

# Design of High Strength Concrete Mixes M60 and Investigation of its Strength Parameter

D. Ramesh<sup>1</sup>, S. Murali<sup>2</sup>, S. Balaji<sup>3</sup> and V.Ganesan<sup>4</sup>U.G. Student, Department of Civil Engineering, Prist University, Thanjavur, Tamil Nadu, India<sup>1,2,3,4</sup>

**ABSTRACT:** Concrete is the basic engineering material used in most of the civil engineering structures. Its popularity as basic building material in construction is because of, its economy, good durability and ease with which it can be manufactured at site. The ability to mould it into any shape and size, because of its plasticity in green stage and its subsequent hardening to achieve strength, is particularly useful. Concrete like other engineering materials needs to be designed for properties like strength, durability, workability and cohesion. Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way. Design of concrete Mix design requires complete knowledge of the various properties of these constituents' materials, the implications in case of these conditions at the site, the impact of the properties of plastic concrete on the hardened concrete and the complicated inter-relationship between the variables. Even then the proportions of the materials of the concrete found at the laboratory require modification and readjustments to suit the field calculation. In this design project we have designed M60 grade concrete using Design mix of American Concrete Institute method, and also found out compressive strength for design mix method. Based on the test result we achieved our target mean strength by design mix method.

**KEYWORDS:** High strength concrete, silica fume, super plasticizer, admixtures.

## I. INTRODUCTION

Day by day different structures have been designed and constructed. Long-term performance of such structures has become vital to the economies of all nations. Concrete is a more essential material which is widely used for many kinds of structures. Concrete is composed of an inert matrix of sand, gravel, crushed rock, or other aggregates held together by a harden paste of hydraulic cement and water. The strength of concrete depends upon the strength of these components, their deformation properties, and the adhesion between the paste and aggregate surface.<sup>1</sup>

High strength concrete (HSC) provides economic benefits through thinner (lighter) construction. According to ACI 363, any concrete with a specified compressive strength of 6000 psi (41 MPa) or greater is "High strength concrete". Production of HSC may or may not require special materials, but it definitely requires materials of highest quality and their optimum proportions.<sup>2</sup> With most natural aggregates, it is possible to make concretes with compressive strength up to 120 MPa. This can be achieved by improving the strength of the cement paste, which can be controlled through the choice of water-content ratio and type and dosage of admixtures.<sup>3</sup>

In order to achieve the higher strength in concrete, an attempt was made in this study to utilize the admixtures like silica fume and Super Plasticizer.

## II. MATERIALS

The following ingredients are used in the concrete specimens throughout this study: Cement - It is the basic binding material in concrete; Water - It hydrates cement and also makes concrete workable; Coarse Aggregate - It is the basic building component of concrete; Fine Aggregate - Along with cement paste it forms mortar grout and fills the voids in the coarse aggregates; Silica Fume (Very effective in lowering the water - cement ratio required for Workable concrete) is a waste by-product of the production of silicon and silicon alloys Silica fume is available in different forms of which the most commonly used in a densified form. In developed countries it is already available readily blended with

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cement; Super Plasticizer - Reduced the amount of water needed and Use of low water– cement ratio. The properties of the materials used in this research work are given in the table 1.

<b>Table 1: Physical properties of the materials used</b>		
S. No	Property	Value
<b>Cement - Portland Pozzaland cement (43-grade)</b>		
1.	Normal Consistency	33%
2.	Initial Setting Time (min)	65
3.	Final Setting Time (min)	250
4.	Specific Gravity	3.15
5.	Fineness of Cement	1.1
<b>Coarse aggregate - 20mm(angular)</b>		
1.	Specific Gravity	2.65
2.	Fineness Modulus	2.80
3.	Uniformity coefficient	3.33
4.	Coefficient of curvature	0.906
<b>Fine aggregate - River sand</b>		
5.	Specific Gravity	2.65
6.	Fineness Modulus	6.19
7.	Uniformity coefficient	1.26
8.	Coefficient of curvature	1.13

### III. MIX DESIGN

Mix design aims to achieve Good quality concrete at site economically. Quality concrete means: i) Better strength, ii) Better Imperviousness and durability, iii) Dense and homogeneous concrete.

Different design mix methods help us to arrive at the trial mix that will give us required strength, workability, cohesion etc. These mix design methods have same common threads in arriving at proportions but their method of calculation is different. They are a) Arbitrary proportion, b) Fineness modulus method, c) Maximum density method, d) Surface area method, e) Indian Road Congress, IRC 44 method, f) High strength concrete mix design, g) ACI committee 211 method, h) DOE method.

In this study the chosen mix design method is American Concrete Institute Method ACI 211.4R ACI recommends a relationship between compressive strength and w/c ratio. Water demands for aggregates sizes are summarized in relation to the concrete workability (consistence) required. This leads to an estimate of cement content and aggregate content from an assumed concrete plastic density. The rounded bulk volume for the course aggregate is estimated from tables giving the fineness modulus of the fine aggregate and the coarse aggregate size, hence the split between course and fine aggregate calculated. The designed proportions are shown in the table 2.

<b>Table 2: Mix proportions</b>			
Cement	Fine aggregate	Coarse aggregate	Water
460	590.72	1180	155.73
1	1.28	2.56	0.35

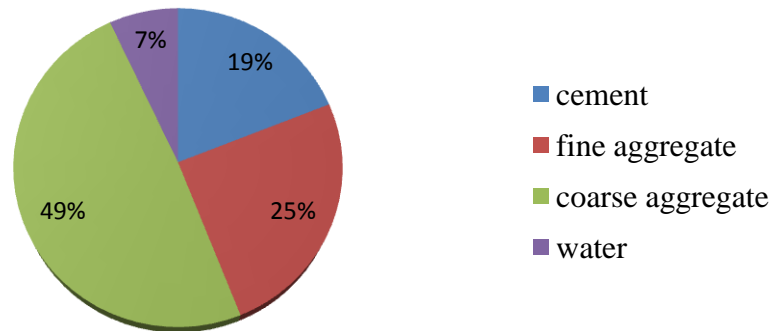


Figure 1: Typical Distribution of Materials in concrete

#### IV. EXPERIMENTAL INVESTIGATION

Compressive strength is one of the most important properties of concrete and influences many other describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water-cement ratio of the mix.

Compressive strength of concrete is usually found by testing Cubes. Cube of size 150mm x 150mm x 150mm concrete specimens were casting using M60 grade concrete. Specimens with different percentages 0%, 2.5% and 5% replacement of cement by silica fume were casted. During casting the concrete cubes were manually compacted using tamping rods. After 24 hours, the specimens were removed from the mould and subjected to water curing for 7, 14, 28 days. The specimens are not to be allowed to become dry at any time until they have been tested. The specimens are tested immediately on removal from the water whilst they are still in a wet condition. The dimensions of the specimens are their weight was recorded before testing. The specimens were tested for compressive strength as per IS 516-1959 using a calibrated compression testing machine of 2000KN capacity. For each, proportions and day of testing three cubes were molded and the average compressive strength was taken.

#### V. RESULTS AND DISCUSSIONS

The compressive strength of hardened concrete is considered one of the most important properties and is often used as an index of the overall quality of concrete. The average compression strength of the specimens using 0% silica fume replacement is shown in the table 3. It was identified that the required strength was not achieved.

DESCRIPTIONS		VALUE		
Grade of concrete		<b>M60</b>		
Age of strength in days		7	14	28
No. of cubes		3	3	3
Cube Strength (N/mm <sup>2</sup> )	Cube 1	14.32	28.26	38.91
	Cube 2	15.30	27.14	38.76
	Cube 3	15.26	28.32	38.75
Avg. Strength (N/mm <sup>2</sup> )		14.96	27.90	38.80

The average compression strength of the specimens using 2.5% silica fume replacement is shown in the table 4. The required strength was not completely achieved while replacing the cement with 2.5% of silica fume.

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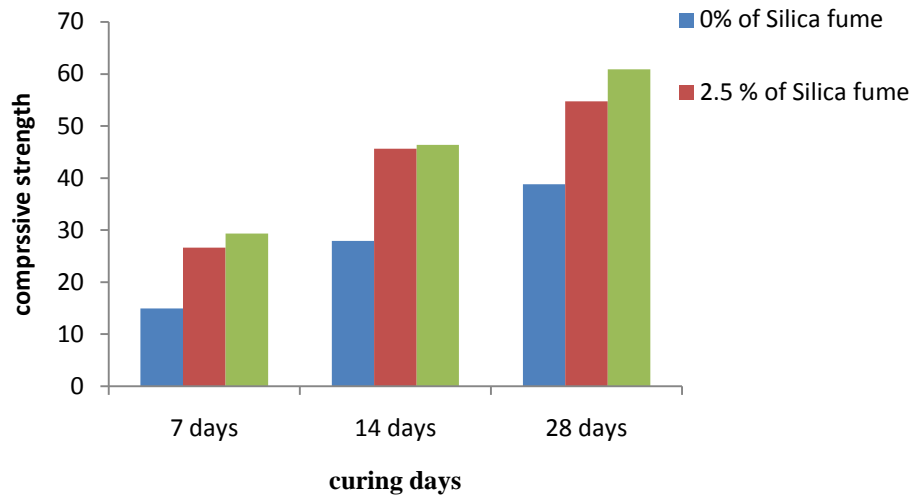
<b>Table 4: Average compression strength of concrete for 2.5% replacement of Silica fume</b>				
DESCRIPTIONS		VALUE		
Grade of concrete		<b>M60</b>		
Age of strength in days		7	14	28
No. of cubes		3	3	3
Cube Strength (N/mm <sup>2</sup> )	Cube 1	21.33	42.66	53.72
	Cube 2	28.44	48.88	55.18
	Cube 3	30.22	45.33	55.34
Avg. Strength (N/mm <sup>2</sup> )		26.66	45.62	54.74

The table 5 shows that the replacement of cement with 5% silica fume achieved the required strength of the concrete at 28 days.

<b>Table 5: Average compression strength of concrete for 5% replacement of Silica fume</b>				
DESCRIPTIONS		VALUE		
Grade of concrete		<b>M60</b>		
Age of strength in days		7	14	28
No. of cubes		3	3	3
Cube Strength (N/mm )	Cube 1	28.36	46.62	58.38
	Cube 2	29.92	45.52	63.22
	Cube 3	29.76	46.98	61.16
Avg. Strength (N/mm )		29.34	46.37	60.92

The comparison of the compressive strength of the concrete using 0%, 2.5% and 5% replacement of silica fume at 28 days is given in the table 6.

<b>Table 6: Test Result of Cube for Compression</b>				
S. No	Curing days	Average Compressive strength in N/mm <sup>2</sup>		
		0% of Silica fume	2.5 % of Silica fume	5 % of Silica fume
1	7	14.96	26.66	29.34
2	14	27.90	45.62	46.37
3	28	38.80	54.74	60.92



**Figure 2: Development of Compressive strength of Cubes**

## VI. CONCLUSION

Out of the various methods of mix design, some of them are not very widely used these days because of some difficulties or drawbacks in the procedures for arriving at the satisfactory proportions. The ACI committee 211 methods, the DOE method and Indian standard recommended methods are commonly used. The ISI method can be applied both medium strength and high strength concrete. The ACI committee method has the advantage of simplicity in that it applies equally well, and with more or less identical procedure to round or angular coarse aggregate, to regular or light-weight aggregates and to air-entrained or non-air-entrained concretes. Preparation of trial mix and test the compressive strength at 7 days will give the actual idea about the mix proportion. Increase the percentage of silica fume 5 % gives the target strength 60.92 N/mm<sup>2</sup>. Finally replacement of cement with silica fume 5 % showed good result in compression strength test.

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