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High Performance Concrete Two Way Slabs In Flexure Loading

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***Abstract*—This study is main aim is to investigate the High Performance Concrete (HPC) two way slab under impact loading. The development of high performance concrete (HPC) has brought about the essential need for additives both chemical and mineral to improve the performance of concrete. Most of the developments across the work have been supported by continuous improvement of these admixtures. However, for better practical applications, behavior of different structural elements like slabs, beams, columns, etc., made of HPC need to be evaluated. Accordingly, the present work proposes to evaluate the behaviour of HPC two way slabs in flexure, shear and impact loading.**

I. Introduction

High Performance Concrete (HPC) exceeds the properties and constructability of normal concrete. Normal and special materials are used to make these specially designed concretes that must meet a combination of performance requirements. Special mixing, placing, and curing practices may be needed to produce and handle high performance concrete. Extensive performance tests are usually required to demonstrate compliance with specific project needs. High performance concrete has been primarily used in tunnels, bridges for its strength, durability, and high modulus of elasticity. It has also been used in shotcrete repair, poles, parking garages, Irrigation structures and agricultural applications.

Gerd Birkle and Walter H. Dilger (2008) studied the influence of slab thickness on the punching shear strength of flat slabs clearly demonstrated the significant effect of size on the shear stress resistance, particularly for tests without shear reinforcement. New tests were carried out in which the slab thickness varied between 160 and 300 mm and the tests by others with slabs up to 500 mm thick. Concluded that slabs with shear reinforcement increases in shear capacity and ductility when compared with slabs without shear reinforcement.

Jahangir et al., (2009)59 investigated the punching shear capacity of flat slabs. Fifteen slabs were cast and tested ascertain the influence of boundary restraint, influence of flexural reinforcement and the effect of the thickness of slabs and punching load-carrying capacity, monitored crack pattern and load-deflection behaviour of slabs. Punching shear strengths are calculated as per the American, British, Canadian, European and Australian codes and concluded that some codes are not effectively estimated the punching shear strength.

Koh Heng Boon et al., (2009 conducted experimentation on one-way reinforced concrete slabs with rectangular central openings. Five types of RC slabs which include one control slab without opening and remaining four slabs with rectangular opening at the centre, first slab with additional rectangular bars all around the opening, second slab provided additional diagonal bars located at the edge of the opening, for third slab provided additional and rectangular and diagonal bars around the opening and for fourth slab no additional reinforcement is provided. Results shows the reduction of area due to central opening is 15% and the corresponding flexural strength reduces 3.6% and also provision of addition reinforcement around the opening increases the flexural capacity of the RC slab.

Solmaz (2009) reported the slab analysis with yield line method to determine yield line pattern. Correct pattern of yield line should be obtained for exact determination of slab ultimate load. It could be probable more than one yield line pattern for slab. Plastic analysis of some concrete reinforced slabs with ANSYS and the stress and strain distributions were obtained for each case. Also, the yield line pattern for each case was presented and compared.

Stefano Guandalini et al., (2009) presented the results of test specimen on the punching behaviour of slabs without transverse reinforcement and varying flexural reinforcement ratios. The size of the specimens and aggregates was also varied to investigate the effect on punching shear with low reinforcement ratios. The results are compared with design codes and critical shear crack theory. On comparison it was clear that the formulation of ACI 318-08 lead to less conservative estimates of punching strength for thick slab and for lower reinforcement ratios than the test results. Satisfactory results are obtained using Eurocode 2 and the critical shear crack theory.

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II. MATERIAL PROPERTIES

Ordinary Portland cement of 43 grade of Ultra-tech Cement confirming to IS: 8112-1989 standards was used.

The locally available sand confirming to Zone-II grade of Table 4 of IS 383-1970 has been used as Fine Aggregate.

The locally available crushed granite has been used as coarse aggregate in this investigation.

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial use of silica fume in concrete is of its chemical and physical properties, it is a very reactive pozzolan. Elkam brand silica fume is used for the investigation and the properties supplied by the supplier are, colour appears to be Gray, Bulk density is 500 Kg/m^3, specific surface are 15-30 m^2/gm and average particle size is 0.2 micron.

To impart the required workability superplasticizer has been used in this investigation. Superplasticizers are linear polymers containing sulfuric acid groups attached to the polymer backbone at regular intervals.

III. MIX DESIGN

Target Mean Strength for 28 days of the HPC concrete was set as 68.25 MPa, and Control concrete was 31.60 MPa. The water cement ratios for the above mixes used are 0.29 and 0.50 respectively.

IV. MECHANICAL PROPERTIES

Compression testing machine of capacity 2500 KN is used for testing the concrete specimens. While testing the specimens, precautions were taken to ensure load is axial. Tests are conducted on the specimens for cube compression, cylinder compression and split tensile strengths. A Graph is drawn for cube compressive strength Vs percentage replacement of cement by silica fume are shown in Figure 1, similarly graph were drawn for cylindrical compressive strength Vs percentage replacement of cement by silica fume and split tensile strength Vs percentage replacement of cement by silica fume and are shown in Figure 2 and 3 respectively.

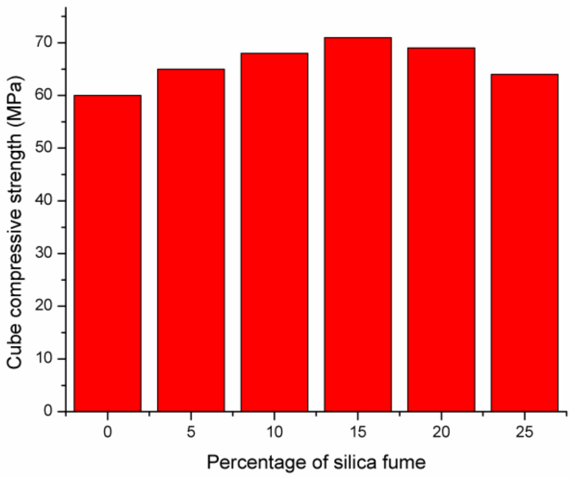

Fig.1: Percentage of silica fume Vs Cube compressive strength

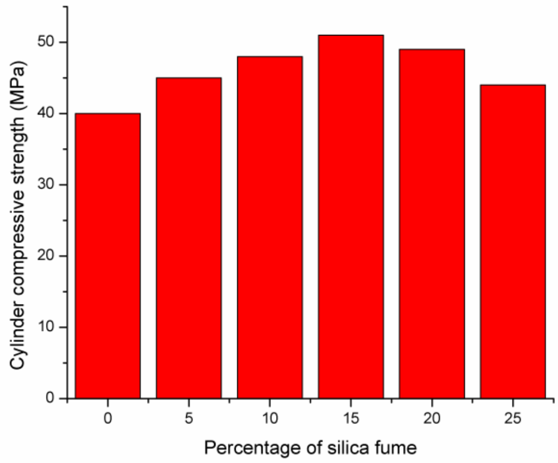

Fig: 2: Percentage of silica fume Vs Cylindrical compressive strength

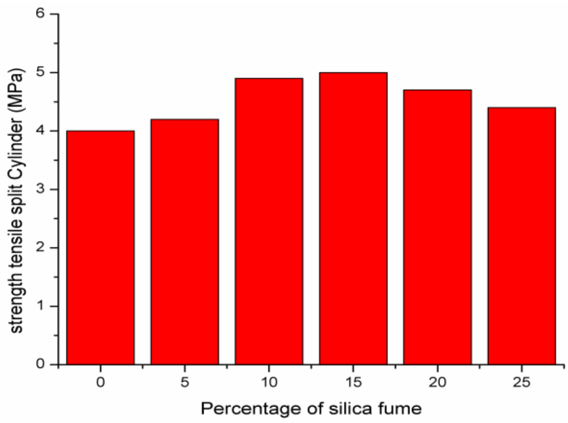

Fig: 3: Percentage of silica fume Vs split tensile strength

V. *BEHAVIOUR OF HIGH PERFORMANCE CONCRETE TWOWAY SLABS IN FLEXURE*

VI. *The behaviour of flexure strength is very important aspect for the slabs, because in major applications they have to resist various flexural loads. The detailed review of literature is presented in chapter-2, it is observed that little information were available on the flexural behaviour of HPC two way slabs though major research has been carried out on RCC. Hence investigation has to be carried out to detect the effect of different edge conditions on flexural behaviour of HPC slabs. Hence, there is a need to investigate the flexural behaviour of HPC slabs, accordingly experimental investigation had been carried out in the present work. The details of experimentation and analysis of various results obtained are presented in this chapter to understand the flexural behaviour of HPC and RCC slab specimens. Based on the present experimental results and yield line pattern for HPC slabs (HPC-0 to HPC-25) have been studied for different edge conditions using yield line theory.*

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A Total of 21 slab specimens were cast for simply supported condition for flexure, in which 18 slabs specimens are HPC and remaining 3 slabs are RCC slab specimens. The slab specimens were tested and the results are discussed below.

A. First crack load

The first crack loads of slab specimens tested in the investigation are tabulated in Table 1. The values presented represent, the average of flexural strengths, load and their deflection obtained for three specimens in each group.

Table 1: First crack load of simply supported slab specimens

Sl.No	Specimen ID	First crack load (kN)
1	HPCS-0	31.65
2	HPCS-5	33.32
3	HPCS-10	34.15
4	HPCS-15	34.98
5	HPCS-20	34.15
6	HPCS-25	33.32

B. Ultimate load

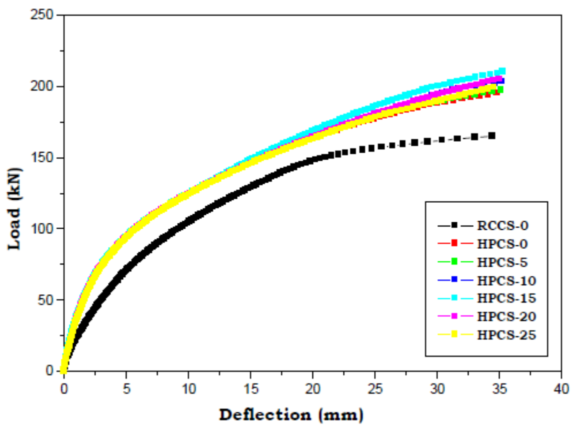
The ultimate loads of the present experimental investigation are summarized in Table 2. The values presented here represent the average of flexural load and their corresponding deflection obtained for three specimens in each group.

Table 2: Ultimate load of simply supported slab specimens

Sl.No	Specimen ID	First crack load (kN)
1	HPCS-0	187.42
2	HPCS-5	204.08
3	HPCS-10	212.41
4	HPCS-15	224.91
5	HPCS-20	208.25
6	HPCS-25	195.75

C. Load deflection response

The central deflections of various slab specimens are recorded at first crack and are listed in Table 4.4. The central Load Vs deflection response of various slab specimens is shown in Figure. 4.7. From Figure 4.7 and Table 4.4 it is observed that central deflections corresponding to first crack load of HPCS-0 to HPCS-15 is decreased from 1.16 to 1.04 mm and for HPCS-15 to HPCS-25 the central deflection is increased from 1.04 to 1.11 mm and that of RCCS-0 is 1.27 mm in flexure. The variations of deflections are more at first crack stage.



Load Vs deflection curves of simply supported slab specimens

VII. CONCLUSIONS

Based on the results of the experimentation and analysis of the results, following are the conclusions.

1) The literature review carried out led to the identification of the need for conducting the feasibility study of producing HPC slab elements.

2) The cube compressive strengths of HPC-0 to HPC-15 have increased from 59.55 to 71.11 MPa, and for HPC-15 to HPC-25 the values decreased from 71.11 to 63.11 MPa, where as the RCC-0 reported 40.18 MPa.

3) The cylinder compressive strengths of HPC-0 to HPC-15 have increased from 47.37 to 55.85 MPa, and for HPC-15 to HPC-25 the values decreased from 55.85 to 48.78 MPa, where as the RCC-0 reported 32.01 MPa.

4) The split tensile strength of HPC-0 to HPC-15 have increased from 5.12 to 5.66 MPa, and for HPC-15 to HPC-25 the values decreased from 5.66 to 5.33 MPa, where as for RCC-0 reported a

split tensile strength 3.21 MPa.

5) The first crack loads of HPCS-0 to HPCS-15 have increased from 31.65 to 34.98 kN and HPCS-15 to HPCS-25 decreased from 34.98 to 33.32 kN, where as RCCS-0 reported 29.98 kN. For first crack load there has an increase of 5.57 to 16.68%, when compared with RCCS-0 in flexure.

6) The ultimate loads of HPCS-0 to HPCS-15 have increased from 187.42 to 224.91 kN and HPCS-15 to HPCS-25 decreased from 224.91 to 195.75 kN, where as RCCS-0 reported 174.09 kN. For ultimate load there is an increase of 7.66 to 29.19%, when compared with RCCS-0 in flexure.

7) The central deflections corresponding to first crack load of HPCS- 0 to HPCS-15 are 1.16 to 1.04 mm and for HPCS-15 to HPCS-25 the central deflection are 1.04 to 1.11 mm and that of RCCS is 1.27 mm in flexure.

8) The central deflections corresponding to ultimate load of HPCS-0 to HPCS-15 are 34.84 to 35.30 mm and for HPCS-15

to HPCS-25 the central deflection are 35.30 to 34.60 mm and that of RCCS is 34.46 mm in flexure..

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