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A Study on Strength Behavior of High Performance Concrete

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ABSTRACT
High Performance Concrete can be seen of as a natural progression from Cement Concrete, where the elements are balanced and chosen to effectively contribute to the many features of Cement Concrete in both the fresh and hardened phases. One of High Performance Concrete's characteristics that offers important structural advantages is higher strength. Concrete, steel reinforcement, and formwork make up the three main expenses for a structural member. This study compares these important elements when higher-grade concrete is used in the design, with the goal of demonstrating that high strength concrete offers the most cost-effective solution for designing load-bearing members and for carrying a vertical load to the building foundation through columns. The water-cementitious material ratio, total cementitious material, cement-admixture ratio, and amount of super plasticizer dosage are the mix design elements that have the greatest impact on concrete strength. To create a higher-grade concrete mix, these variables need to be examined.

Keywords
High-Performance Concrete, Mineral admixture, chemical admixture, cementitious material, GGBS, Silica fumes.

1. INTRODUCTION
In India, concrete is the most widely used construction material, with annual use reaching 100 million cubic metres. Additionally, the recent earthquakes in many regions of the world have highlighted the importance of designing systems with high levels of ductility. At particular, the strength and deflection of systems depend on the proper detailing of reinforcement in beam-column joints. The neighbourhood of the beam-column joint is subjected to excessive horizontal and vertical forces during seismic excitations, with magnitudes that are significantly greater than those of the adjacent beams and columns. Traditional ordinary Portland cement concrete, which is built on the theory of compressive strength, no longer fulfils many functional requirements because it is lacking in a number of areas, including competitive environments, time to create, strength absorption capacity, restoration and retrofitting jobs, etc. It also loses its tensile resistance after a few cracks form. Because the ingredients in high performance concrete contribute to the various needs most effectively, it may be necessary to design high performance concrete that is far more advanced than conventional concrete.

The term "High Performance" denotes an aggregate of structural properties that have been optimised, taking into account the final value of the material and, most importantly, the product being produced. These properties include strength, toughness, strength absorption capacity, stiffness, durability, a few cracking and corrosion resistance. Generally speaking, excessive performance is intended to distinguish structural elements from the conventional ones and to optimise a group of homes during the final phase of civil engineering. In order to meet those requirements, HPC concretes are typically designed using materials other than cement alone, such as Fly Ash (from the coal-burning process), Ground Blast Furnace Slag (from the metal-making process), or Silica fume (from the reduction of excessively high-satisfactory quartz in an electric-strengthened arc).

There are many definitions for high performance concrete (HPC), but the one that is most frequently used is that provided by the American Concrete Institute (ACI), which reads as follows: "High performance concrete is concrete that meets unique performance and uniformity requirements that cannot always be carried out automatically through the use of only conventional materials and conventional mixing, setting, and curing practises. It isn't always possible to provide a completely original description of HPC without first determining the performance requirements of the specific application.

In systems created in a wide range of contexts, HPC is required as a production component. Systems like seabed tunnels, sewage tunnels and pipes, offshore piers and platforms, containment systems for solid and liquid wastes containing toxic chemicals and radioactive elements, jetties and ports, sea link bridges, pier and superstructures, high-upward-pressure systems, chimney and towers, foundations and mounds in a competitive environment. If designed and constructed appropriately, concrete has performed rather well in the past in favourable environments. Concrete strength, which is easily controlled by adjusting the water-cement ratio, has successfully functioned in the past as the primary criterion for overall performance of regular concrete.

In this paper two experimental investigations will be made on the High strength Concrete. In first The effect of silica fumed usage and the dose of super plasticizer on the strength of concrete have been evaluated using an experimental program aimed at achieving a High strength concrete mix. And in the second the effect of silica fume on compressive strength on high strength concrete was studied by carrying out. The silica fume was replaced by 0%, 5%, 10% and 12.5% for water-binder ratio of 0.26. Also for the constant replacement of flyash by 10% along with the above mention edre placement.

2. SIGNIFICANCE OF STUDY

High performance concrete is the major topic of the article. Section III provides an explanation of the study's methodology, while Sections IV and V address the study's experimental findings and conclusion.

3. METHODOLOGY

3.1 Experimental Programme - I

The major objective of the Experimental Program was to arrive at a mix proportion for M60 in the lab that we could recommend for further use and that could be utilised to determine cost factors for the above grade of concrete. The Entroy and Shackalock methods were utilised to obtain the control mix. It was created with a very low workability in mind. In test batches, silica fume and super plasticizers were added to increase the material's strength and workability. Instead of silica fume, 5%, 10%, and 15% were used. Superplasticizers were added in dosages of 1%, 1.25%, and 1.5% for each percentage of silica fume replacement. Three portions of coarse aggregate—one retained on a 5 mm filter, one retained on an 8 mm sieve, and one retained on a 10 mm sieve—passed through a 15 mm sieve. The ratio of the control mix is 1: 0.812: 2.088. Total aggregate: 28% fine aggregate Water to binder ratio is 0.3. In this mixture, silica fume was used in place of 5% cement while maintaining the same water-to-binder ratio. Super plasticizer dosages of 1%, 1.25%, and 1.5% were then added, and the mixtures were given the names Ms5/1, Ms5/2, and Ms5/3, respectively. So, other from the super plasticizer dosage, all other quantities in MS5/1, MS5/2, and MS5/3 stay the same. In a similar vein. 10% and 15% were used in place of silica fume.

Table 1: Details of MIX 1 (Ms5)

Mix	Cement (in kg)	Silica Fume (in kg)	Fine aggregate (in kg)	Coarse aggregate (in kg)	Super plasticizer (in kg)
Ms5/1	570.4	30.02	488.8	1257.5	6.02
Ms5/2	570.4	30.02	488.8	1257.5	7.5
Ms5/3	570.4	30.02	488.8	1257.5	9.0

Table 2: Details of MIX 2 (Ms10)

Mix	Cement (in kg)	Silica Fume (in kg)	Fine aggregate (in kg)	Coarse aggregate (in kg)	Super plasticizer (in kg)
Ms10/1	540.4	60.04	488.8	1257.5	6.02
Ms10/2	540.4	60.04	488.8	1257.5	7.5
Ms10/3	540.4	60.04	488.8	1257.5	9

3.2 Experimental Programme - I

The concrete that was employed in this study was proportioned to have a 75 MPa strength. For the M75 design, the ACI committee's recommendations were used. The mixes MSG1, MSG2, and MSG3 were created by substituting silica fume for 5, 7.5, and 10% of the cement mass, respectively. Then, MSFG1, MSFG2, and MSFG3 mixes were created by adding 10% fly ash and substituting the cement mass with the aforementioned ratio of silica fume. It is assumed that the water cement ratio (w/c) is 0.26. The mix design was implemented in accordance with ACI 211.4R-93.

Table 3: Details of MIX (Ms15)

Mix	Cement (in kg)	Silica Fume (in kg)	Fine aggregate (in kg)	Coarse aggregate (in kg)	Super plasticizer (in kg)
Ms15/1	510.4	90.07	488.8	1257.5	6.02
Ms15/2	510.4	90.07	488.8	1257.5	7.5
Ms15/3	510.4	90.07	488.8	1257.5	9.0

4. RESULTS AND DISCUSSION

The above-mentioned concrete mixes were tested for the compression, tension and split tensile strength and results were tabulated below

4.1 Results of Experimental Analysis - I

Workability:

Table 4: Mix Proportions

Mix	% Silica Fume	% Fly Ash	% Glass Fibre	W/C Ratio
MSG1	5	0	0.3	0.26
MSG2	7.5	0	0.3	0.26
MSG3	10	0	0.3	0.26
MSG4	12.5	0	0.3	0.26
MSFG1	5	10	0.3	0.26
MSFG2	7.5	10	0.3	0.26
MSFG3	10	10	0.3	0.26
MSFG4	12.5	10	0.3	0.26
C	0	0	0	0.26

Compressive strength

Table 5: Slump Values in mm for different mixes

MIX	SLUMP VALUE (in mm)
Ms5/1	5
Ms5/2	10
Ms5/3	25
Ms10/1	4
Ms10/2	8
Ms10/3	15
Ms15/1	0
Ms15/2	3
Ms15/3	15

Split Tensile Strength
Flexural Strength

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Table 6: Compressive strengths for MIX1, MIX2, MIX3

MIX	28 days compressive strength (N/mm^2)
Ms5/1	60.1
Ms5/2	54.3
Ms5/3	51.2
Ms10/1	45.4
Ms10/2	51.1
Ms10/3	51.8
Ms15/1	47.3
Ms15/2	41.9
Ms15/3	45.2

Table 7: Compressive strengths for MIX4

Mix	W/CM ratio	28 days compressive strength in N/mm^2
Ms10/1.25/0	0.3	51
Ms10/1.25/1	0.325	38.67
Ms10/1.25/2	0.35	37.33
Ms10/1.25/3	0.375	36.74

Table 8: Compressive strengths Results

Mix	% Silica Fume	% Fly Ash	% Glass Fibre	28 Days N/mm^2
MSG1	5	0	0.3	68
MSG2	7.5	0	0.3	70
MSG3	10	0	0.3	78
MSG4	12.5	0	0.3	73
MSFG1	5	10	0.3	67
MSFG2	7.5	10	0.3	71
MSFG3	10	10	0.3	81
MSFG4	12.5	10	0.3	77
C	0	0	0	69

Table 9: Split Tensile Strength Results

Mix	% Silica Fume	% Fly Ash	% Glass Fibre	28 Days N/mm^2
MSG1	5	0	0.3	5.092
MSG2	7.5	0	0.3	5.410
MSG3	**10**	0	**0.3**	**6.040**
MSG4	12.5	0	0.3	5.729
MSFG1	5	10	0.3	5.729
MSFG2	7.5	10	0.3	6.366
MSFG3	**10**	**10**	**0.3**	**6.684**
MSFG4	12.5	10	0.3	6.040
C	0	0	0	5.729

Table 10: Flexural Strength Results

Mix	% Silica Fume	% Fly Ash	% Glass Fibre	28 Days N/mm^2
MSG1	5	0	0.3	4.551
MSG2	7.5	0	0.3	4.866
MSG3	**10**	**0**	**0.3**	**5.179**
MSG4	12.5	0	0.3	4.748
MSFG1	5	10	0.3	4.238
MSFG2	7.5	10	0.3	5.023
MSFG3	**10**	**10**	**0.3**	**5.337**
MSFG4	12.5	10	0.3	4.866
C	0	0	0	4.395

5. CONCLUSION

In order to obtain the combination true layout for the specified High Performance Concrete, it is necessary to analyses the mix design variables that affect concrete strength and are the most important for strengthening concrete, such as the water-cementitious ratio, overall cementitious material, and cement-admixture ratio quantity of exceptional plasticizer dose.

By using less metal and concrete that contributes specifically to the cost of the structural member, High Performance Concrete with better compressive strength offers the most cost-effective way to design the weight-bearing individuals and to hold a vertical load to the building foundation through columns. When improving the strength of concrete, the most important mix design factors, such as the water-to-cementitious material ratio, cement-admixture ratio, and the amount of exceptional plasticizer dose, must be analysed and the best values must be taken in order to obtain the combinationture design for the specified use. Concrete with High Performance

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