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EXPERIMENTAL INVESTIGATION ON HIGH PERFORMANCE CONCRETE USING FIBRE & NON FIBRE MIXTURES

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ABSTRACT

The high performance concrete (HPC) are cementious composites with enhanced material properties like high compressive strength, high durability, high fatigue resistance etc. The HPC mix composites are characterized by high grade cement, fly ash, quartz powder and superplasticizer. The water cement ratio (W/C) is generally low, the coarse aggregate and fine aggregate are used. 25% replacement of cement, fly ash and sand by quartz powder in addition of low SP and 0.5% volumetric fraction of nylon fibre to the cubes exhibit the maximum compressive strength, which was determined by the comparison.

Key words: High performance concrete, Fly ash, Quartz powder, HRWR, Superplasticizer, Compressive strength.

INTRODUCTION

High performance concrete is rapidly getting acceptability for a wide range of applications in the construction of concrete structures. HPC is the most widely used construction materials in India with an annual consumption exceeding 100 million cubic meters every year[1]. It is a tailor made material for specific applications, having advantageous properties like high strength, high durability and high workability as compared to the conventional type of normal strength concrete[2]. In this project, experimental efforts were taken to produce High Performance Concrete (HPC), targeting a compressive strength more than 40 Mpa using conventionally available materials. Both Non fibre and fibre mixtures in different proportion were used in the production of HPC. The low percentage of Fly ash and Quartz powder in the HPC (almost 25% of the weight of cement and sand) changes the

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hydration kinetics and mechanical properties. The Fly ash reacts with the Carbon Hydroxide and thus increases the final age strength of the concrete. While quartz powder acts as micro filter in the HPC and the Superplasticizer helps in increasing the workability and strength of the concrete. In this experimental project initiative were taken to produce HPC using both fibre and non fibre mixtures in different mix proportion. Cubes and beams were casted that are cured using water for 7 days, 14 days and 28 days, respectively. Then the compressive strength for cubes and flexural strength for beams were calculated, respectively.

Need for study

The maximum demand for OPC (ordinary Portland cement) and FA (fine aggregate) can be minimized by the partial replacement using Fly ash and Quartz powder respectively. The compressive strength of HPC can be targeted above 40 Mpa. The amount of water can be reduced by adding HRWR or SP in HPC in order to attain more strength and workability. The compressive strength and flexural strength of the specimens moulded can be increased by addition of fibres.

Objectives

(i) To prepare HPC using fibre and non fibre mixtures of various proportions.

(ii) To attain a compressive strength of above 40 Mpa using HPC.

(iii) To compare the variation between conventional concrete and HPC

EXPERIMENTAL

Materials used

Ordinary Portland cement: Ultra-tech Cement 53 Grade was used in this experimental study. It provides high strength and durability of the structures because of its optimum particle size distribution superior crystalline structure. It attains a compressive strength of 53 Mpa on 28 days. The materials used were shown in Fig. 1.

Fly ash: It improves long term strength, later age strength and durability performance of the concrete and even the rate of concrete bleeding are reduced while the workability is increased.

Quartz powder: It acts as a reactive powder which produces concrete that is more strong and durable than conventional concrete, reduces permeability and porosity and increases the early age strength of concrete.

Fine aggregate (Standard fine sand less than 2.36 mm size): It binds all the component of concrete together and reduces permeability and porosity.

Nylon fibre (3 cm long): It enhances durability and toughness to the concrete, provides resistance to concrete spalling and protects reinforced bars from corrosion.

Coarse aggregate – Gravel (20 mm size): It increases the impact strength of the concrete, helps in attaining high compressive strength by binding all the ingredients of the concrete together.

High range water reducer or super plasticiser (Conplast SP430 DIS): It is primarily highly efficient superplasticizer giving large increase in workability without significant change in compressive strength.

Table 4.1: Specific gravity of materials

Material	Specific gravity
Cement	3.16
Fly ash	2.80
Quartz powder	2.80
Fine aggregate	2.45
Coarse aggregate	2.78

Mix proportion

The design mix of all the 7 mix proportions including the conventional concrete for the cubes were shown in Table 2. The Mix proportions were designed by partial replacement of the major ingredients of concrete (Cement, FA) ranging from 25% and 60% partial replacement of cement by Fly Ash and 25%, 50% and 60% replacement of sand by quartz powder; Addition of nylon fibre by volumetric fraction of the total mass of the cube (0.5%) and addition of low amount of Superplasticizer (5 mL per 1 kg cement).

RESULTS AND DISCUSSION

The various cubes of various mix proportions were cast in cubes (150 mm x 150 mm x 150 mm) and were cured in water for 7 days, 14 days and 28 days, respectively. Then compression test was carried out for the cubes using a compression testing machine and thus the following results were obtained.

Conventional concrete cube: It consists of cement, fine aggregate, coarse aggregate and a w/c ratio of 0.30. A comparison of the 7, 14 and 28 days strength which is 19.2 Mpa, 26.1 Mpa and 35 Mpa, respectively. It was shown in Fig. 8.

Mix proportion 1: The cubes of mix proportion shown in Fig. 2, had a partial replacement of 25% of cement by fly ash and a partial replacement of 25% of sand by quartz powder and a low amount of superplasticizer (5 mL per 1 kg cement). It was obtained a compressive strength of 35.11 Mpa, 56.88 Mpa and 70.67 Mpa for the curing period of 7, 14 and 28 days, respectively. The two partial replacements carried out resulted in better results for all the curing period when compared to the conventional concrete cubes.

Mix proportion 2: The cubes of this mix proportion had a partial replacement of 25% of cement by fly ash and a partial replacement of 25% of sand by quartz powder and a low amount of superplasticizer (5 mL per 1 kg cement). And a further addition of 0.5 % volumetric fraction of nylon fibre was added, which was shown in Fig. 3. This proportion attained a compressive strength of 45.33 Mpa, 57.78 Mpa and 71.56 Mpa for the curing period of 7, 14 and 28 days, respectively. While comparing the MP1 and MP2 the only difference was the addition of 0.5% of Nylon fibre. And the same further increase in compressive strength during its early age strength.

Mix proportion 3: The cubes of this proportion had a partial replacement of 25% of cement by fly ash and a partial replacement of 50% of sand by quartz powder and a low amount of superplasticizer added to it which was shown in Fig. 4. The compressive strength of 44.44 Mpa, 57.33 Mpa and 69.33 Mpa for the curing period of 7, 14 and 28 days respectively were obtained. The result shows a further increase in the strength for all the curing periods.

Mix proportion 4: The cubes of this proportion had a partial replacement of 50% of cement by flyash and a partial replacement of 50% of sand by quartz powder and a low amount of superplasticizer added to it. Hence it attains a compressive strength of 39.56 Mpa; 43.56 Mpa and 51.33 Mpa for the curing period of 7, 14 and 28 days, respectively. The result shows a decrease in the compressive strength compared to the above two mix proportions which is due to 50% partial replacement of cement by fly ash.

Mix proportion 5: The cubes shown in Fig. 6 is of this proportion had a partial replacement of 60% of cement by fly ash and a partial replacement of 60% of sand by quartz powder and a low amount of superplasticizer added to it. Compressive strength of 17.78

Mpa; 31Mpa and 43.56 Mpa for the curing period of 7, 14 and 28 days respectively were obtained. The results shows a decrease of compressive strength of concrete at the early age of curing, this is because of the increased percentage of partial replacement of cement by fly ash and a gradual increase of strength with increase in curing period.

Table 5.1: Mix proportion of the cubes

Description	Cement (kg)	Fly ash (kg)	Fine aggregate (kg)	Quartz powder (kg)	Coarse aggregate (kg)	Nylon fibre (g)	Sp (mL)	W/c
CC	2.273		1.864		4.773			0.30
MP1	1.704	0.560	1.398	0.466	4.773		11.36	0.30
MP2	1.704	0.560	1.398	0.466	4.773	44.5	11.36	0.30
MP3	1.704	0.560	0.903	0.903	4.773		11.36	0.30
MP4	1.136	1.136	0.9032	0.903	4.773		11.36	0.30
MP5	0.909	1.136	0.7456	1.118	4.773		11.36	0.30
MP6	0.909	1.136	0.7456	1.118	4.773	44.5	11.36	0.30

Cement **Fly Ash** **Sand**

Quartz powder **Nylon fibre** **Superplasticizer**

Fig. 1: Materials used

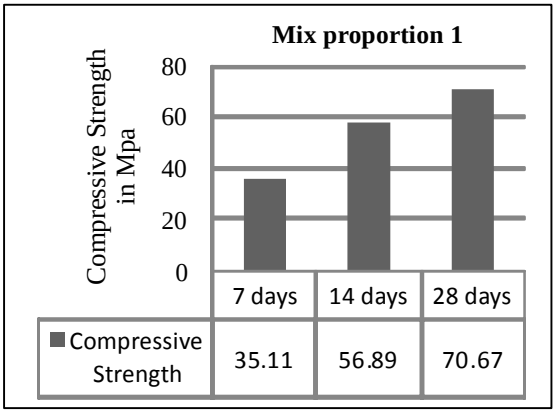

Fig. 2: Compressive strength of MP1

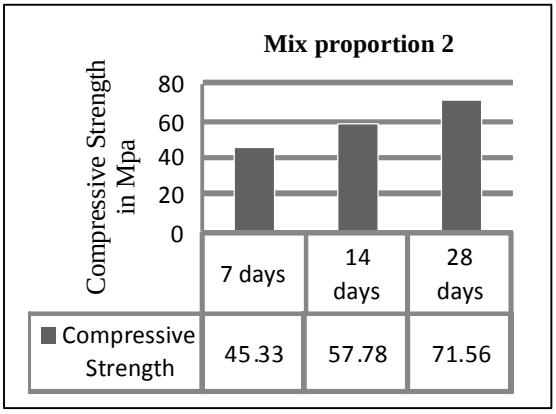

Fig. 3: Compressive strength of MP2

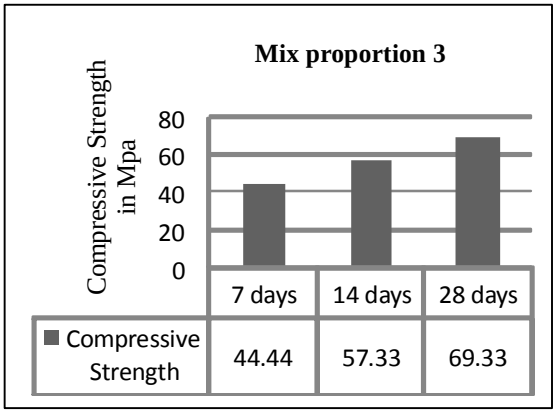

Fig. 4: Compressive strength of MP3

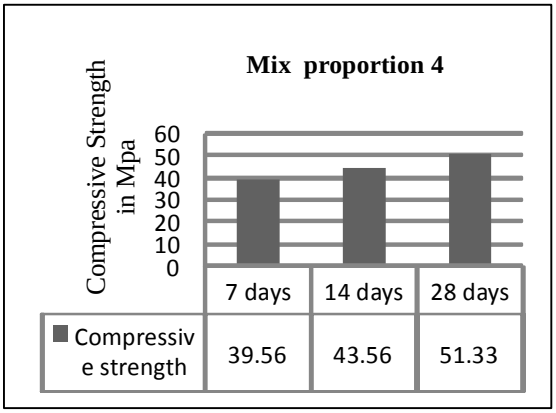

Fig. 5: Compressive strength of MP4

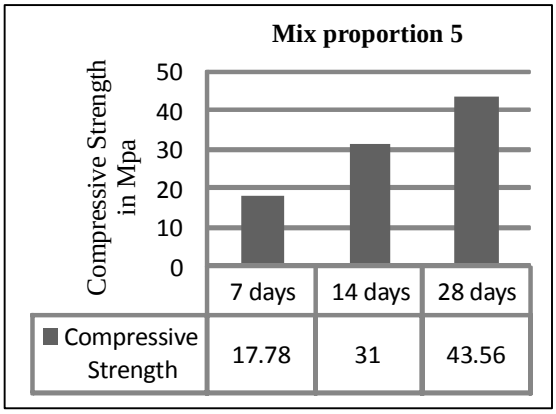

Fig. 6: Compressive strength of MP5

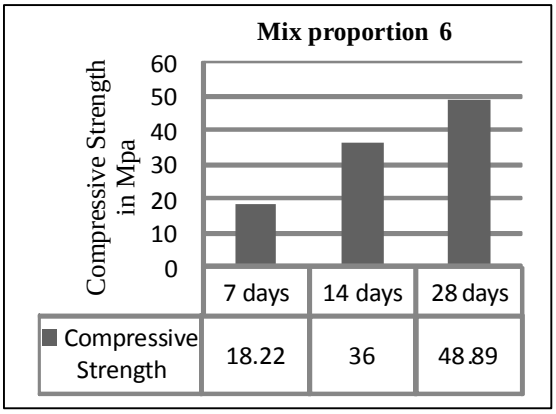

Fig. 7: Compressive strength of MP6

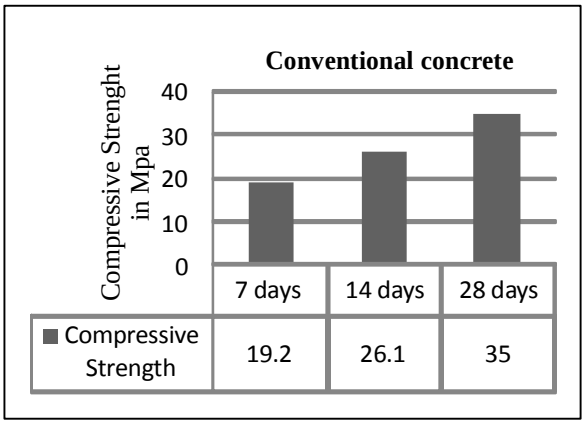

Fig. 8: Compressive strength for conventional cubes

Mix proportion 6: The cubes shown in Fig. 7 is of this proportion had a partial replacement of 60% of cement by fly ash and a partial replacement of 60% of sand by quartz powder and a low amount of superplasticizer added to it. In addition 0.5% volumetric fraction of Nylon fibre was added. It was attained a compressive strength of 18.22 Mpa, 36 Mpa and 48.89 Mpa for the curing period of 7, 14 and 28 days, respectively. This shows a smaller increase in compressive strength to a greater extent when compared to the mix proportion 5, this is due to the addition of the nylon fibres.

Comparison

In the comparison of compressive strength for **7** days curing period shown in Fig. 9.

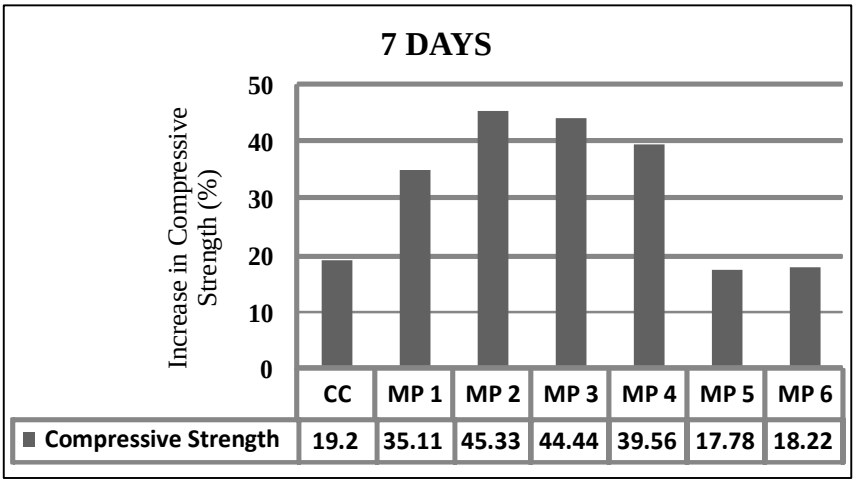

Fig. 9: Comparison of compressive strength for 7 days curing period

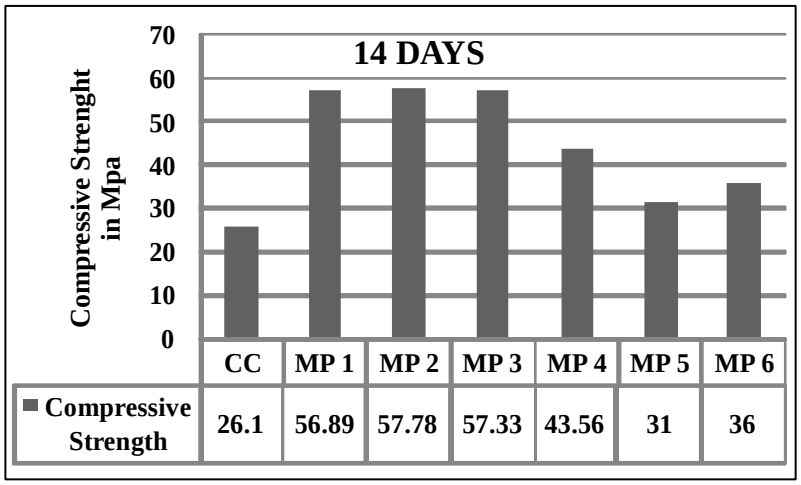

Fig. 10: Comparison of compressive strength for 14 days curing period

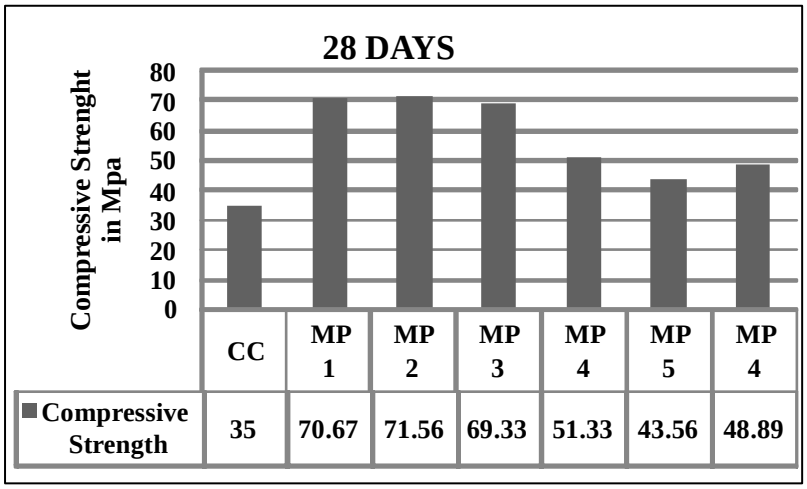

Fig. 11: Comparison of compressive strength for 28 days curing period

The compressive strength of mix proportion 2 is maximum while the strength attained from mix proportion 6 is even less than the conventional concrete cubes. In the comparison of compressive strength for 14 days curing period shown in fig 10, Mix proportion 2 reaches the maximum strength while the mix proportion 5 reaches the least strength. From the comparison of compressive strength for 14 days curing period, mix proportion 2 results in a maximum strength while the mix proportion 5 results with a least strength. This show that 25% partial replacement of cement by fly ash and 25% partial replacement of sand by quartz powder, which got best result.

CONCLUSION

- From all the above comparisons, it was found out that 25% replacement of cement by fly ash and 25% replacement of sand by quartz powder in addition of low SP and addition of 0.5% volumetric fraction of nylon fibre to the cubes attained the maximum compressive strength for all the curing periods.
- While the 60% replacement of cement by fly ash and 60% replacement of sand by quartz powder attained the lowest compressive strength in case of the cubes during the early age of 7 days but which gradually increased in the later age of 28 days to extent.
- Hence from the study it is inferred that the replacement of cement more than 60% by fly ash reduces the early age of concrete while at the later age the strength increases gradually.
- MP 1 and MP 2 had the same mix proportion, but in MP 2, the compressive strength of the later mix proportion was increased after the addition of 0.5% Nylon Fibre

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