

Article Info

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Effect of Coarse Aggregate Size on Strength of High Performance Concrete

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ABSTRACT

The development of new methodologies for manufacturing high performance concrete has led to massive increase in its usage worldwide. The higher strength development in concrete has increased the construction of skyscraper, bridges and special structures. Apart from higher strength and better performance the usage of this concrete also lends technical and economical viability to the entire project. The main criteria of making high strength concrete are to reduce the water content and increase the cement proportions. This however leads to reduced workability which can be overcome by the use of different mineral admixtures like rice husk ash, silica fume and fly ash apart from chemical admixtures.

In our study, an attempt has been made to determine the effect of varying size of aggregate on high strength concrete using silica fume with and without fly ash. The concrete was manufactured using usual ingredients like cement, coarse aggregates, fine aggregates, water, and mineral admixture in the form of silica fume and fly ash and super plasticizer. Three sizes of coarse aggregates i.e, 10 mm, 12.5mm and 16mm with two types of fine aggregates with fineness modulus 2.65 and 2.88 were used in concrete. The percentage of silica fume and fly ash that replaced cement by weight was 7.5% and 10% respectively. It was concluded that concrete made from 10 mm coarse aggregate and with fine aggregate of fineness modulus 2.88 with silica fume showed higher compressive strength at 28 day curing.

Keywords: Coarse Aggregate; Compressive Strength; Sieve Analysis; Fineness Modulus.

1.0 Introduction

One of the most important parameter while manufacturing the concrete is its structural strength. The strength of concrete comes from its matrix, the bond between cement and aggregates. In a mix with same quality of cement but different properties of aggregates in terms of its shape, size, texture and geo chemistry may result in different strength of concrete. However, more is the strength desired lesser should be the water/cement ratio.

Therefore, for high strength concrete the water/cement ratio is limited to less than 0.4 and the strength at the interface of cement and aggregate is similar to the crushing strength of coarse aggregates. Although the improvement in strength leads to increases in brittleness of concrete thereby, limiting its use. Thus, it is very important to use the coarse aggregate with higher crushing strength, less brittleness, proper size and texture and good

mineralogical properties for improving the mechanical properties of concrete.

2.0 Material Used

The determination of the properties of the constituents of concrete is necessary to ensure that they do not contain and deleterious element which may affect the behaviour of the composite or they may not conform to the specified requirement necessary to achieve a standard of performance. The sub-sections under this head give the details of the tests carried out and the specifications as mentioned in the IS code. 2.1 Cement Ordinary Portland cement 43 grade has been used for the experimental investigation.

The recommendations started in IS 4031:1999 have been strictly adhered to during the experimentation. The physical properties of the cement determined in the laboratory are as follows:

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Table 1: Physical Properties of Cement

S.No.	Properties	Observed Value
1.	Specific Gravity	3.15
2.	Soundness(Le-Chatelier)	10 Mm
3.	Setting (A) Initial (B)Final	35 Min 41 5min
4.	Compressive Strength (28 Day)	41 N/Mm ²
5.	Normal Consistency	27%

2.2 Fine aggregates

Locally available coarse sand lying in zone 2 with specific gravity of 2.6 was used as fine aggregate which confirms IS 383-1983. The results of sieve analysis and physical properties are tabulated.

2.3 Coarse aggregate

The locally crushed quartzite aggregate of maximum nominal size of 10mm, 12.5mm and 16mm with specific gravity of 2.68 are used as coarse aggregate.

2.4 Mineral admixtures

The commercially available micro silica of grade 920 U conforming to IS 15388:2003 and fly ash collected from thermal power plant was used.

2.5 Water

The water used for the study was free of acids, organic matter, suspended solids, alkalis and impurities which when present may have adverse effect on the strength of concrete.

Table 2: Sieve Analysis of Fine Aggregate (FM= 2.65)

Is Sieves	Weight Retained(Gm)	Percentage Weight Retained	Percentage Weight Passing	Cumulative Percentage Weight Retained	Cumulative Percentage Weight Passing
4.75 Mm	0.00	0.00	100.00	0.00	100.00
2.36 Mm	90.00	4.50	95.50	4.50	95.50
1.18 Mm	320.00	16.00	84.00	20.50	79.50
600 Micron	660.00	33.00	67.00	53.50	46.50
300 Micron	700.00	35.00	65.00	88.50	11.50
150 Micron	200.00	10.00	90.00	98.50	1.50
Pan	30.00	1.50	98.50	-	-

Table 3: Sieve Analysis of Fine Aggregate (FM= 2.88)

Is Sieves	Weight Retained(Gm)	Percentage Weight Retained	Percentage Weight Passing	Cumulative Percentage Weight Retained	Cumulative Percentage Weight Passing
4.75 Mm	20.00	1.00	99.00	1.00	99.00
2.36 Mm	200.00	10.00	90.50	11.00	89.00
1.18 Mm	360.00	18.00	82.00	29.00	71.00
600 Micron	550.00	27.50	72.50	56.50	43.50
300 Micron	770.00	35.00	65.00	91.50	8.50
150 Micron	150.00	7.50	92.50	99.00	1.00
Pan	20.00	1.00	99.00	-	-

Table 4: Mix Design

Mixes	Cement (kg/M ³)	Coarse Aggregate (kg/m ³)	Sand (Kg/M ³)	Silica Fume (kg/m ³)	Fly (kg/m ³)	Ash	Water/Cement Ratio
Cube A	472.8	1061	588.5	42.9	57.3	0.3	
Cube B	530.1	1061	588.5	42.9	-	0.3	

Table 5: Compressive Strength at 28 Days

Compressive Strength (MPa) At 28 Days					
Size Of Coarse Aggregate	Cube A		Cube B		
	Fine Aggregate(Fm 2.65)	Fine Aggregate(Fm 2.88)	Fine Aggregate(Fm 2.65)	Fine Aggregate(Fm 2.88)	
10 Mm	52.1	53.4	59.9	61.0	
12.5 Mm	51.9	53.0	59.1	60.5	
16 Mm	49.4	51.1	57.2	58.9	

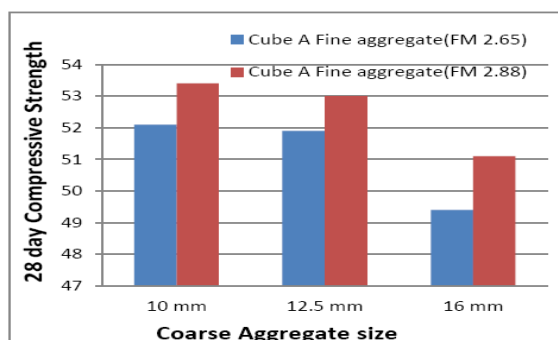
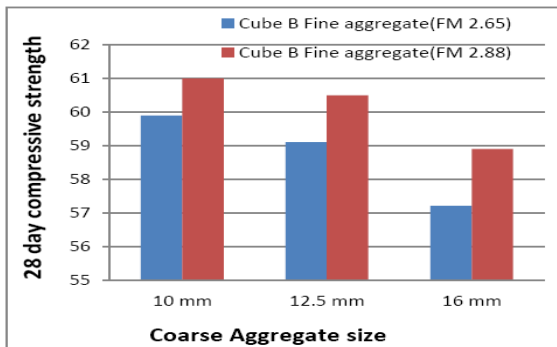
Fig 1: Compressive Strength of Cube a for Fine Aggregate with FM 2.65 and 2.88

Fig 2: Compressive Strength of Cube b for Fine Aggregate with FM 2.65 and 2.88



2.6 Super plasticizer

Commercially available super plasticizer named CONSFLO HP was used.

2.7 Mix design

The concrete of average design strength as 60 MPa was designed as per the guidelines specified in I.S. 10262-2009.

3.0 Experimental Results

3.1 Compressive strength

The test was carried out conforming to IS 516:1959 to obtain compressive strength of desired grade of concrete and the results are shown in table 5. It was observed that in cube A concrete made with 10mm, 12.55 mm and 16 mm showed a increase of 2.49 %, 2.11% and 3.44 % in 28 day compressive strength when fine aggregate of 2.88 FM was used as compared to 2.65 FM. Whereas in cube B an increase of 2.50%, 2.36% and 2.97% was observed.

4.0 Conclusions

Based on the results of the study and test which have been discussed above, the following conclusions can be drawn:

- i. Concrete made with 10mm maximum coarse aggregate size showed higher compressive strength that that made with 12.5mm and 16mm maximum coarse aggregate size for all the replacement of silica fume with or without fly ash.
- ii. Concrete made with sand whose fineness modulus is 2.88, show higher compressive strength that made with sand whose fineness modulus is 2.65 for all the replacement of silica fume with or without fly ash.

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