



Cold Formed Composite Beam Using Light Weight Concrete

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ABSTRACT

Composite beam is constructed to increase stiffness or strength or to reduce cost. Beams are built of more than one material are called composite beam. An experimental study was made to determine the flexural behaviour of composite beam consists of cold-formed steel with lightweight concrete using expanded polystyrene beads in place of coarse aggregate by 30%. The ultimate objective of this study is to reduce the overall weight of the composite structure and a comparative study was analysed between composite beam with the conventional beam. Cold-formed steel (CFS) is the type of steel fabricated by the cold forming process. Cold-formed steel structural members have been used for housing for many years. Since 1960, numerous projects have concentrated on the research and development of cold-formed steel products for housing. During recent years, the use of cold-formed steel framing in residential construction has been on a rapidly increasing scale. During the construction of CFS residential buildings, however, one of the disadvantageous features is that the several requirements arising during design can only be satisfied by several different materials (heat insulation, insulation against moist, finishing of the surface). This drawback can be avoided if a single material with optimized material properties is used.

Key Words: Composite beam, Expanded polystyrene beads, Overall weight.

1. INTRODUCTION

Cold formed steel are produced by rolling or pressing steel into semi-finished or finished goods at relatively low temperature. The use of cold formed steel as constructive material has become more popular. Expanded polystyrene beads is a low density form having uniform size and has good impact resistance which can be easily mixed with cement mortar to produce light weight concrete. Cold formed composite beam, the steel frame which is enclosed and infill with light weight concrete. Commonly light weight concrete has low density used as infill material.

Cold formed steel is fabricated into I- section having flange thickness 1.8 mm and the remaining hollow section on both sides of I-section is enclosed by two cement or wooden planks and filled with M35 light weight concrete replacing coarse aggregate by 30% using expanded polystyrene beads.

2. PREVIOUS STUDY

Aman mulla [1], In order to reduce the overall weight of the concrete, used two mix proportion one is partially replacing and another type is fully replaced coarse aggregate by expanded polystyrene beads. The result shows that compressive strength slightly lower than conventional concrete but good workability. The fully replaced concrete has low density and strength more than burnt brick and the partially replaced concrete gives more strength as 15mpa used as filling material in slab concreting.

Mohd ariffin [2], Cold framed steel frame is infill with light weight concrete as composite beam used as lintel and partition wall. The expanded polystyrene concrete can be used as light weight concrete as its density in the range between 300-1850 kg/m³. The maximum compressive strength of concrete at 28th day is obtained by mix proportion 1:3.5:2 out of three different mix ratio. Also the concrete infilled CFS shows higher lateral strength than CFS frame without infill concrete as 63.18KN.

Anand babu [3], discussed about the bonding properties between concrete and steel section and used shear connectors to achieve the bonding as distance between shear connectors varying from 75mm, 125mm and 150mm and concluded that the ultimate load carrying capacity and ultimate bending moment is maximum in beam having spacing 125mm. The moment carrying capacity is maximum in 125mm spacing than 75mm and 150mm because closely spaced shear connectors has additional confinement.

Nimmy Thomas [4], used three steel structure, normal steel frame, truss beam and composite tress beam. Compared the flexural behaviour of each section and stated that 1.08% load carrying capacity increase when comparing normal steel frame with tress beam and the same truss beam is encased with concrete shows 2.25% increase in load carrying capacity than the tress beam without infill material.

3. OBJECTIVES OF THE STUDY

- To evaluate the bending resistance of cold-formed steel built-up sections subjected to flexure.
- To Reduce the overall weight of the composite section using light weight concrete.
- Reduce weight of concrete by partially replacing coarse aggregate with Expanded polystyrene beads
- To study the properties of materials and to derive the mix design for expanded polystyrene beads concrete.
- To analyse the load versus deflection behavior under flexure.

In this study an attempt is made to determine the flexural strength of I section steel infilled with light weight concrete replacing coarse aggregate by 30% with expanded polystyrene material. And also a comparative study was made between cold formed composite beam and conventional beam.

4. MATERIAL PROPERTIES AND MIX PROPORTION

Ordinary portland cement of grade 53 conforming to IS-12269 2013 has been used. Fine aggregate consists of natural sand or crushed stone free from silts passing through 4.74 mm IS sieve is taken and fineness, specific gravity test are conducted for fine aggregate. Coarse aggregate consists of 70% of crushed stone and remaining 30% consists of expanded polystyrene material.

4.1 Properties of EPS beads

EPS beads has different size varying from 3 mm to 40 mm. It has very low density range between 12 kg/m³ to 45kg/m³(density of water 100kg/m³). It has excellent moisture resistant, the ability of EPS to resist moisture is widely used in several construction purpose. EPS has good shock absorption characteristic used in packing chemical and electronic products. It possess non toxic and odourless properties hence used as construction material in eco friendly structures.

4.2 Properties of cold formed steel

The main property of cold formed steel is its lightness in weight, high strength and stiffness. Cold formed steel is widely used in construction purpose.

- 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.

4.3 Mix proportion

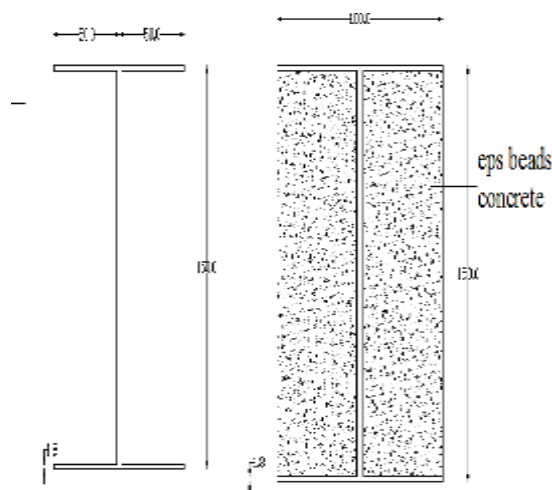
Mix design for m35, the ratio of light weight concrete is 1: 1.63: 2.67. Water cement ratio 0.45.

Table 1. Mix proportion

CEMENT kg	FINE AGGREGATE kg	COARSE AGGREGATE kg	EPS beads kg	WATER lit
7.6	12.4	14.8	1	10.4

5. EXPERIMENTAL SETUP

The test specimen, I section has span 1.2 meter having flange thickness 1.8 mm and web thickness 3.6 mm, height and width of the specimen are 150 mm and 100 mm respectively.



ALL DIMENSIONS ARE IN mm

Figure 1. Welded I section and concrete encased section

Three cubes having dimension 150 x 150 are moulded along with the test specimens, for determining the compressive strength of concrete during day 7 and day 14. And three cylinder(150 x 300) also casted to determine the split tensile strength of the concrete. The test specimens are cleaned and oiled before concreting for easy to dismantling. EPS beads having uniform size of diameter 8 to 12 mm is taken and water absorption 4%. The concrete is infilled into the steel section and compacted manually using steel rod. Placing concrete in three layers for better compatibility.

5.1 CASTING OF SPECIMEN

The steel sheet is cut, bent and then formed into two channel sections, and then it is welded back-to-back to form a built up section. The raw material used in this casting PPC (fly ash based cement) as a binding agent, river sand as fine aggregates and EPS beads. Potable tap water was used for mixing and curing throughout the entire work. The mix proportion of EPS beads concrete taken by replacing coarse aggregates by EPS beads and also by changing proportions of all other ingredients.

5.2 Loading Frame

The testing was carried out in a loading frame of 500kN capacity. A loading frame is a high stiffness support structure against which the test forces can react. The load frame comprises a base beam, two columns and a moving cross head. The load frame has the provision of supports and to place the proving ring to calculate the load application.

5.3 Proving ring

Proving ring is used to calibrate the amount of forces used within various force-testing devices. In general, it is used to measure the forces. The device is made using a ring of metal with a spring- like consistency. Inside the ring, there is a screw attached to a dial with measurement on it. The contraction in the centre works to show the ring's diameter after it has been compressed or stretched, which is used to measure force.

5.4 Hydraulic Jack

Hydraulic jack is the device used to apply load in the loading frame. It is almost similar to the one used to lift vehicles. The capacity of the hydraulic jack depends on the load frame. The hydraulic jack can be manually operated or mechanically controlled.



Figure 2. Failure of back to back channel section



Figure 3. crack pattern in encased beam

6. RESULTS AND DISCUSSIONS

All the beams were tested until the failure and the readings from dial gauge for concrete encased section were observed. Load increment is 2 kN. Corresponding deflection is noted and tabulated below. Here the ultimate load is 40 kN with maximum deflection of 4.42 mm.

Table 2. Load and Deflection of concrete encased section

S.NO	LOAD(kN)	DEFLECTION(mm)
1	0	0
2	4	0.50
3	8	0.77
4	12	1.12
5	16	1.33
6	20	1.77
7	24	2.35
8	28	2.75
9	32	2.95

10	36	3.28
11	40	4.42

The experimental load-deflection curve for polystyrene aggregate concrete encased section is shown in figure 4

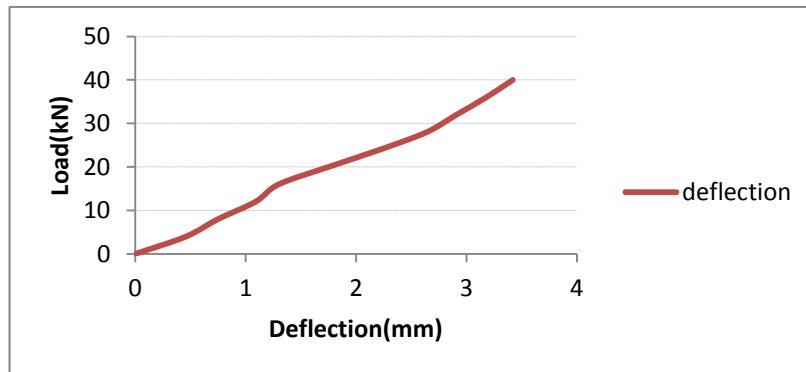


Figure 4. Load V/S deflection graph for concrete encased section

6.1 COMPARISON OF SPECIMEN

Ultimate load and deflection of welded I section and Polystyrene Aggregate Concrete encased section are tabulated below.

TABLE 3 COMPARISON BETWEEN ULTIMATE LOADS OF SPECIMENS

Section	Ultimate load(kN)	Deflection (mm)
I section	14	1.37
Encased section	40	4.42

From the table encased section have high load bearing capacity and deflection before failure than the other two sections. Back-to-back section failure early due to lateral torsional buckling. In encased section the failure was typically in the form of flexural cracks originating from the bottom of the specimen and extends towards the top of the specimen. The majority of cracks were formed between the zone of two point loading and also some cracking was also observed near the supports end.

7. CONCLUSIONS

Preliminary work to carry out the main objective of the project was studied and the literatures related to the project were summarized briefly. The properties of cold-formed steel, Expanded Polystyrene beads (EPS), cement and fine aggregate were studied. Further mix design for EPS beads concrete was derived. Assumed w/c ratio = 0.50, the proportion of concrete mix is, 1:1.68:0.036. The compressive strength of EPS beads concrete is 14 N/mm², which is less than M35 concrete. The ultimate load carrying capacity of Back-to-back channel section and Polystyrene Aggregate Concrete encased section are 14 kN and 40 kN respectively. The ultimate deflection of welded I section and Polystyrene Aggregate Concrete encased section are 1.37mm and 4.42mm. Various modes of failures of the different sections were studied. Polystyrene Aggregate Concrete encased section is used to restrain global and distortion failure.

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