International Journal of Science and Engineering Applications
Volume 6 Issue 04, 2017, ISSN-2319-7560 (Online)

Performance of Composite Beam

Vigneshwar S K.
Department of Civil Engineering
ACE, Hosur, India

Vivetha S.
Department of Civil Engineering
ACE, Hosur, India

Satheesh V S
Department of Civil Engineering
ACE, Hosur, India

Abstract: Composite construction dominates the non-residential multi-storey building sector. This has been the case for over twenty years. Its success is due to the strength and stiffness that can be achieved, with minimum use of materials. The reason why composite construction is often so good can be expressed in one simple way - concrete is good in compression and steel is good in tension. By joining the two materials together structurally these strengths can be exploited to result in a highly efficient and light weight design. In this project, we have determined the flexural strength of composite beams. Various specimens with water cement ratio 0.45 where casted. The specimens were tested for 28 days strength. To evaluate the effectiveness of the composite beams. The results were tabulated and line chats and conclusions were given.

Keywords: Composite beams, Flexural strength, Flexural behavior, Compression, Tension

1. INTRODUCTION

A structural member composed of two or more dissimilar materials joined together to act as a unit as known as composite. An example in civil structures is the steel-concrete composite beam in which a steel wide flange shape is attached to a concrete floor slab. The many other kinds of composite beam include steel-wood, wood-concrete and plastic-concrete or advanced composite materials-concrete.

There are two main benefits of composite action in structural members. First, by rigidly joining the two parts together, the resulting system is stronger than the sum of its parts. Second, composite action can be better utilize the properties of each constituent material. In steel-composite beams, for example, the concrete assumed to take most or all of the compression while the takes all the tension.

Steel-concrete composite beams have long been recognized as one the most economical structure systems for both multistory steel buildings and steel bridges. Buildings and bridges require a floor slab to provide surface for occupants and vehicles respectively. Concrete is the material of choice for the slab because its mass and stiffness can be used to reduce deflections and vibrations of the floor system and to provide required fire protection. Since both the steel and concrete are already present in the structures, it is logical to connect them together to better utilize of their strength and stiffness.

Steel concrete composite beams consists of a steel beam over which a reinforced concrete slab is cast with shear connectors. In conventional composite construction, concrete slabs are simply rested over steel beams and supported by them. These two components act independently under the action of loads, because there are no connection between the concrete slabs and steel beam.

The basic concept of composite beam lies in the fact that the concrete is stronger in compression than steel (which is susceptible to buckling under compression) and steel is stronger in tension.

1.2 Advantages of composite beam:

- The concrete and concrete is utilized effectively
- More economical steel section is used in composite construction than conventional non-composite construction for the same span and loading
- Depth and weight of steel beam required is reduced.so, the construction depth also reduces increasing the headroom of the building
- Composite beams have higher stiffness, thus it has less deflection that steel beams
- Composite beams can cover for large space without the need of any intermediate columns
- Composite construction is faster because of using rolled steel and pre-fabricated components than cast-in-situ concrete
- Encased steel beam have higher resistance to fire and corrosion

2. MATERIALS AND SPECIMENS

2.1 MATERIALS

2.1.1 CEMENT

Cement is defined as a material with adhesive and cohesive properties which make it capable of binding material fragments into a compact mass. Cement is obtained by burning calcareous and argillaceous materials by partial fusion at about 1450°C. Ordinary Portland cement 53 grade was used for casting all the specimens. The ordinary Portland cement is generally classified into three grades, they are 33grade, 43grade, and 53 grade. In this study OPC 53 grade has been used.

Table 2.1.1 physical properties of cement

S.NO	PROPERTY OF CEMENT	VALUE
1	Grade of cement	53 grade (OPC)
2	Specific gravity	3.13
3	Initial setting time	30mins.
4	Final setting time	60mins.

5	Normal consistency	35%

2.1.2 FINE AGGREGATE

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. As with coarse aggregates these can be from primary, secondary, or recycled sources. Aggregates are the major ingredients of concrete, as they constitute 70-74% of the total volume, provide a rigid skeleton structure for concrete, and act as economical space fillers. In India river sand is used as fine aggregate. The sand was washed and screened at site to remove deleterious materials and tested as per the procedure given in the IS 2386-1963.

Table 2.1.2 properties of fine aggregate

S.NO	PROPERTY OF FINE AGGREGATE	VALUE
1	Specific gravity	2.65
2	Fineness modulus	2.25
3	Water absorption	1.5%

2.1.3 COARSE AGGREGATE

Coarse aggregate consists of river gravel, crushed stone or manufactured aggregate with particle size equal to or greater than 4.75mm. It shall comply with the requirements of IS383-1970. For the coarse aggregates, the following test has been carried out conforming to IS2386 (part 1). Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste –aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

Table 2.1.3 properties of coarse aggregate

S.NO	PROPERTY OF COARSE AGGREGATE	VALUES
1	Specific gravity	2.70
2	Size of aggregates	20mm
3	Fineness modulus	5.96
4	Water absorption	2.0%

2.1.4 STEEL TUBE (Hallow Structural Section)

HSS Manufacturing Methods The transformation of steel strip into hollow structural sections (HSS) is the result of a series of operations including forming, welding and sizing. Currently three methods are being used in North America for the manufacture of HSS. Each method meets ASTM A-500 and CSA G-40.21-92 requirements for the manufacture of HSS.

2.1.5 POTABLE WATER

Casting and curing of specimens were done with the potable water that is available in the college premises. Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Potable water with ph value 7 is used for mixing and curing throughout the experiment.

2.2 PREPARATION OF SPECIMENS

2.2.1 FLEXURAL SPECIMEN

A steel tube of 1*0.102*0.102m is used as reinforcement for casting beam specimen.

2.2.2 CASTING OF SPECIMENS

All the ingredients in the concrete were weighted carefully by the balance. For composite beam specimen -cement, fine aggregate, coarse aggregate were weighted and mixed thoroughly to get a uniform mixture. The mixing is done on a water-tight platform, the required quantity of water was added slowly and wet mixing was done.

The fresh concrete was filled in the moulds layer by layer and each layer was compacted thoroughly by tamping rod. The surface was levelled and finished by using a trowel. The specimen were removed from the mould after 24 hours of casting and kept for curing in the curing tank.

3. MIX DESIGN

Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportions with the object of certain minimum strength and durability as economically as possible.

3.1 OBJECTIVE OF MIX DESIGN

The objective of concrete mix design as follows

- The first objective is to achieve the stipulated minimum strength
- The second objective is to make concrete in the most economical manner. Cost wise all concretes depend primarily on two factors, namely cost of material and cost of labour. Labour cost, by way of formwork, batching, mixing, transporting and curing is namely same for good concrete

3.2 MIX PROPORTION

Based on the simplified mix design procedure as per IS 10262:2009, a concrete mix proportions with characteristic compressive strength was designed without the admixtures.

- The grade of concrete M_{25} is used further proportion of 1:1:2 respectively
- Characteristic compressive strength required at the end of 28 days is 25 N/mm^2

The mix adopted for the study is tabulated

Table 3.2 mix proportion

	CEMENT	WATER	FINE AGGREGATE	COARSE AGGREGATE
Kg	4.74	2.13	4.74	9.48
Ratio	1	0.45	1	2

4. EXPERIMENTATION

This chapter presents the details of experimental investigations carried out on the test specimens to study the

performance evaluation of composite beam. The flexural strength of the composite beam were studied.

4.1 EXPERIMENT PROCEDURE

- The concrete typically consists of cement, fine aggregate, coarse aggregate, and potable water
- The mix design for M_{25} grade of concrete and the required mix proportions for the ingredients used are calculated
- Some of preliminary tests are carried out on the materials to be used so that to check their suitability for making concrete
- After casting the specimens they were set free for 24 hours and then the specimens are taken to curing tanks for proper curing
- Then the strength properties such as flexural beam test are conducted for 28th day of concrete
- The maximum strength of the casted composite beam is founded.

5. TESTING PROCEDURES

5.1 PRELIMINARY TESTS ON MATERIAL

Some of the preliminary tests are required to check their suitability of making concrete such as follows

- Specific gravity test
- Setting time test
- Consistency test

5.1.1 SPECIFIC GRAVITY TEST OF CEMENT

Specific gravity of the cement is calculated by using density bottle method. For finding specific gravity of cement kerosene is used

Specific gravity of cement is 3.13

5.1.2 SETTING TIME TEST OF CEMENT

Initial and final setting time on cement is obtained by vicat's apparatus, for the initial setting time of the cement vicat's needle should penetrate to a depth of 33-35mm from the top, for final setting time the vicat's needle should pierce through the paste more than 0.5mm. We need to calculate the initial and final setting time as per IS: 4031(part5)

Initial setting time of cement: 30mins

Final setting time of cement: 60mins

5.1.3 STANDARD CONSISTENCY TEST

The standard consistency test of a cement paste is defined as that consistency which will permit vicat plunger having the 10mm diameter and 50mm length to penetrate a depth of 33-35 from the top of the mould. The basic aim to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (part4)

Standard consistency of cement is 35%

5.1.4 SPECIFIC GRAVITY OF FINE AGGREGATE

Specific gravity of fine aggregate is calculated as 2.65

5.1.5 SPECIFIC GRAVITY OF COURSE AGGREGATE

Specific gravity of coarse aggregate is calculated as 2.70

5.2 TESTS ON FRESH CONCRETE

The fresh concrete are tested by following methods

- Slump cone test
- Compaction factor test

5.2.1 SLUMP CONE TEST

Slump cone test is a very common test for determination of workability of concrete. This test was carried out for M_{25}, before casting the specimens

The slump cone value of concrete is 60mm

5.2.2 COMPACTION FACTOR TEST

This test is more accurate than slump cone test and this test is used to determine the workability of low water cement ratio more accurately. The specimen was tested after the surface gets dried the load was applied on the smooth sides without shock and increased continuously till the specimen failed.

The compaction factor value is 0.85

5.3 TESTS ON HARDENED CONCRETE

The tests were conducted on the hardened concrete are as follows

- Flexural strength test

5.3.1 FLEXURAL STRENGTH TEST

During the testing, the beam specimens of size 1000mm×102mm×102mm were used. Specimens were dried in open air after 28 days of curing and subjected to flexural strength test under flexural testing assembly. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicates in the tension surface within the middle third of span length. Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a materials ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique.

The flexural strength represents the highest stress experienced within the material at its moment of rupture. The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibres are at the largest stress so, if those fibres are free from defects, the flexural strength will be controlled by the strength of those intact 'fibres'. However, if the same material was subjected to only tensile forces then all the fibres in the material are at the same stress and failure will initiate when the weakest fibre reaches its limiting tensile stress.

6. FLEXURAL STRENGTH TEST

FIRST CRACK LOAD = 10 kN
ULTIMATE LOAD = 44.6 kN

6.1 FLEXURAL STRENGTH TEST

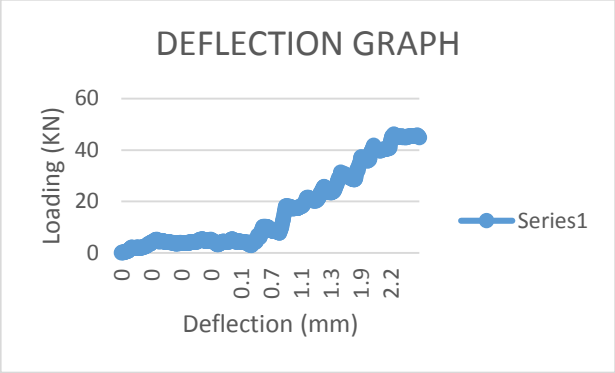

Fig 6.1 Deflection graph

7. CONCLUSION

- The test result indicates that split tensile strength increases in M25 grade of concrete
- Flexural strength is maximum at 65 kN where as normal M25 grade can achieve as this much.

7.1 SUMMARY

- The use of steel concrete composite beams is much effective than ordinary RCC beam.
- The study concluded that flexural strength of composite beam is achieved as maximum than RCC beam.
- The cost the beam is little higher than the ordinary RCC beam.
- This type of construction is used for high storey building and fire resisting build which is much effective than ordinary RCC construction.

8. REFERENCES

[1] **Tai-Kuang Lee and Austinc D. E. Pan,** "Analysis of composite beam-columns under lateral cyclic loading", Journal of Structural Engineering / February 2001, 127(2): 186-193.

[2] **Lin-Hai Han, Zhi-Bin Wang, Wu Xu and Zhong Tao,** "Behavior of Concrete Encased CFST Members under Axial Tension", Journal of Structural Engineering, © ASCE, ISSN 0733-9445.

[3] **Pedro R. Mufioz, Member,ASCE, and Cheng-Tzu Thomas Hsu,2Fellow, ASCE,** "Behavior Of Biaxially Loaded Concrete-Encased Composite Columns", Journal of Structural Engineering,Vol. 123, No. 9, September, 1997. ©ASCE, ISSN 0733-9445/97/0009-1163-l.

[4] **S. A. Mirza, F.ASCE and E. A. Lacroix,** "Comparative Strength Analyses of Concrete-Encased steel composite columns", Journal of Structural Engineering, Vol. 130, No. 12, December 1, 2004. ©ASCE, ISSN 0733-9445/2004/12-1941–1953.

[5] **Chang-Soo Kim, Ph.D., Hong-Gun Park, M.ASCE, Kyung-Soo Chung, Ph.D. and In-Rak Choi, Ph.D.,** "Eccentric Axial Load Capacity of High-Strength Steel-Concrete Composite Columns of Various Sectional Shapes", Journal of Structural Engineering, © ASCE, ISSN 0733-9445/04013091(12).

[6] **Mahbuba Begum, Robert G. Driver, M.ASCE and Alaa E. Elwi, M.ASCE**, "Finite-Element Modeling of Partially Encased Composite Columns Using the Dynamic Explicit Method", Journal of Structural Engineering, Vol. 133, No. 3, March 1, 2007. ©ASCE, ISSN0733-9445/2007/3-326–334.

[7] **P. Visintin, D. J. Oehlers, M. Haskett and C. Wu,** "Mechanics-Based Hinge Analysis for Reinforced Concrete columns", Journal of Structural Engineering, Vol. 139, No. 11, November 1, 2013. ©ASCE, ISSN 0733-9445/2013/11-1973–1980.

[8] **B. Lakshmi and N. E. Shanmugam**, "Nonlinear Analysis of In-Filled Steel-Concrete Composite columns", Journal of Structural Engineering, Vol. 128, No. 7, July 1, 2002. ©ASCE, ISSN 0733-9445/2002/7-922–933.

[9] **Charles W. Roeder, Member, ASCE, Robert Chmielowski, A Associate Member, ASCE, and Colin B. Brown, Honorary Member, ASCE, "**SHEAR CONNECTOR REQUIREMENTS FOR EMBEDDED STEEL SECTIONS", Journal of Structural Engineering, Vol. 125, No. 2, February, 1999. ©ASCE, ISSN 0733-9445/99/0002-0142 – 0151/ Paper No. 18089.

[9] **Sherif El-Tawil, Assosiate Member, ASCE, and Gregory G. Deierlein, Member, ASCE, "**STRENGTH AND DUCTILITY OF CONCRETE ENCASED COMPOSITE COLUMNS", Journal of Structural Engineering, Vol.125, No. 9, September, 1999. ©ASCE, ISSN 0733-9445/99/1009–1019/ Paper No. 19768.

[10] **Chang-Soo Kim, Hong-Gun Park, M.ASCE, Kyung-Soo Chung, Ph.D. and In-Rak Choi, Ph.D.,** "Eccentric Axial Load Testing for Concrete-Encased Steel Columns Using 800 MPa Steel and 100 MPa Concrete", Journal of Structural Engineering, Vol. 138, No. 8, August 1, 2012. ©ASCE, ISSN 0733-9445/2012/8-1019–1031.