m	32.47	1269.90	53.36
2S-5X5 m	40.01	1503.30	81.55

Load carrying capacity and ductility propertiesare increasing with increasing size of the specimen. Maximum load carrying capacity 1503 kN and maximum deflection about 40.01. Percentage of increase in load is about 80 %. Load deflection curve as shown in Fig-13 and deformation of slab size of 5X5m as shown in Fig-14.

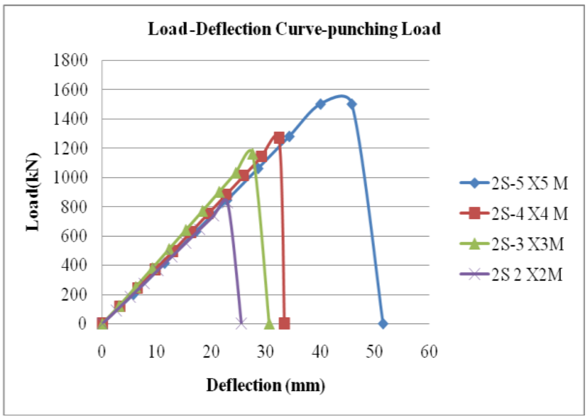

Fig-13 Load deflection curve

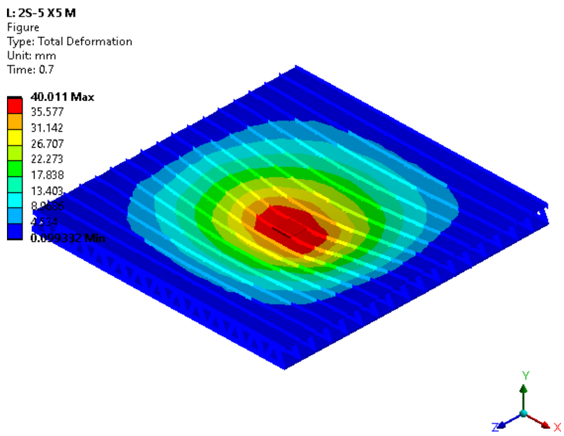

Fig-14 Deformation of square slab along with CFS truss beam

8. CONCLUSIONS

Cold formed steel is a type of steel which is entirely different from hot rolled steel. Manufacturing process of the cold formed steel undertaken at room temperature. Cold formed steel available in various sections such as lipped channel sections, C shaped sections, U shaped sections etc. These sections can be together will form a truss beam. We can use this as roof truss as well as floor truss. Lipped channel sections are used here to form truss beam. The sections are connected by back to back connection which posses high load carrying capacity and ductility. Multi span CFS truss beam posses high load carrying capacity than single span CFS truss. Breadth of the beam taken as the spacing between truss beams. Flexural strength and load carrying capacity increasing with increasing size of slab. In case of punching shear test load carrying capacity increases up to 80 % than smaller size slab. Floors with light weight cold formed steel multi span trusses can be effectively used in all types of buildings. They posses high load carrying capacity, high flexural strength and economical.

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