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Study on Flexural Behaviour of RCC Slab Filled with Hollow Roofing Tiles

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Abstract:
The whole weight of the building is very much influenced by the self- weight of the reinforced concrete. In order to reduce the amount of concrete and self-weight of slabs, normally preferred slabs are voided slabs or hollow slabs. Such slabs have inherent benefits including reduced weights, economical longer spans, reduced floor-to- floor heights etc. Cost reductions in roofs/ floors are achieved through the adoption of filling a part of concrete in tension zone with cheaper substitutes. Roof tiles are better substitutes; here the concrete consumption as well as reinforcement could be significantly controlled. In this paper a hollow roofing tile is used as a filler material so that portion of concrete below the neutral axis can be replaced by these materials. Flexural behaviour of the slab is conducted using the loading frame equipment. The test specimen consists of a solid slab as a reference slab, a hollow core slab with fully covered hollow roofing tile on the bottom region, and a hollow core slab with hollow roofing tile only on all the four edges. The diameters of the steel reinforcement used are 8mm and 6mm deformed bars. The slab thickness was 13 cm. The results showed that hollow core slab can reduce the weight as compared to the solid slab. Flexural strength of hollow core slab with hollow roofing tile only on all the four edges is having higher value than the hollow core slab with fully covered hollow roofing tile on the bottom region; whereas these are lower than the solid slab. The value of ultimate loading capacity of solid slab is greater than the hollow concrete slabs. However, the hollow slab satisfies the design criteria.

Keywords—**Flexural behaviour, hollow slabs, hollow roofing tile.**

I. INTRODUCTION

A concrete slab is a common structural element of modern buildings. Slabs in buildings mainly support dead and live loads. Since a large portion of the building's weight is caused by the dead load, reducing self- weight of slabs is necessary in order to reduce the total cost of structures. The increasing of slab thickness makes slab heavier, and it leads to increase column and base size. Thus, it makes building consume more materials such as concrete and steel. One of the alternatives to reduce this increase in slab weight is to adopt slab with hollow roofing tiles, normally referred as filler slabs.

Filler-slab technology is nothing but an alternative of R.C.C. slab. The reason why, concrete and steel are used together to construct RCC slab, is in their individual properties as separate building materials and their individual limitation. Concrete is good in taking compression and steel is good in tension. Thus Reinforced Cement Concrete (RCC) slab is a product which resists both compression as well as tension. The basic concept behind the use of filler-slab technology is to reduce the use of substantial portion of concrete below the neutral axis. A lot of concrete below the neutral axis does not contribute to the tensile properties, hence serves only as filler material. This portion of concrete can be replaced by locally available and light weighted filler materials such as double-layer Mangalore tiles, hollow burnt bricks or conventional bricks, hollow concrete blocks, etc., which are less costly, locally available and possess better thermal insulation properties. It reduces the dead load of the slab as these materials are light in weight as compared to the conventional R.C.C. slab that uses concrete only. This in turn reduces the quantity of reinforcementused in the slab thereby reducing the cost of the slab.

In this study a hollow roofing tile is used to serve the purpose of filler material. The relevance of this paper comes with the ease of availability of materials and a variety of inherent features of using this hollow roofing tile, as a substitute for the bottom portion of concrete below the neutral axis of the slab. Various studies related with hollow slabs were available whereas use of these hollow roofing tiles was limited.

II. METHODOLOGY

A. Material properties

The various materials that are used in this study and its material property tests are carried out as per IS specification. The material that are used in this study are portland pozzolana cement of 2.9 specific gravity, M sand as fine aggregate with 2.44 specific gravity, crushed granite of 20mm size as coarse aggregate with 3.03 specific gravity, steel reinforcement of 6mm and 8mm diameter deformed bars and the hollow roofing tile of 35x 25x 6.5 cms, each weighing 4.5 kgs. Mix design is prepared with the aid of IS 10262: 2009 and the obtained mix proportion for M20 grade is 1: 1.67: 3.67 with water cement ratio of 0.55.

B. Specimens

Cubes of sizes 150x150x150 mms were utilized to investigate the compressive strength of concrete. The slab specimen consists of a conventional RCC slab functioning as a reference specimen (Fig. 1), hollow slabs SB- 1 with hollow roofing tile fully covered on the bottom region (Fig. 2) and hollow core slab SB- 2 with hollow roofing tiles only on all the four edges (Fig. 3). The properties of the slab used are as follows:

- Cross- section : 1mx 1.05m
- Thickness : 0.13m

All the slabs were casted in the mild steel mould which can be adjusted to required dimensions. For the required specimens to be casted the mould is also arranged as per the slab dimensions i.e. 1m x 1.05 m.

Fig. 1 Reference slab SB- C

Fig. 2 Hollow core slab SB- 1

Fig. 3 Hollow core slab SB- 2

C. Test setup

The specimens were simply supported and subjected to point load at the center. Linear variable differential transducers (LVDT) were placed at center bottom and at diagonal of the slab bottom. LVDT is used to measure the displacement of the test specimens. The measured displacement is displayed in the digital indicator and further it is connected to the Data Acquisition system (DAQ).

The load is applied at each step and continued until failure. Compression type load cells are used to measure the load applied on the test specimen, in which it is fixed to the ram of the hydraulic jack, which will be pressing the specimen under the given load. The failure load was defined as a load that caused the specimen to fail in flexure or that caused failure at the interface between the substrate and overlay. Mid-span deflections were recorded for every load increment.

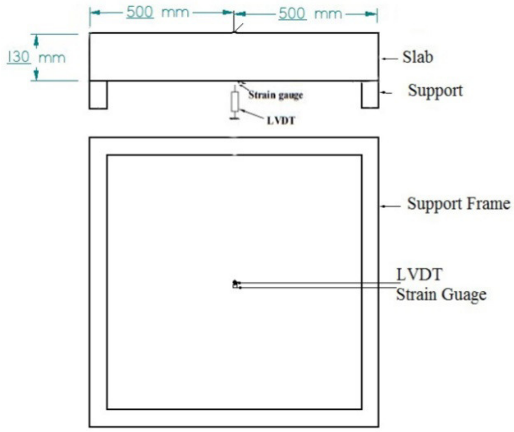

Fig. 4 Schematic diagram of test set up

The DAQ software, used to take the reading should be set to zero in order to find out the maximum load and the deflection coming to the slab as a result of gradual load application. The fig. 4 shows the test set up of the hollow core slab.

Fig. 5 Hollow core slab test set up

III. RESULTS AND DISCUSSIONS

Table I presents the self- weight of each specimen. Hollow core slab SB- 1 and hollow core slab SB- 2 reduced the weight by 33% and 28% respectively compared to the reference slab SB- C.

TABLE I THE SELF- WEIGHT OF EACH SPECIMEN

Sl No.	Slab	Weight (kg)
1	SB- C	328
2	SB- 1	218
3	SB- 2	236

After the testing of different specimens under loading frame machine, different test results are obtained. During testing, the load corresponding to the first crack point is noted as well. The loading frame machine automatically tabulates the test results in the system associated with the machine. From these data the failure load and the corresponding deflection for each specimen is noted down and is shown in Table II.

TABLE II TESTING RESULT

Sl No.	Slab designation	First cracking load (kN)	Ultimate load(kN)	Deflection(mm)
1	SB- C	53	94.3	16.46
2	SB- 1	26	42.6	10.55
3	SB- 2	23.2	47.3	8.43

Load vs. Deflection graph for each specimen is plotted based on the results obtained from loading frame machine. From these plotted graphs, the comparison graph between each specimen is also drawn and is shown in Fig. 9.

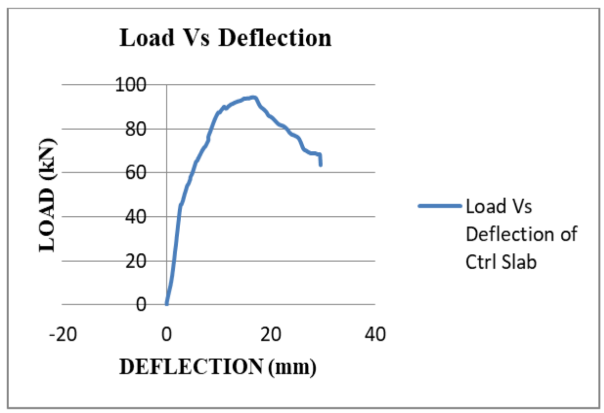

Fig. 6 Load vs. deflection graph for SB- C

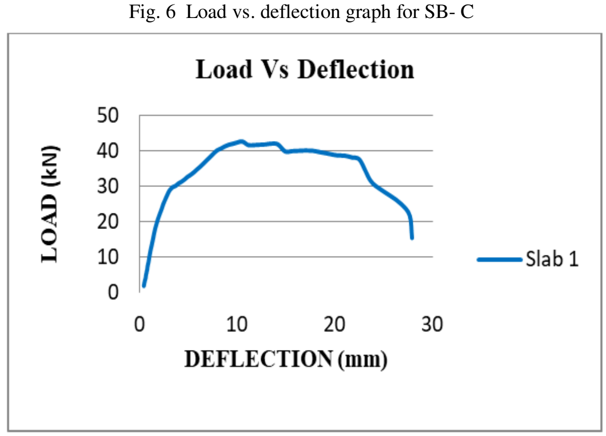

Fig. 7 Load vs. deflection graph for SB- 1

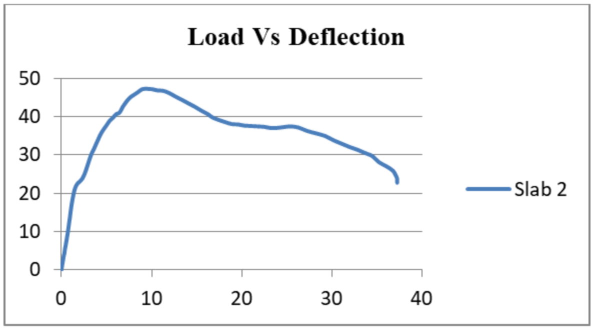

Fig. 8 Load vs. deflection graph for SB- 2

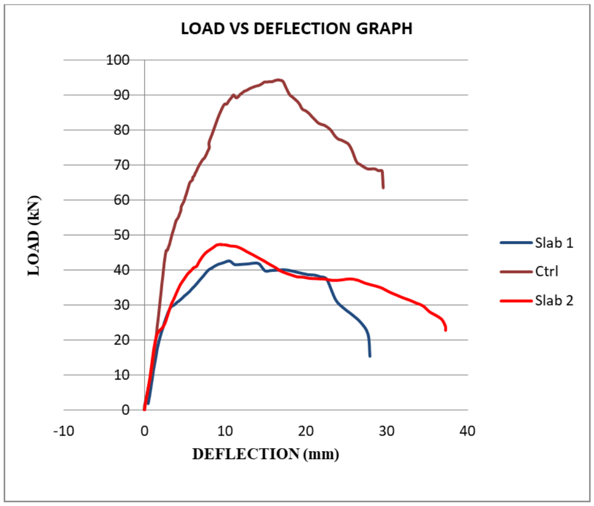

Fig. 9 Load vs. deflection comparison graph

From the above graph, it is seen that the slab SB- 2 is having higher load carrying capacity compared to that of the slab SB- 1. However, the maximum load carrying capacity is found on the conventional slab SB- C.

Based on the Table 2, the bar chart for different test results are plotted and compared and is shown below:

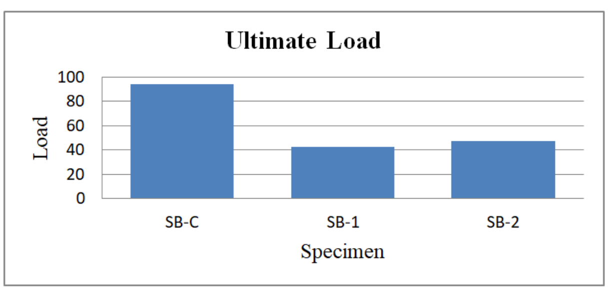

Fig. 10Bar chart representing ultimate load of different specimen

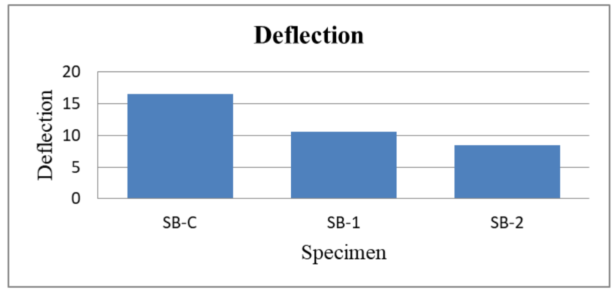

Fig. 11Bar chart representing deflection of different specimen

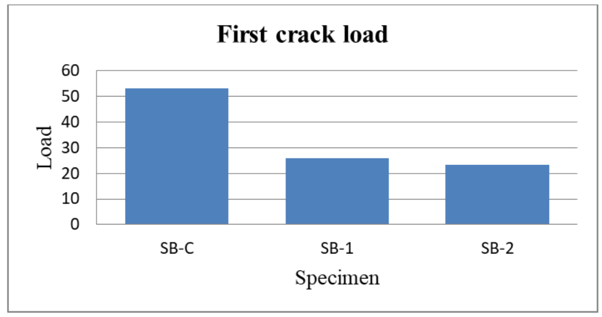

Fig. 12Bar chart representing first crack load of different specimen

From the observations, after the testing of specimens, it was seen that the crack pattern that was formed on the conventional RCC slab was flexural crack. While the cracks that occurred on the hollow core slabs SB- 1 and SB-2 were shear cracks.

IV. CONCLUSIONS

Experimental investigations on control specimen and slab with different arrangement of the hollow roofing tiles were carried out. Load carrying capacity, maximum deflection and failure patterns were analysed.

- The maximum load carrying capacity found on the control specimen is 94.3 kN and the central deflection corresponding to that load is 16.46mm.
- By reducing the self-weight of slab SB – 1 of about 33.52 %, compared to that of normal slab SB – C, the maximum load carrying capacity is 42.6 kN and the central deflection corresponding to the maximum load is 10.55mm.
- By reducing the self-weight of slab SB – 2 of about 27.93 %, compared to that of

normal slab SB – C, the maximum load carrying capacity is 47.3 kN and the central deflection corresponding to the maximum load is 8.43mm.

- In comparison with the two test specimens SB- 1 and SB- 2, the slab with hollow roofing tiles only on the edges is having a higher load carrying capacity of about 9.93 % compared to the other one. Whereas the deflection is more for the slab SB-1 of about 20.13%.

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