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Flexural Behavior of Cold Formed Steel Beams with end Stiffeners and Encased Web

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Abstract— **Cold- formed steel members are extensively used in the building construction industry, especially in residential, commercial and industrial buildings. In recent times, the use of cold- formed high strength steel members has rapidly increased. . This paper presents the results of the experimental study on the behaviour of cold-formed steel section with plain web, with end stiffened web and with encased web. The moment carrying capacity of cold-formed steel beam with plain web was studied and compared with the moment carrying capacity of beam with end stiffened web and encased .The specimens were tested under two point loading for its pure flexural behaviour. From the study, it is found that the cold-formed steel beam with end stiffened and encased web have higher load carrying capacity when compared to that of section with plain web.**

Keywords: Cold-formed, deflection, strength, stiffeners, I-section

I. INTRODUCTION

Cold-formed steel (CFS) is the common term for products made by rolling or pressing thin gauges of sheet steel. Cold-formed steel goods are created by the working of sheet steel using stamping, rolling, or presses to deform the sheet into a usable product. Cold worked steel products are commonly used in all areas of manufacturing of durable goods like appliances or automobiles but the phrase cold form steel is most prevalently used to describe construction materials. The use of cold-formed steel construction materials has become more and more popular since the introduction of codified standards in 1946. In the construction industry both structural and non-structural elements are created from thin gauges of sheet steel. These building materials encompass columns, beams, joists, studs, floor decking, built-up sections and other components.

In this investigation a total of three experiments were conducted on cold-formed steel section with plain web, with end stiffened web and with encased web. The specimens were tested under two point loading for its pure flexural behaviour.

II. EXPERIMENTAL INVESTIGATION

A. *Test Specimen Details*

The test specimens consisted of cold-formed steel beams with plain web, end bracing web and encased web. The span of the beam was 2000 mm and the cross-sections of the I-beams were 150 mm x100 mm x 2 mm. The yield strength of steel used was obtained from coupon test and was found to be 380 Kn/mm^2. 6mm diameter mild steel rods were welded on either side of web at both the ends of the stiffened beam. In the encased beam the web was encased with M30 grade fly ash concrete. The mix design used is given in Table.1and Table 2 shows the details of the beams tested

TABLE 1 MIX DESIGN

Particulars	*Quantity*
Cement	370.346 kg/m^3
Fine aggregate	819.97 kg/m^3
Coarse aggregate	1096.32 kg/m^3
Water	166.65 kg/m^3
Fly ash	148.138 kg/m^3
Lime	18.51 kg/m^3
Admixture	0.858 kg/m^3
Water cement ratio	0.43

TABLE 2: BEAM DESIGNATION

Sl no:	**Beam Specification**	**Beam Designation**
1	Normal I section-I	NB-I
2	Stiffened Beam-I	SB-I
3	Normal I section Encased with Concrete-I	ENB-I

B. Test set-up

The testing was carried out in a loading frame of 400kN capacity. All the specimens were tested for flexural strength under two point loading in the vertical loading frame. The specimens were arranged with simply supported conditions. Loads were applied at one-third distance from the supports at a uniform rate till the ultimate failure of the specimens occurred. Linear Voltage Displacement Transducers (LVDTs) was used for measuring deflections at id span. Strain gauges and LVDTs were connected to a data logger from which the readings were captured by a computer at every load intervals until failure of the beam occurred.

III. RESULTS AND DISCUSSIONS

A. LOADS versus DEFLECTION CURVES

The experimental load-deflection curves of the cold – formed steel beams with plain webs, end stiffened webs and encased web are shown in figure 1, 2 and 3.

The specimen with plain web NB-I failed at an ultimate load of 15kN with a central deflection of 4.5mm. The other specimens SB-I and ENB-I failed at an ultimate load of 38kN and 70.6kN with the corresponding deflections of 7 mm and 12mm respectively.

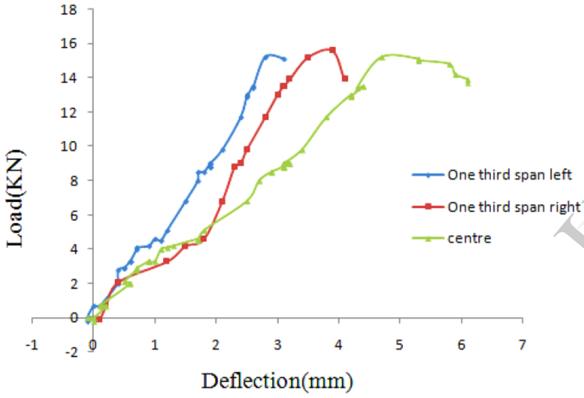

Fig: 1 Load v/s deflection graph for normal I section

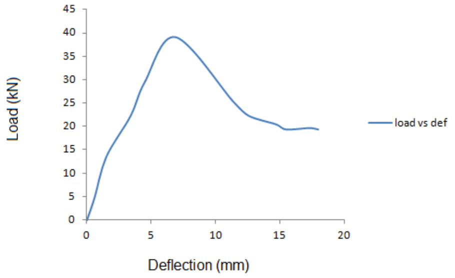

Fig 2 Load v/s deflection graph for stiffened beam

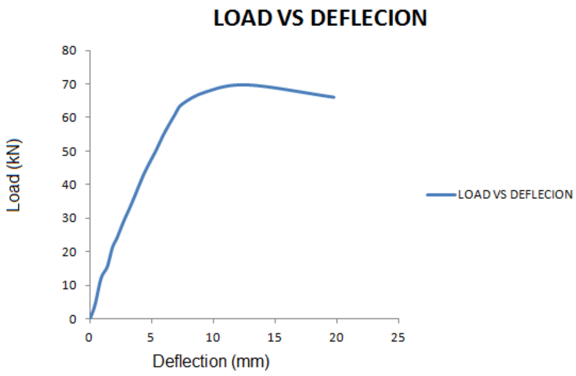

Fig: 3 Load v/s deflection graph for Normal I section Encased with Concrete

C. LOADS versus STRAIN

Strain gauges were placed at different points off the beam to measure the strain at the time of loading.

Following graphs show the strain at the time of loading

1. Normal I section

Strain gauges were placed at top side of the flange (ts), top web side (tws), bottom web side (bws), bottom flange side (bs). The strain value is high for normal I sections. Fig. 4 shows the load v/s strain graph for a normal I section beam

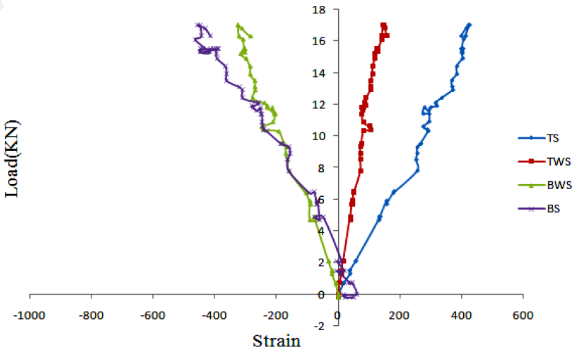

Fig: 4 Load v/s strain graph for normal I section

2. Stiffened beam

Strain gauges were placed at top side of the flange (s1), top web side (s2), bottom web side (s3), bottom flange side (s4). The strain value is low compared to that of normal I sections. Fig. 5 shows the load v/s strain graph for a stiffened beam

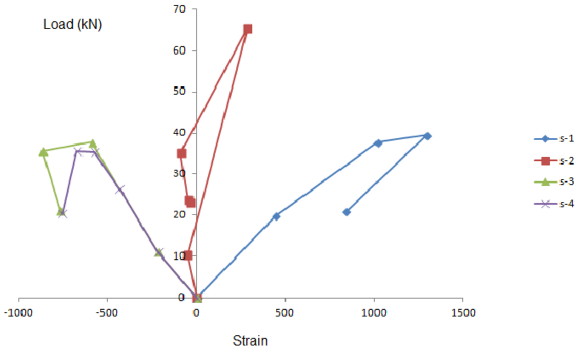

Fig: 5 Load v/s strain graph for stiffened beam

3. Normal I section Encased with Concrete

Strain gauges were placed at top side of the flange (s1), top web side (s2), bottom web side (s3), bottom flange side (s4). The strain value is very low compared to that of normal I sections as well as stiffened beams. Fig. 6 shows the load v/s strain graph for a normal I section encased with concrete beam

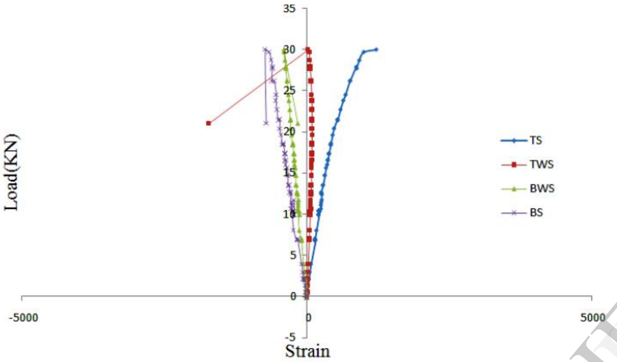

Fig: 6. Load v/s strain graph for Normal I section Encased with Concrete

D. COMPARISON OF ULTIMATE LOADS

Comparison of the ultimate loads of normal I section, end stiffened beams, normal I section encased with concrete were carried out. The normal I section has the least where as the normal I section with encased concrete has the maximum value of the ultimate load. The ultimate load of normal I section was 15 kN and the ultimate deflection was 4.5 mm. The ultimate load of beam with bracing in the web was 38kN and ultimate deflection was7 mm. The ultimate load of normal I section encased with concrete was 70.6 kN and ultimate deflection of 12 mm.

Fig: 7 show the comparison of ultimate load carrying capacity of the three different types of beams.

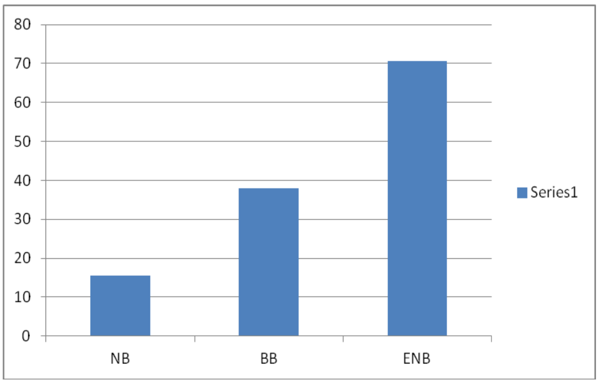

Fig: 7 Comparison of ultimate load carrying capacity

E. COMPARISON OF ULTIMATE DEFLECTION

Comparison of the ultimate deflection of normal I section, end stiffened beams, normal I section encased with concrete were carried out. The normal I section encased with concrete has the least value where as the normal I section has the maximum value for the ultimate deflection. At 15KN the deflection for normal I section is 4.5mm and for the same load the beam with bracing in the web has a deflection of 3mm. Similarly in the case of normal I section encased with concrete, the deflection is 2.5mm

Fig: 8 show the comparison of ultimate deflection of the three different types of beams

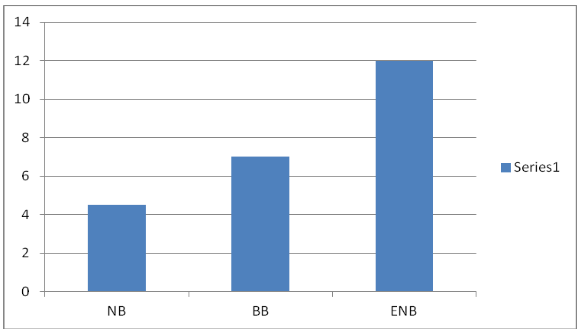

Fig: 8 Comparison of ultimate deflection

F. MODES OF FAILURE

From the results of experimental analysis the failure modes of the specimens are discussed.

The failure was typically in the form of flexural cracks originating from the bottom of the specimen and extending towards the top of the specimen in the case of encased specimens. The majority of cracks were formed between the zone of two point loading and also some cracking was also observed near the supports end.

The load carrying capacity of encased web beam was significantly higher than that of normal web beam.

IV. CONCLUSIONS

Experimental investigations were carried out to make a comparative study on the flexural behaviour of cold -formed light gauge steel I section, cold -formed light gauge steel I section with stiffeners and cold- formed light gauge I section encased with M-30 concrete and following conclusions were drawn.

- The ultimate load carrying capacity of cold- formed light gauge steel I section with stiffener was 60-65% higher than that of cold- formed light gauge steel I section.
- The ultimate load carrying capacity of cold- formed light gauge steel I section filled with concrete was 75-80% higher than that of cold- formed light gauge steel I section.
- The ultimate load carrying capacity of cold- formed light gauge steel I section filled with concrete was 45-50% higher than that of cold- formed light gauge steel I section with stiffeners.
- The ultimate deflection of cold- formed light gauge steel I section with stiffeners was 35-40% higher than that of cold- formed light gauge steel I section.
- The ultimate deflection of cold- formed light gauge steel I section filled with concrete was 60-65% higher than that of cold- formed light gauge steel I section.
- The ultimate deflection of cold- formed light gauge steel I section filled with concrete was 40-45% higher than that of cold- formed light gauge steel I section with stiffeners

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