Strength Characteristics of High Strength Concrete (HSC) with and without Coarse Aggregate

M Preethi, P Ashveen Kumar, Mohd. Hamraj

ABSTRACT---This paper aimed to investigate the mechanical characteristics of HSC of M60 concrete adding 25% of fly ash to cement and sand and percentage variations of silica fumes 0%,5% and 10% to cement with varying sizes of 10mm,6mm,2mm and powder of granite aggregate with w/c of 0.32. Specimens are tested for compressive strength using 10cm X 10cmX10cm cubes for 7,14,28 days flexural strength was determined by using 10cmX10cmX50cm beam specimens at 28 days and 15cm diameter and 30cm height cylinder specimens at 28 days using super plasticizers of conplast 430 as a water reducing agent. In this paper the experimental set up is made to study the mechanical properties of HSC with and without coarse aggregate with varying sizes as 10mm, 6mm, 2mm and powder. Similarly, the effect of silica fume on HSC by varying its percentages as 0%, 5% and 10% in the mix studied. For all mixes 25% extra fly ash has been added for cement and sand.

Keywords: Fly Ash, Granite Aggregates, High Strength Concrete, Silica Fume

I. INTRODUCTION

Conventional concrete usage in current construction practices is technically and economically not feasible. Normal concrete lacks required strength, durability, workability, which are generally required for large structures, flyovers, bridges.

The advancement of material technology and production has led to higher grades of concrete strengths. High-strength concrete (HSC) offers significantly better structural engineering properties, such as higher compressive and tensile strengths, higher stiffness, better durability, compared with conventional normal-strength concrete (NSC). Many structures built now have at least some components constructed with HSC. The main concern regarding the use of HS Concrete is the reduction in ductility with the increase in compressive strength observed under uniaxial compression.

Revised Manuscript Received on December 30, 2019.
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Major codes of practice around the world are still based on experimental and theoretical results derived from investigations on NSC. Individual design rules codified in any of the national and international design codes need to be experimentally verified and categorized with a view to taking further action. By improving the strength and durability of concrete, the thickness required and cost can be reduced, therefore, felt that to improve the strength of concrete with suitable admixtures like super plasticizers, Silica Fume (SF) and Fly Ash (FA). By using FA and SF we are making eco-friendly concrete. In this study 25% of extra fly ash is added for both cement and sand and varying silica fume to obtain HSC.

II. LITERATURE REVIEW

Jeyabalan (2008) investigated the properties of HPC using silica fume and concluded that silica fume is an ideal ingredient for high performance concrete as it has inherent ability to strength development through their pozzolanic/cementation reactivity and durability with chemical resistance through their pore refinement. Jinxing Ma,Markoorgass (2004) studied the ultra-high performance concrete using with and without coarse aggregate of Basalt with particle size of 2 to 5mm and concluded that compressive strength has reached as equal as reactive powder concrete (RPC).The utilization of the coarse aggregate led to decrease in cementations paste volume fraction, mixing time. Collepardi, Coppola, Troli, &Collepardi studied, effect of original Reactive powder concrete (RPC) with altered RPC where a natural aggregate (maximum size 8mm) can be substituted with fine sand and concluded that the substitution of graded aggregate does not affect the compressive strength. Camoes et al (2003) investigated the probability of producing low cost enhanced HPC with 28 day strength in the range of 60Mpa replacing fly ash for cement in different percentages. The results indicate that HPC of 60Mpa can be obtained by replacing up to 40% of cement by fly ash and crushed granite aggregates. The sufficient research has been for studying the effect of HSC & HPC with coarse aggregate in the past two decades. So, there is a need to investigate effect of HSC in combination with and without coarse aggregate, therefore an attempt has made to study Mechanical properties of HSC with and without coarse aggregate.

III. DESIGN MIX FOR HIGH STRENGTH CONCRETE

Table I shows quantities of cement, water, sand, aggregate per cubic meter of concrete in dry and moist aggregate conditions. Table II shows 12 different samples with constant OPC, sand, fly ash, aggregate with varying silica fume, water and super plasticizer.

Table- I: Batch quantities per cubic meter of concrete

Ingredients	***Dry Aggregate (Kg)***	Moist Aggregate (Kg)
Cement	647.96	647.96
Water	207.347	168.60
F.A	566.319	596.125
C.A	885.243	894.185

Table- II: Mix design proportions of high strength concrete

Sample	Quantity (m^3)	OPC (kg)	FA (kg)	SF (kg)	Sand (kg)	Aggregate (kg)	Water (Lts)	Supper plasticizer (ml)	Type
P1	0.04	25.92	12.14	0	22.65	35.41	10.37	810	10mm Aggregate & 0% SF
P2	0.04	25.92	12.14	1.3	22.65	35.41	10.78	842.5	10mm Aggregate & 5% SF
P3	0.04	25.92	12.14	2.6	22.65	35.41	11.2	875	10mm Aggregate & 10% SF
P4	0.04	25.92	12.14	0	22.65	35.41	10.37	810	6mm Aggregate & 0% SF
P5	0.04	25.92	12.14	1.3	22.65	35.41	10.78	842.5	6mm Aggregate & 5% SF
P6	0.04	25.92	12.14	2.6	22.65	35.41	11.2	875	6mm Aggregate & 10% SF
P7	0.04	25.92	12.14	0	22.65	35.41	10.37	810	2mm Aggregate & 0% SF
P8	0.04	25.92	12.14	1.3	22.65	35.41	10.78	842.5	2mm Aggregate & 5% SF
P9	0.04	25.92	12.14	2.6	22.65	35.41	11.2	875	2mm Aggregate & 10% SF
P10	0.04	25.92	12.14	0	22.65	35.41	12.31	810	Granite powder& 0% SF
P11	0.04	25.92	12.14	1.3	22.65	35.41	12.80	842.5	Granite powder& 5% SF
P12	0.04	25.92	12.14	2.6	22.65	35.41	13.30	875	Granite powder & 1 0% SF

IV. RESULTS AND DISCUSSIONS

The object is to find the dosage of super plasticizer to be added for the M60 mix. Compressive Strength(CS), Flexural Strength(FS), Split Tensile Strength(TS) and Modulus of Elasticity(E) of M60 mix for 10mm,6mm,2mm and powder aggregate sizes with varying SF % of 0,5, and10.

Compressive strength for 7days, 14days and 28days has been found using 10cmx10cmx10cm cubes, flexural strength for 28days has been found using 10cmx10cmx50cm beams, TS& E for 28days has been found using 15cm diameter and 30cm height cylinder.

Complast SP430 made by Forsac Chemicals (India) Private limited Bangalore has been used as super plasticizer. Dosage of 13lts/m^3 16.2lts/m^3 19.5lts/$m^3$and 22.7lts/$m^3$of cement is added for the mix and compressive strength is determined as shown in Table III and Fig. 1.

Table- III: Dosage of super plasticizer to be added for M60

Dosage of Super plasticizer in lit/m^3	Compressive Strength (N/mm^2)		
	7Days	14Days	28Days
13	15.75	18.93	Fail
16.2	38.55	46.42	58.31
19.5	47.49	52.07	56.69
22.7	26.76	33.79	34.15

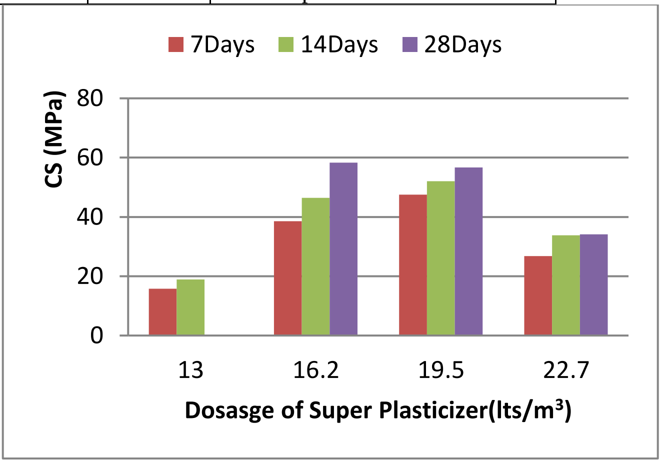

Fig. 1: Dosage of Super plasticizer to be added for M60

CS for 7days, 14days and 28 days has found for M60 mix using 10mm, 6mm, 2mm and granite powder with varying % of SF 0,5,10 and the results are shown in Tables IV, V and VI and figures 2, 3 and 4.

Table- IV: CS of M60 concrete with 0% SF

	CS(N/mm^2)		
Granite Size	7Days	14Days	28Days
10mm	43.07	47.21	61.83
6mm	40.03	46.28	57.61
2mm	36.85	44.65	55.83

Powder	33.11	36.29	43.15

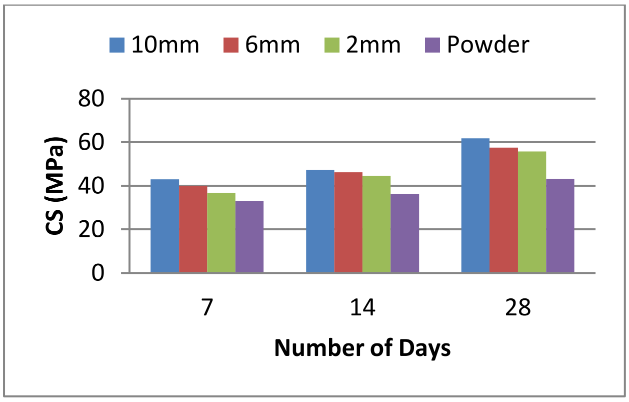

Fig. 2: CS of M60 concrete with 0% SF

Table- V: CS of M60 concrete with 5% SF

Granite Size	CS (N/mm^2)		
	7Days	14Days	28Days
10mm	45.95	49.83	63.2
6mm	42.83	53.87	61.53
2mm	49.48	60.24	65.49
Powder	33.81	38.06	43.15

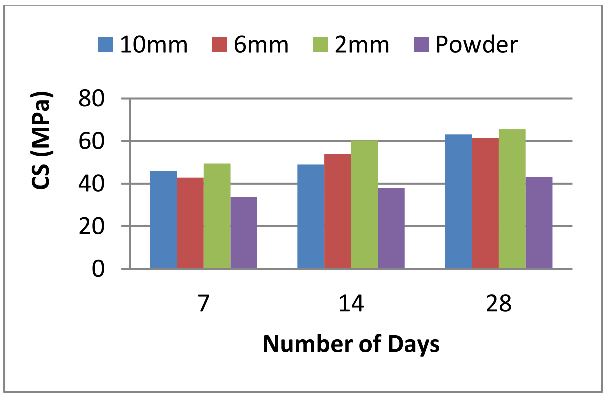

Fig. 3: CS of M60 concrete with 5% SF

Table- VI: CS of M60 concrete with 10% SF

Granite Size	CS (N/mm^2)		
	7Days	14Days	28Days
10mm	46.26	57.53	64.17
6mm	45.8	56.32	62.21
2mm	53.26	61.11	67.86
Powder	35.63	39.27	48.02

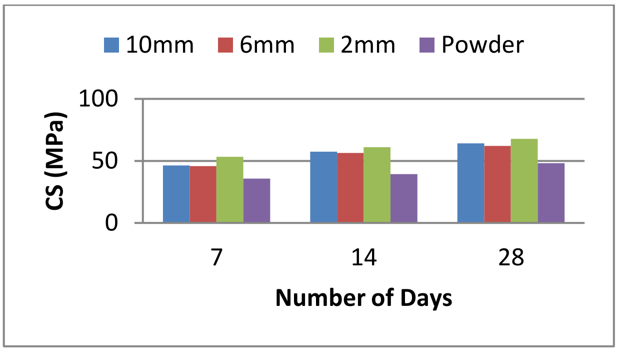

Fig. 4: CS of M60 concrete with 10% SF

FS for 28days has found for M60 mix using 10cmx10cmx50cm beams for varying10mm, 6mm, 2mm and granite powder with variation of 0%, 5% and10% SF and results are shown in Table VII and fig. 5.

Table- VII: 28-day FS of M60 concrete with different sizes of aggregate and different % of SF.

Granite Size	FS(N/mm^2) for various percentages of SF		
	0 %	5 %	10 %
10mm	5.75	6.34	6.73
6mm	5.27	6.14	6.24
2mm	6.14	6.92	7.22
Powder	4.68	4.97	5.66

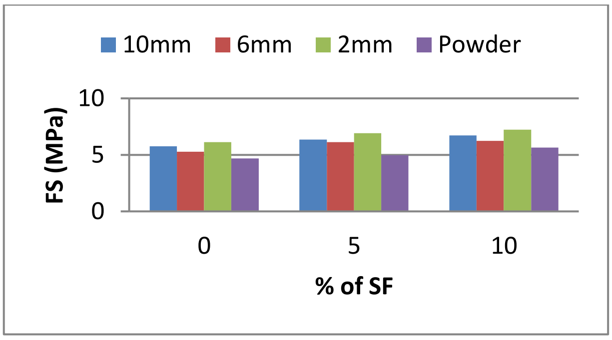

Fig. 5: 28 day FS of M60 grade concrete with different sizes of aggregate and different % of SF

Table- VIII: 28-day TS of M60 grade concrete with different sizes of aggregate and different % of SF

Granite Size	TS(N/mm^2) for various % of SF		
	0 %	5 %	10 %
10mm	3.69	3.72	4.18
6mm	4.49	4.95	4.99
2mm	4.36	4.47	4.53
Powder	2.68	2.84	3.68

Retrieval Number: B5131129219/2019©BEIESP
DOI: 10.35940/ijeat.B5131.129219
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
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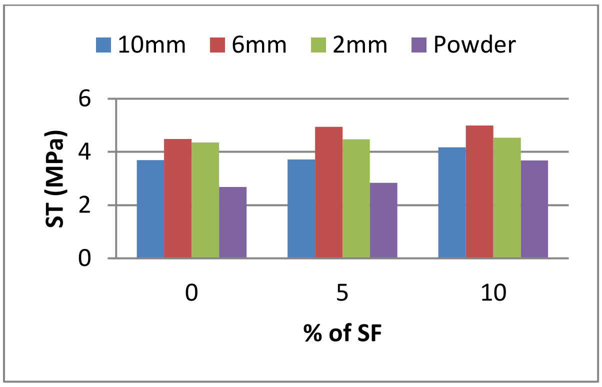

Fig. 6: 28-day TS of M60 concrete with different sizes of aggregate and different % of SF

Split tensile strength of 28days is determined for M60 mix using 15cm diameter and 30cm height cylinder for 10mm, 6mm, 2mm and granite powder with varying 0%, 5%and 10% silica fume and results are shown in TableVIII and figure 6.

Modulus of Elasticity of 28days is determined for M60 mix using 15cm diameter and 30cm height cylinder for 10mm, 6mm, 2mm and granite powder with varying 0%, 5% and10% silica fume and results are shown in Table IX and figure 7.

Table- IX: 28-day E of M60 concrete with different sizes of aggregate and different % of SF

Granite Size	E(GPa) for various % of SF		
	0 %	5 %	10 %
10mm	41.07	45.2	48
6mm	37.64	43.85	44.57
2mm	43.8	49.4	51.5
Powder	33.4	35.5	40.4

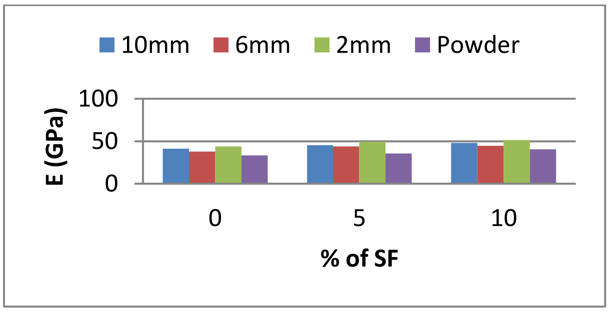

Fig. 7: 28-day E for M60 concrete with different sizes of aggregate and different % of SF

V. CONCLUSION

Concrete with crushed granite aggregate of 2mm developed higher compressive strengths. This indicates to increase surface area and more homogeneous concrete. By trial and error method the dosage of super plasticizer of 16.2 lts/m^{3}of cement or 7.8% that of water has given good result. The silica fume effect on the compressive strength seems to be more significant in concretes with smaller size aggregates (2mm) than coarse aggregates (6mm &10mm). When the coarse aggregate replaced by granite powder to make concrete mix workable, an increase in the w/c ratio from 0.32to0.38 and water by 20% was observed. Using granite powder in place of coarse aggregate in HSC is not recommended because Compressive Strength (CS), Flexural Strength (FS), Split Tensile Strength (TS) and Modulus of Elasticity (E)are very low compared to10mm, 6mm & 2mm size aggregate with and without silica fume. IS: 456 equations for comparison of Flexural Strength (FS) to Compressive Strength (CS) and Modulus of Elasticity (E) to Compressive Strength (CS) are satisfied for all the mixes without silica fume. It is observed that concrete with higher strength can be produced without using coarse aggregate fraction, which is the basis for Reactive Powder concrete

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