EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF COLD FORMED STEEL LATTICED BEAMS

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Abstract: The main objective of this paper is to determine experimentally and analytically, the buckling-modes and maximum load carrying capacity of six built-up latticed beams with top chord as CFS angle sections of 1.2 thick (three specimens of 5 mm lipped and other three specimens of non-lipped) with 8mm rod spot welded and 12mm rod as bottom chord. The top and bottom chords are connected by a 6mm lattice links. The stiffeners and base plates of 1.2 mm thick are provided at equal intervals and the sizes of CFS angles, stiffeners, and base plates vary for different types of specimens. The analysis is carried out using ANSYS 13.0 and the results are compared with experimented results.

***Index Terms* – Buckling-modes, CFS, load carrying capacity, built-up latticed beam, ANSYS 13.0.**

I. INTRODUCTION

The cold formed steels are generally light gauge thickness flat steel sheets, and they exhibits greater strength when they are subjected to be made as desired shapes. The self-weight of these, materials are generally low when compared to hot rolled sections and they are formed at very low temperatures easily. Unlike the hot rolled sections, the cold formed sheet can be bent and formed at different cross-sections.

II. CROSS SECTION OF THE SPECIMENS

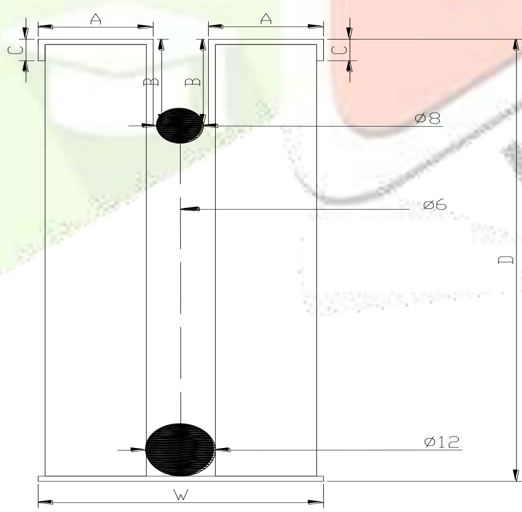

Fig.1 Cross section of the specimens

Where, the top chord of the specimen comprises of a bar of 6 mm, which is spot welded with the CFS angle sections as shown in the figure 1, and the 12 mm bar is taken as bottom chord and the top and bottom chords are spot welded with the Lattice links of 6mm bars. The diameter of the bars provided for all the specimens are taken as same, and provided for the entire length of the specimen 900 mm.

Table.1 Specimen details

S. no	N	L	T	A	B	C	D
1	LS20	900	1.2	20	20	5	102.2
2	LS30	900	1.2	30	30	5	102.2
3	LS40	900	1.2	40	40	5	102.2
4	S20	900	1.2	20	20	-	102.2
5	S30	900	1.2	30	30	-	102.2
6	S40	900	1.2	40	40	-	102.2

Where,
N = Name of the specimen,
L = Length of the specimen in mm,
T = Thickness of the angle sections, stiffeners and base plates in mm,
A = Flange width in mm,
B = Web depth in mm,
C = lip size in mm,
D = Overall depth of the specimen in mm.

Table.2 Stiffener, base plate and lattice details

S. no	N1	S	S1	S2	W1	L1
1	LS20 & S20	17.6 x 99.8	8	300	49.6 x 20	12
2	LS30 & S30	27.6 x 99.8	8	300	69.6 x 30	13
3	LS40 & S40	37.6 x 99.8	8	300	89.6 x 40	16

Where,
N1 = Name of the specimen,
S = Size of the stiffeners,
S1 = Number of stiffeners,
S2 = Spacing of the stiffeners,
W1 = Size of the base plates,
L1 = Number of lattice links of 6mm diameter bars.

III. COUPON TESTS

The coupon tests are conducted for the three test coupons of 1.2 mm thick, based on the provisions of IS 1663-1960 part1, and the yield stress of the CFS coupons found to be 270Mpa, and the 'E' modulus of elasticity is found to be 1.80 x 10^5 N/mm^2. The yield stress of the 6mm, 8mmand 12 mm bars are found to be 250Mpa from tensile testing, and 'E' values for the rod is taken as 2 x 10^5 N/mm^2, and these tests are performed on computerized universal testing machine.

Fig.2 Coupons and coupon test

IV. NUMERICAL ANALYSIS

4.1 Modelling

The finite element method is used to divide the specimen in to several elements in ANSYS13.0 and the elements are created in this software without any pivot errors. For the beam element, BEAM188 is taken, and for the CFS elements, SOLID181 is taken.

4.2 Material properties

The material properties for the elements are given from the yield stress and 'E' values identified from the coupon and tensile tests. The density of the steel material is taken as 7850 kg/m^3.

4.3 Coupling and displacement constrains

The coupling is provided in the places where the spot welding is to be provided and constrained in all degrees of freedom. The one end of the bottom rod with base plate is constrained in the displacements of X, Y and Z directions and other end is constrained in displacements of Y & Z directions, taking it as in simply supported conditions. The upper portion of the stiffener plates are constrained in displacement direction Z.

4.4 Loading and analysis

The pressure is provided at two point loading conditions on the elements of the CFS section acting on normal direction, and the Non-linear analysis is carried out and solutions are obtained.

V. ANALYTICAL GRAPHICAL RESULTS

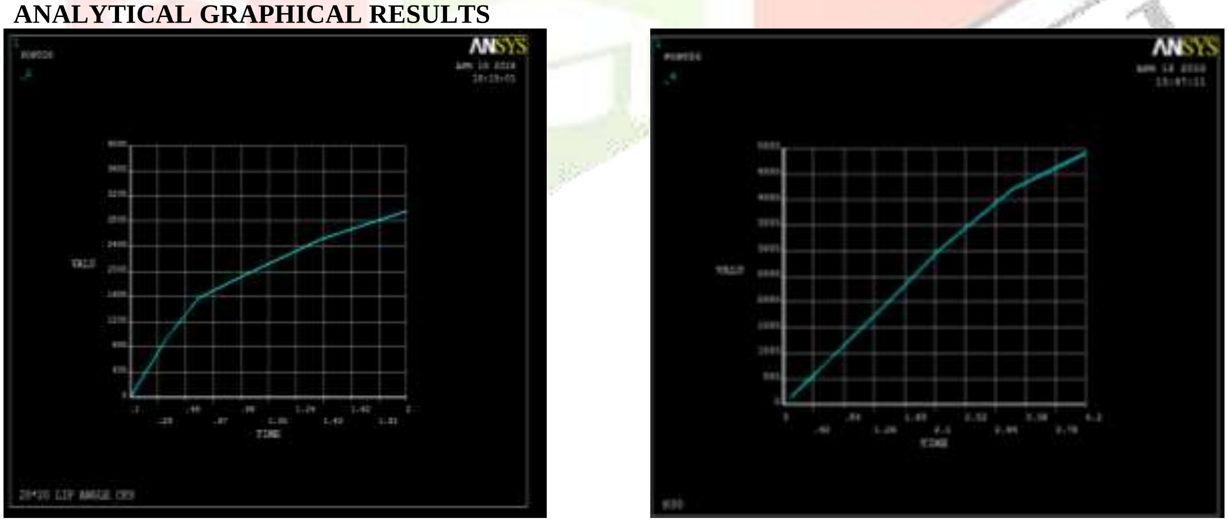

Fig.3 S20 & S30 Specimen analysis result

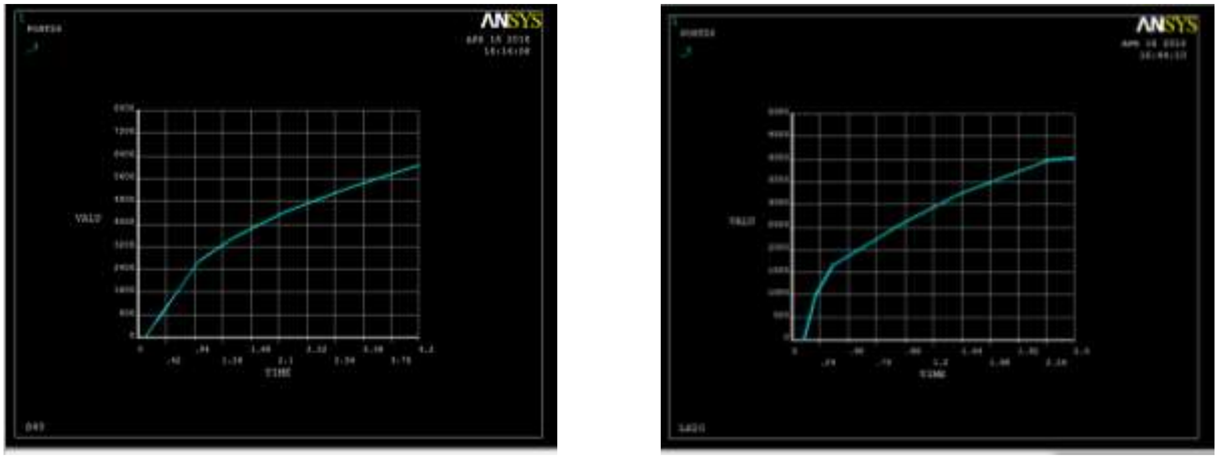

Fig.4 S40 & LS20 Specimen analysis result

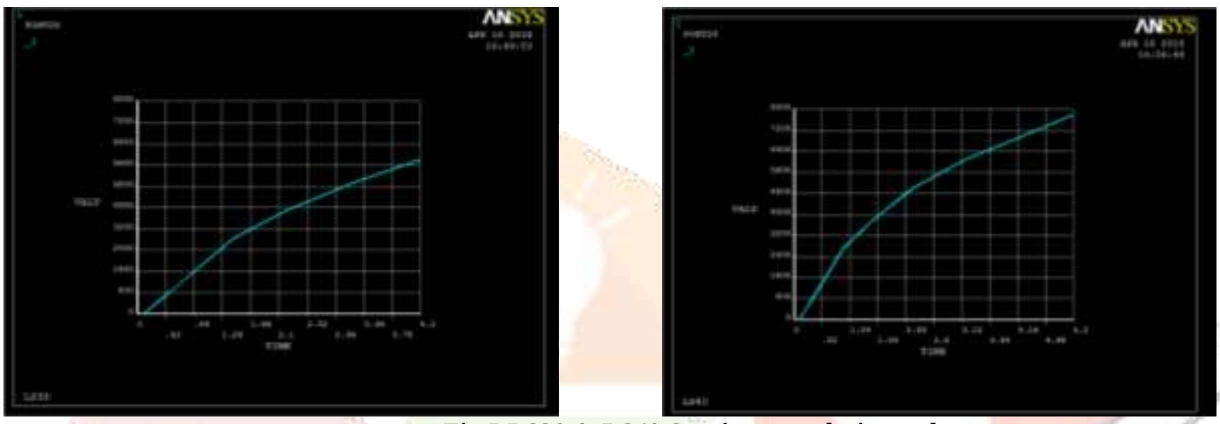

Fig.5 LS30 & LS40 Specimen analysis result

VI. EXPERIMENTAL ANALYSIS

At L/3 distance, from either end of the specimen, two points loading is applied, the deflection values are recorded by using the LVDT setup placed at a distance of L/2 and L/3 distances. The hydraulic jack of 50 tonnes is kept on the top of the load cell of 50 KN which is kept above the spreader beam above the specimen at L/3 distance. The pressure is controlled by means of hydraulic power pack, and the load values from the load cell and the deflection values from the LVDT are collected in the Universal Data Acquisition system and are monitored using the PROFSOFV.2.4 data acquisition software.

The experimental setup comprises of the following:

1. Loading frame
2. Hydraulic jack (50 tonnes)
3. Load cell (50 KN)
4. Spreader beam
5. Specimen
6. Simply supports.
7. LVDT (One at distance L/2 and other at distance L/3).

Fig.6 Experimental setup & test specimens

VII. EXPERIMENTAL GRAPICAL RESULTS

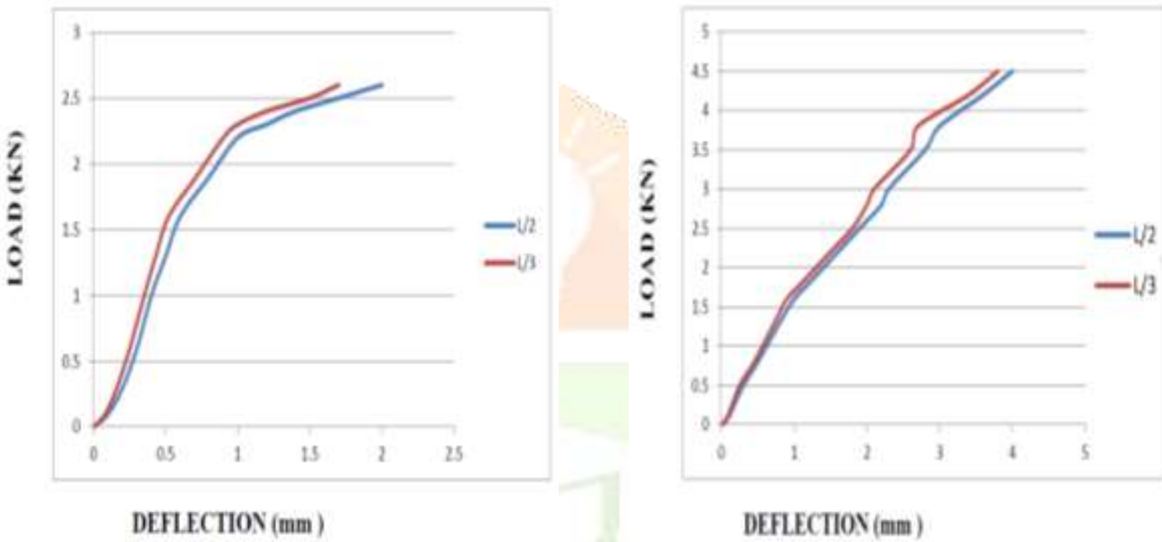

Fig.7 Load vs Deflection curve for S20 & S30

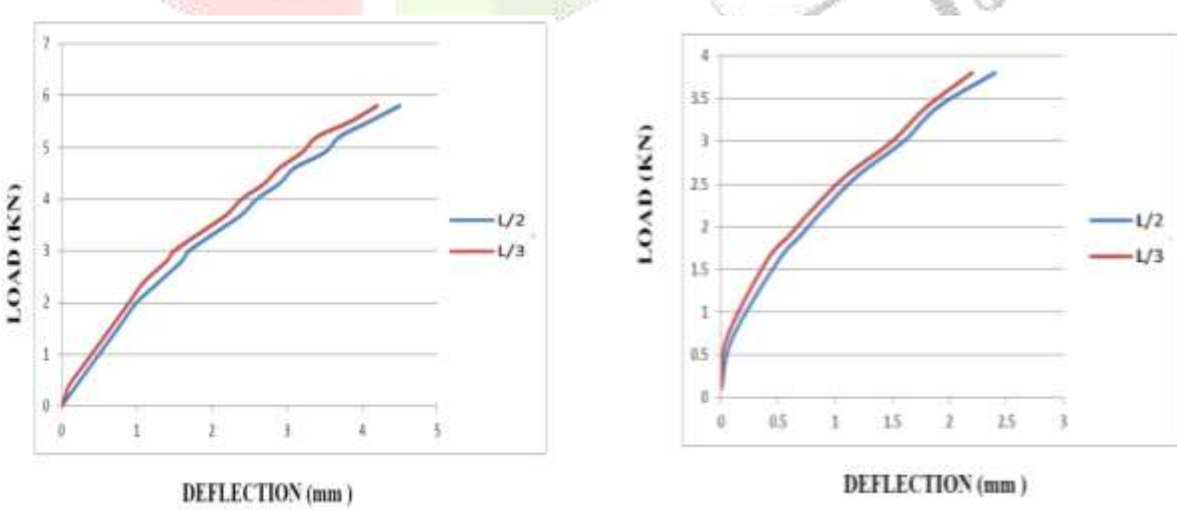

Fig.8 Load vs Deflection curve for S40 & LS20

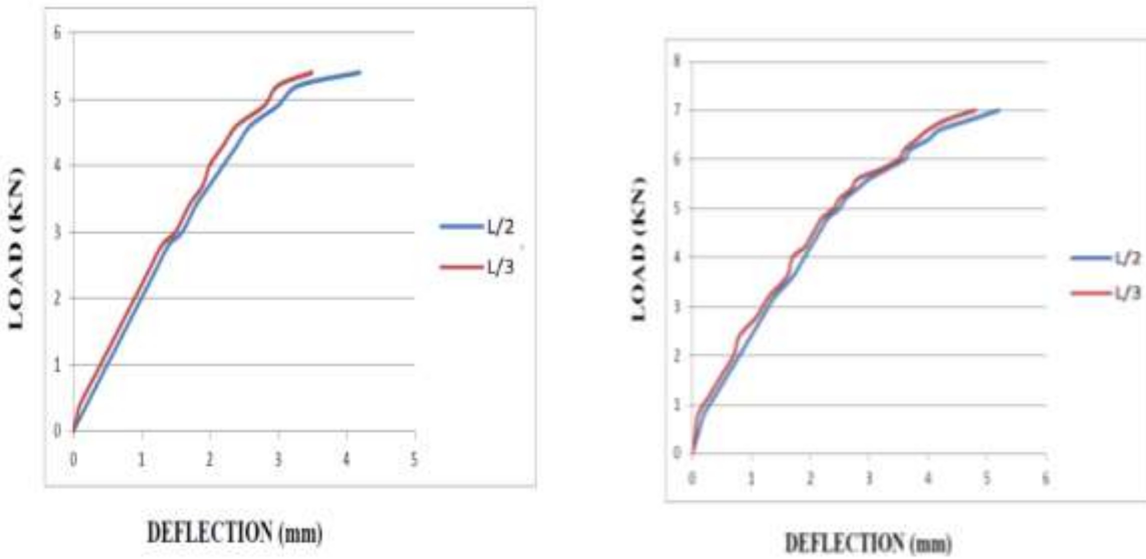

Fig.9 Load vs Deflection curve for LS30 & LS40

VIII. ANALYTICAL AND EXPERIMENTAL RESULTS OF BUCKLING MODES OF SPECIMEN

Fig.10 Buckling-modes of S20

Fig.11 Buckling-modes of S30

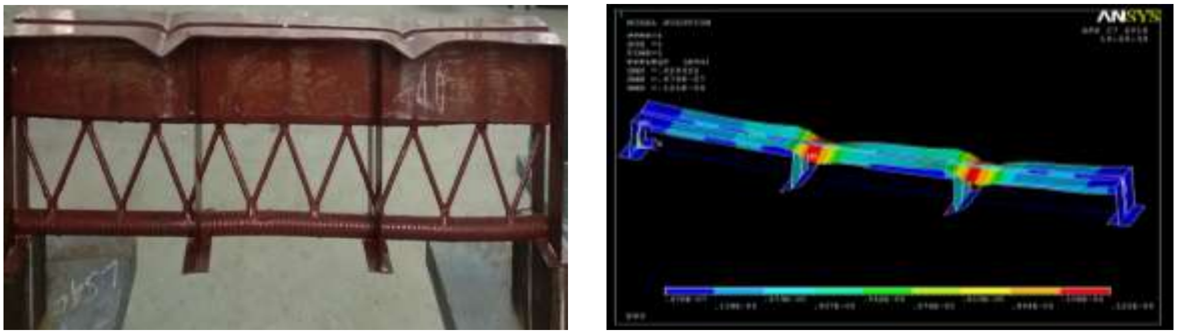

Fig.12 Buckling-modes of S40

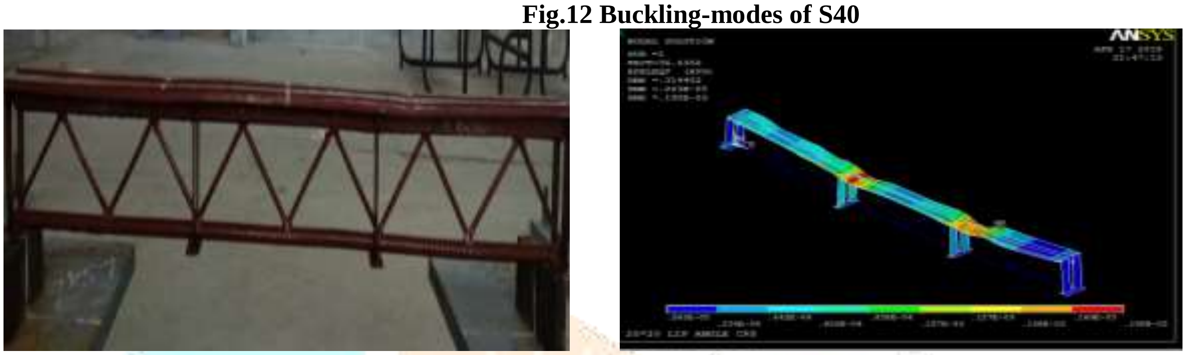

Fig.13 Buckling-modes of LS20

Fig.14 Buckling-modes of LS30

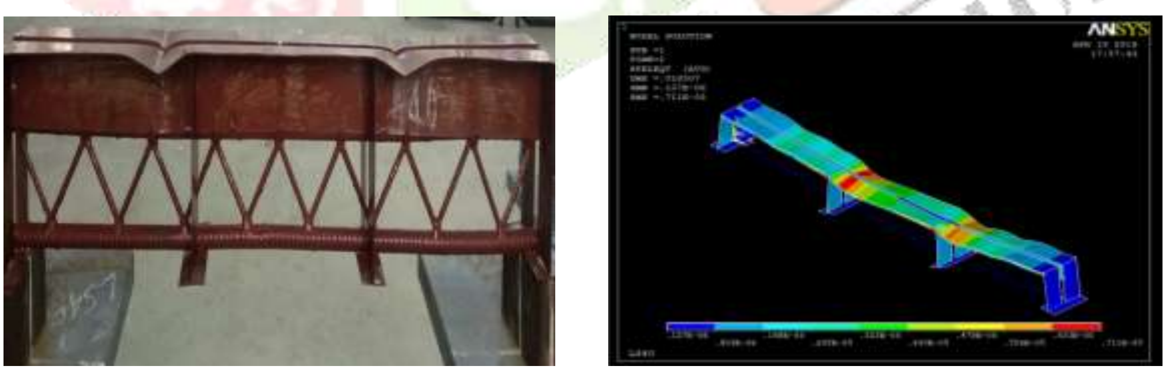

Fig.15 Buckling-modes of LS40

IX. RESULTS AND DISCUSSIONS

The analytical and experimental load carrying capacity for different specimens are stated in the table.3 and the maximum load carrying capacity of the lipped CFS latticed built-up beams shows much result when compared to non-lipped CFS latticed built-up beams, and also the load carrying capacity increases with increase in sizes of CFS angle sections in latticed built-up beams.

Table.3 Comparison of Numerical and Experimental values

SPECIMEN NAME	SPECIMEN DIMENSIONS	EXPERIMENTAL LOADS	NUMERICAL LOADS	BUCKLING FAILURE MODE

	(mm)	(KN)	(KN)	
S20	49.6 x 102.2 x 900	2.6	3	Distortional Buckling
S30	69.6 x 102.2 x 900	4.5	4.9	Local buckling
S40	89.6 x 102.2 x 900	5.8	6.3	Local buckling
LS20	49.6 x 102.2 x 900	3.8	4.2	Weld failure
LS30	69.6 x 102.2 x 900	5.4	5.8	Local buckling
LS40	89.6 x 102.2 x 900	7	7.8	Distortional buckling

X. CONCLUSIONS

In this thesis, the load carrying capacity and failure modes of latticed built up section with bottom cord as circular rod and CFS angle sections connected with circular rod as top cord section have been analysed and studied using ANSYS 13.0 software.

The load carrying capacity of the single lipped CFS built-up latticed beams shows higher results when compared to non-lipped CFS built-up latticed beams.

Different modes of buckling of lipped and non-lipped CFS sections of varying sizes are studied.

The numerical and Analytical results were compared, and the deviations in the results are studied, this is mainly because of lack in accuracy of welding of lattices and in fabrication.

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