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Experimental Investigation on Flexural Strength of Steel-Concrete Composite Beam

B.J Karthikeyan[1], R.S Lakshan[2]

[1]*Assistant Professor, Dept. of Civil Engineering, Vel Tech High Tech Dr. Rangarajan Dr. Sakunthala Engineering College, Tamil Nadu, India*

[2]*Post-Graduate Student, Dept. of Civil Engineering, Vel Tech High Tech Dr. Rangarajan Dr. Sakunthala Engineering College, Tamil Nadu, India*

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Abstract - *The flexural behaviour of steel-concrete composite beam is to be determined using experimental investigation. Flexural strength is a critical property for beam elements. It is used to predict the failure method of the beam element by applying concentrated load at two or more points. A composite beam is fabricated by casting a concrete beam on a steel I-section suitable dimension. The steel and concrete section is joined together using stud connectors. This makes the steel-concrete composite beam to behave as a T-beam. On determining the flexural strength of a beam we can conclude whether a Steel-concrete composite beam can be an efficient alternative in structures.*

Key Words: Flexural Behaviour, Composite Beam, Stud Connectors, I-section, T-beam

1. INTRODUCTION

Steel-concrete composite structures have been used extensively in bridges, both highway and railway bridges, due to the benefits of combining the two construction materials, their higher span-to-depth ratio, reduced deflections, and higher ratios than traditional steel or concrete beam structures (Lin et al., 2016a). For simply supported composite beams, the concrete is in compression and the steel is in tension, the composite section is strong to sustain the external loads. For composite beams in the negative moment regions, however, the concrete slab is in tension and the lower flange of the steel beam is in compression which generally has shortcomings in view of the durability, loading capacity, and service life of the structures as shown in Fig. 1.1, for the negative bending moment regions, the concrete cannot resist the tensile stress and therefore cracking occurs, thus only the embedded reinforcement is still effective in resisting moment. Simultaneously, the steel section near the intermediate support is in compression, and the buckling becomes possible and should be considered in the design. The images of the composite girder subjected to negative bending moment in the laboratory test are shown in Fig. 1.1

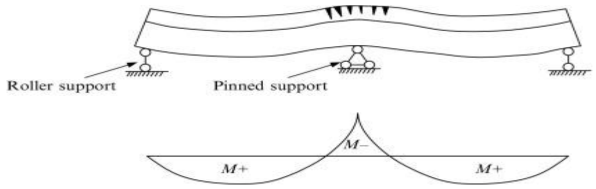

Fig -1: Composite girder subjected to negative bending moment

1.1 Scope

The steel section and concrete act compositely to resist axial force and bending moments. A composite tubular column was developed because they provided permanent and integral formwork for a compression member and were instrumental in reducing construction time and consequently costs. They reduce the requirement of lateral reinforcement and costly tying, as well as provide easier connection to steel beams of a framed structure. Composite slabs have been introduced recently to consider the increase in strength that can be achieved if the profiled steel sheeting is taken into account in strength calculations. Composite slabs provide permanent and integral reinforcement, which eliminates the need for placing and stripping of plywood and timber formwork. More recently, composite slab and beam systems have been developed for reinforced concrete framed construction; this provides advantages similar to those attributed to composite slabs for reinforced concrete slab and beam systems. These advantages include reduced construction time due to elimination of formwork and elimination of excessive amounts of reinforcing steel. This subsequently reduces the span-to depth ratios of typical beams and also reduces labour costs.

1.2 Advantages of Composites

For building members, the solution need not be restricted to elastic concepts, therefore the testing program was planned so that the ultimate strength of members could be carefully investigated, and Elastic design has been found to possess certain shortcomings in both reinforced concrete design and steel design. These shortcomings still exist when the two materials are combined into a composite member, One additional disadvantage of elastic design occurs with regard to the design of shear connectors, Elastic design concepts are not able to provide an answer to the question of what is the minimum number of shear connectors required in a composite member which will carry only static loading

2. METHODOLOGY AND MATERIALS

2.1 Methodology

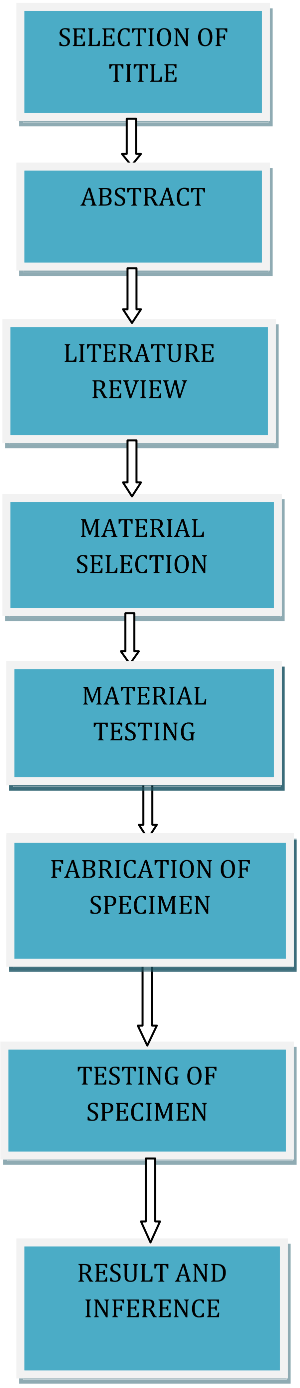

Fig -2: Flowchart

2.2 Materials Used

Cement

In entire project OPC 43 grade cement conforming to IS12269-1987 was used. Cement is a binding material used in the preparation of concrete. It binds the coarse aggregate and fine aggregate with help of water, to form a monolithic material and also it fills the fine voids in the concrete.

Fine aggregate

Locally available river sand is used as fine aggregate. Sand is a naturally occurring granular material composed of different particle size. Seashore sand may contain chloride, which may cause corrosion to reinforcement. Hence river sand is mostly preferred as fine aggregate.

Coarse aggregate

It is the aggregate most of which passes through a 4.75mm IS sieve and contain only so much coarser material as is permitted by the specification. According to the sieve, the fine aggregate may be described as coarse, medium and fine sand.

Water

Water is an important ingredient of concrete as it actively participates in hydration process that is chemical reaction between cement and water to harden the concrete. Water used for concrete preparation is free from objectionable quantities of oil, acid, alkali, salt and organic matter.

Mild Steel

Mild steel is used in the composite section as a part of the beam element to add strength to the beam element. It is connected using shear connectors with the concrete section to ensure composite action of the element. The behaviour of the beam as a composite beam by using ISHB 150 at 30.6 kg/m is used as the steel section.

3. TESTING AND RESULTS

3.1 Testing

After curing of the beams for the entire period of 28 days the beams are tested for flexural strength using two-point load test in a UTM. The support span of 900 mm is chosen to conduct the test. The two points for load application are at distance of 200 mm from the centre of the beam.

Table -1: Result of Flexural test for Beam 1

Load (Kn)	Deflection (mm)	Flexural Strength (N/mm^2)
0	0	0
10	0	1.13
20	0	2.25
30	0.02	3.38
40	0.08	4.5
50	0.18	5.63
60	0.21	6.75
70	0.35	7.88
80	0.44	9
90	0.58	10.13
100	0.68	11.25
110	0.76	12.38
120	0.84	13.5
130	0.93	14.63
140	1.02	15.75
150	1.3	16.88
160	1.38	18
170	1.45	19.13
180	1.75	20.25
190	1.9	21.38
200	2.01	22.5
210	2.23	23.63
220	2.61	24.75
225	2.83	25.31

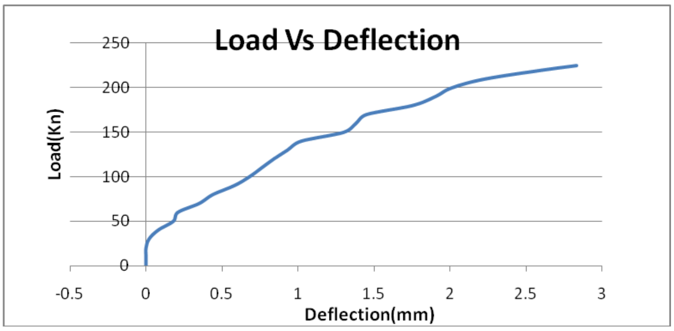

Chart -1: Load Vs Deflection Curve for Beam 1

Table -2: Result of Flexural test for Beam 2

Load (Kn)	Deflection (mm)	Flexural Strength(N/mm^2)
0	0	0
10	0	1.13
20	0	2.25
30	0.04	3.38
40	0.13	4.5
50	0.2	5.63
60	0.26	6.75
70	0.38	7.88
80	0.46	9
90	0.61	10.13
100	0.7	11.25
110	0.79	12.38
120	0.86	13.5
130	0.95	14.63
140	1.03	15.75
150	1.28	16.88
160	1.42	18
170	1.5	19.13
180	1.71	20.25
190	1.88	21.38
200	2	22.5
210	2.19	23.63
220	2.45	24.75
225	2.58	25.31
230	2.87	25.88
237	3.15	26.66

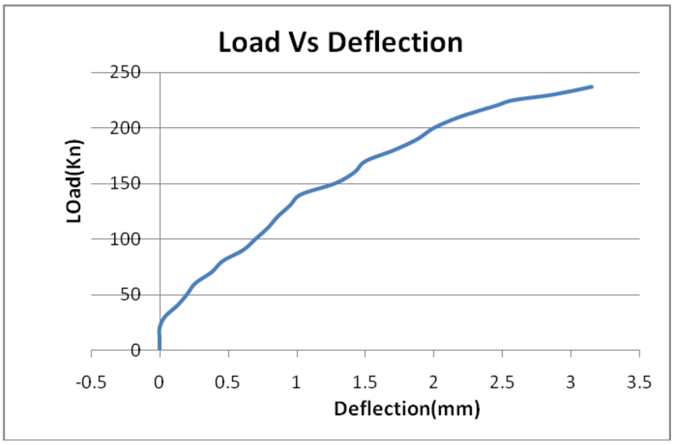

Chart -2: Load Vs Deflection Curve for Beam 2

Using the above tables and graphs it can be inferred that the ultimate load for the beam1 and beam2 are 225Kn and 237Kn respectively. Beyond these values of ultimate load when load is applied the deflection continues to decrease and leads to failure. The maximum flexural strength for the beams can be taken as 25.31 N/mm^2 and 26.66 N/mm^2 respectively for the beams.

The mean flexural strength is found to be 25.98 N/mm^2 which is much greater than corresponding flexural strength for Reinforced concrete beams of M25 grade concrete. M25 grade concrete itself has a flexural strength of 3.5 N/mm^2. Hence we can infer that in terms of flexural strength steel-concrete composite beam is more efficient than conventional reinforced concrete beams.

3. CONCLUSIONS

The first phase of the project was concluded by studying the literatures to understand the research work carried out in the area of steel-concrete composites. This helped to choose the nature of the project work to be carried out and the methodology to be followed. There is already a large amount of work done in studying behaviour of steel concrete composites. Through this project we hope to create an experimental proof for the efficiency of steel-concrete composite beams. Material selection and testing was completed in this phase and materials to be collected for the next phase were decided.

In the second phase the casting of the beams was done and beams were allowed to undergo curing. After the curing period of 28 days the beams were tested for flexural strength using two point load test. In the test results that were obtained, it was found that flexural performance of Steel-concrete composite beams is higher when compared to conventional reinforced concrete beams. This aspect has been proven experimental in this project

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