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Experimental Study on Flexural Performance of Precast Concrete Slab with Fiber Reinforced Concrete Topping

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Abstract:

The positive effects of various types of fibers on concrete ductility and other engineering properties, such as the tensile, flexural, fatigue, toughness and load-bearing capacity after cracking and toughness, are well known. Steel fibers as well as glass fibers have been used increasingly along with concrete in recent years and they show positive results. Considerable interest has been developed in using these fibers in concrete to increase the load-carrying capacity of the structural members in service. Recently, it has been used to improve the capacity of concrete slabs by applying a layer of concrete layer onto an existing slab. It is to be investigated about the flexural behaviour of a precast concrete slab with a steel fiber of different proportion as well as glass fiber concrete topping. The performance of this composite slab depends on the bonding between the old and new concrete. The interface has been chipped using chipping tools to provide good bonding between the two layers. Researches were made on slabs with steel fiber reinforced topping and improved the performance of the specimen when SFRC topping was made compared with slab with normal steel reinforced concrete topping. So here the slabs without topping, slab with normal steel reinforced topping, slab with SFRC topping and slab with glass fiber reinforced concrete topping were casted and tested. Based on tests, the flexural performance depends on the type of reinforcement provided to the topping. When FRC topping was used, the flexural capacity was found to increase and as a result, the central deflection of specimens with FRC topping were considerably decreased. Among these, slab with SFRC topping had better performance compared to others.

Keywords — **Glass Fiber, Steel Fiber, Overlay, RCC, Topping, Flexural Capacity**

I. INTRODUCTION

Overlay technique has been used to strengthen the performance of concrete slabs by adding a layer of reinforced concrete to the existing slab. The purpose is to improve the load-carrying capacity of the slab by increasing its thickness. Precast concrete flooring offers versatile solution to ground and suspended floors in any type of building construction. Cast in-situ concrete toppings are added to precast slab for the purpose of making a completed floor finish, or, more usually, to enhance the structural performance of the floor by producing a composite structure. In-situ concrete is usually cast on a precast slab and there is usually no reinforcement provided between the two concretes. Reliance has to be made on the bond and shear strength between the contact surfaces.

The in-situ concrete toppings are usually 40 to 100 mm in thickness, and contain a small amount of steel reinforcement to control shrinkage. The concrete toppings compressive strength usually varies between 25 to 40 N/mm^2. Steel reinforcing in the form of tied bars and welded mats is normally used for overlay reinforcement. However, using steel bars or welded fabric behind thin covers lead to wide cracks and can only be used in relatively thick overlays. Substitution of fibers in concrete is expected to overcome these problems and delay overlay debonding. Fibers are not affected by such constraints and, they present a reduced risk of corrosion. Fibers also reduce the amount of steel bars required and accelerate the construction time because they are added directly to the concrete. Although all types of reinforcement act in similar ways, the studies show that fiber reinforcement has a higher effectiveness It has been recognised that the behaviour of concrete remarkably improves by reinforcing it with discontinuous fibers. Compressive tests showed that fibers in concrete will increase the strength of concrete little.

II. NEED FOR THE STUDY

There are some drawbacks for concrete. It is a quasi-brittle material, lower tensile strength, low toughness, low specific strength, etc.

- FRC is much tougher
- Better durability
- Improves ductility
- Improvise tensile strength
- Better fire resistant
- Limitations in contraction cracks
- Less weight than RCC

III. EXPERIMENTAL PROGRAMME

Here, the various materials, used for this study were subjected to various tests to identify their basic properties.

A. Material Specification

The materials that are used in the study are

- Portland Pozzolana Cement
- Fine aggregate
- Coarse aggragate
- Steel bars
- Steel fiber and Glass fiber

TABLE I PROPERTIES OF AGGREGATES

Sl. No	Property	Values	
		Fine aggregate	Coarse aggregate
1	Specific Gravity	2.44	3.03
2	Bulk Density	1.360	2
3	Void Ratio	0.8	0.822
4	Porosity	44%	45.2%

TABLE II PROPERTIES OF CEMENT

Sl. No	Property	Value
1	Specific Gravity	2.9
2	Fineness	95.3
3	Consistency	33%
4	Initial setting time	30 min
5	Specific Gravity	15.96 N/mm^2

The steel fiber used as reinforcement is of hooked end type and glass fiber is of alkali resistant type. The mix proportion for th e concrete was found to be 1:1.66:3.67 as a result of mix design

B. Test specimen

Total four specimens were casted for this study. The control specimen is square in plan with a length of 1000 mm and a slab thickness of 100 mm. The slab is lightly reinforced with deformed steel bars. The steel bars with a 8 mm diameter and a spacing of 200 mm is placed in both directions. We provided 20 mm cover. Alternate main bars were cranked at a distance of 250 mm from the edge. Extra piece reinforcement (consisting of 8 mm diameter bars) was also placed.

Fig. 1 Slab casted

For the case of precast slab s with different topping conditions, the precast slab was having the same dimensions as in the case of control specimens were casted and kept for 7 days curing. The toppings were having a thickness of 50mm each reinforced with steel bars,steel fibers and glass fibers respectively.

Fig. 2 Slab with steel reinforced concrete topping

The slab with steel reinforced concrete topping has 8mm diameter bars as reinforcement with spacing of 80 mm which was in the form of mesh.

Fig. 3 Slab with SFRC topping

The slab with SFRC topping (Fig. 3) was having steel fibers as reinforcement whose dosage was in the range of 20-40 kg/m^3 as per company specification. So, here it was adopted in the range of 30 kg/m^3.

Fig. 4 Slab with GFRC topping

The slab with GFRC topping (Fig. 4) was having glass fibers as reinforcement whose dosage was in the range of 1.5-2.5% by volume of concrete, as per company specification. So, here it was adopted 2% by volume of concrete.

Every specimens were cured for 28 days after casting

C. Testing of specimen

The specimens were tested using loading frame where the specimens were lifted and placed. The specimens were whitened by applying a thin layer of white cement for better observation of the development of cracks. The specimens were simply supported and subjected to point load at center. Linear variable differential transducers (LVDT) were placed at bottom center of the specimens.

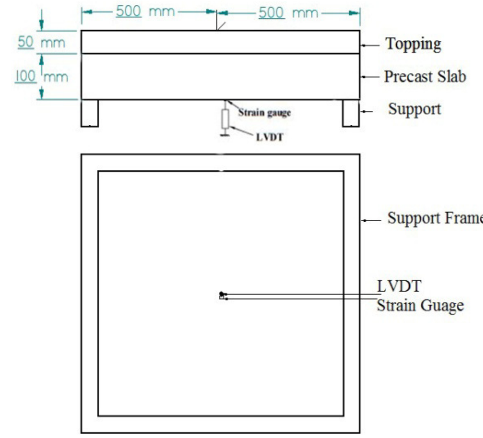

Fig. 5 Test setup

Fig. 6 Slab with topping test setup

LVDT was used to measure the displacement of the test specimen. The load is applied at each step and continued until failure. The failure load is the load that caused the specimen to fail in flexure.

IV. OBSERVATION AND RESULTS

The control specimen and the slabs with topping were tested by using loading frame. The results of the tests are included here.

A. Load Vs Deflection

Maximum load that the all specimens could carry was found as result of load application to the specimens and central deflections of each specimens were also found. The load and deflection will be recorded in the Data Aquisition System software and the results are shown below.

TABLE III CONTROL SPECIMEN

Load (kN)	Deflection (mm)
0	0
16.8	0.39
23.4	0.88
23.8	1.56
28.5	2.5
36	3.41
51.4	5.87
57.7	7.68
64.4	10.41
65.9	14.44
67.2	17.59
60.1	23.33
58.2	24.71

TABLE IV SLAB WITH STEEL REINFORCED CONCRETE TOPPING

Load (kN)	Deflection (mm)
0	0
17.4	0.01
34.6	0.54
45.3	1.74
53.3	2.85
60.4	2.87
69.3	4.55
85.6	6.64
95.4	9.65
103.1	13.79
98.1	17.67
42.8	44.68
31.8	51.65

TABLE V SLAB WITH SFRC TOPPING

Load (kN)	Deflection (mm)
0	0
17.4	0.01
34.6	0.54
45.3	1.74
53.3	2.85
60.4	2.87
69.3	4.55
85.6	6.64
95.4	9.65
103.1	13.79
98.1	17.67
42.8	44.68
31.8	51.65

TABLE VI SLAB WITH GFRC TOPPING

Load (kN)	Deflection (mm)
0	0
17.4	0.01
34.6	0.54
45.3	1.74
53.3	2.85
60.4	2.87
69.3	4.55
85.6	6.64
95.4	9.65
103.1	13.79
98.1	17.67
42.8	44.68
31.8	51.65

The combined Load-Deflection graph is plotted from the above results which is ilkustrated below.

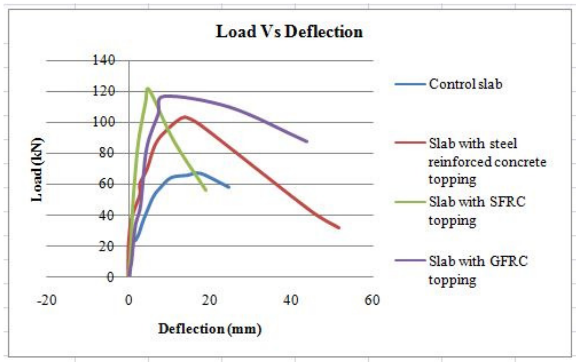

Fig. 7 Comparison of load at first crack

The load corresponding to the first crack point is also noted as well. The whole results needed is tabulated below

TABLE VII MAXIMUM LOAD AND MAXIMUM DEFLECTION AND LOAD AT FIRST CRACK

Specimen	Maximum load (kN)	Maximum deflection (mm)	Load at first crack (kN)
Control specimen	67.2	17.59	37.2
Slab with steel reinforced concrete topping	103.1	13.79	47
Slab with SFRC topping	120.9	4.93	61
Slab with GFRC topping	116.7	8.6	55

B. *Comparison of Parameters*

From Fig.7 and TABLE VII , it is clear that for normal slab, the strength is less and the deflection corresponding to maximum load is higher. But, when concrete overlay was laid to the slab, the strength was improved and the deflection at maximum load has got reduced. The slab having SFRC topping could withstand more load among the specimens with topping and whole deflection is minimum among the four specimens. The comparison of maximum load, maximum central deflection and load at first crack is given using bar charts.

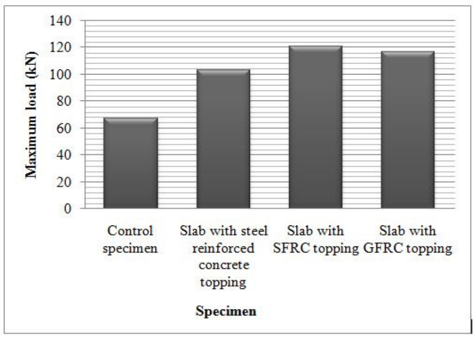

Fig.8 Comparison of load at first crack

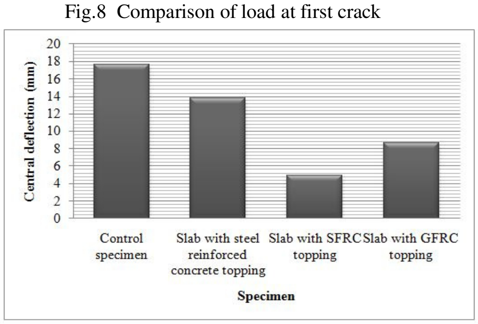

Fig.9 Comparison of central deflection

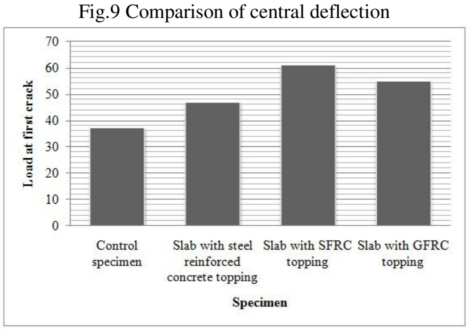

Fig.10 Comparison of load at first crack

The crack patterns of the specimens after testing was observed. **Matthew J. Radik et al** reported almost same crack pattern as result of their experimental programme with two way slab with polypropylene fiber reinforcement.

V. CONCLUSION

Four specimens; ie, control slab, three precast slabs each with normal steel reinforced topping, SFRC topping and GFRC topping respectively were casted with a slab thickness of 100mm and topping thickness of 50mm and tested using the Loading Frame. From the testing of specimens using loading frame; following conclusion can be made,

- Load carrying capacity of specimens with toppings, were found increased.
- Central deflection for specimens with topping were decreased as compared with control slab.
- Maximum load carrying capacity is found on slab with SFRC topping and is 120.9 kN with 80% load increment
- Precast slab with GFRC topping is having capacity of 116.7 kN with load increment of 74% as compared with slab without topping
- Precast slab with steel reinforced concrete topping is having capacity of 103.2 kN with load increment of 53% when compared to control slab
- The reason for the increased load capacity for the slab with SFRC topping can be due to the uniform distribution throughout the specimen
- Central deflection is minimum in the case of precast slab with SFRC topping and is 4.96 mm only and, is the minimum deflection among all specimens
- The load at first crack for the slab with SFRC topping is 61 kN and for control slab, it is 37.2 kN. The increment in crack strength which is 63% as compared to control slab which may be due to the presence of steel fiber that improves crack strength

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