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Design Of High Performance Concrete By The Partial Replacement of Cement With Silica Fume using M60 Grade

Rayees Ahmad Bhat[1], Ankush Tanta[2], Rohit Sharma[3], Abhishek Gupta[4]

1. *M-tech Student Structural Engineering, BADDI UNIVERSITY of Emerging Sciences and Technologies, Baddi, Distt. Solan(H.P), India*
2. *[2]HOD, [34]Assistant Professor Department of Civil Engineering, BADDI UNIVERSITY of Emerging Sciences and Technologies BADDI, Distt. Solan(H.P), India*

Abstract: ***This paper presents a detailed coverage of High Performance concrete developments in civil engineering field.The aim of this study is to evaluate the performance effects on concrete by mineral admixture such as silica fume (as a partial replacement of cement) in concrete when it is mixed in cement concrete for workability, durability and strength of concrete using OPC (53 grade). Silica fume has been used to replace OPC which varies from 10% to 25% at interval of 10% by total weight of OPC.A total ten mixes (trial mix, control mix and variation mix) were prepared for M60 grade of concrete. This study investigates the performance of concrete under influence of silica fume in terms of slump, compressive strength at 7 days 14 days 28 and 56 days, flexural strength of beam at 7,14,28 and 56 days and splitting tensile strength of Cylinder at 7, 14, 28 and 56 days. A number of specimens for cubes, cylinders and beams were Casted respectively, which were casted for testing to study the influence of Silica fume on concrete. These Concrete specimens were deep cured in water under normal atmospheric temperature. The percentage of silica fume that have been replaced with cement was 0%, 10%, 15%, 20%, 25%.***

Keywords:-Silica Fume, Compressive Strength, Split Tensile Strength, Flexural Strength

1. Introduction

Concrete has a wide range of usage in India with annual consumption exceeding 100 million cubic metres. Conventional ordinary Portland cement that is designed for compressive strength is not sufficient to meet the requirements for construction. so it was necessary to find an alternative which will meet the requirements for the current environment So, there is a need to design new type of concrete which is known by high performance concrete which has better properties than conventional concrete the Ingredients of High Performance Concrete contribute most efficiently to the various properties, for a particular application and environment so that it will give excellent performance in the structure in which it will be placed, in the environment to which it will be exposed, and with the loads to which it will be subjected during its design life.

2. Literature Survey

Amudhavalli & Mathew (2012) studied the Effect of silica fume on the strength and durability characteristics of concrete. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by silica fume by 0, 5, 10,15and by 20%.

Kumar & Dhaka (2016) write a Review paper on partial replacement of cement with silica fume and its effects on concrete properties. The main parameter investigated in this study M-35 concrete mix with partial replacement by silica fume with varying 0, 5, 9, 12 and 15% .

Ajileye (2012) Cement replacement up to 10% with silica fume leads to increase in compressive strength for M30 grade of concrete. From 15% there is a decrease in compressive strength for 3, 7, 14 and 28 days curing period. Compressive strength of M30 grade of concrete was increased from 16.15% to 29.24% and decrease from 23.98% to 20.22%.

3. MATERIALS AND THEIR PROPERTIES

3.1 Silica Fume

Silica fume is a by-product from the silicon factory. It cools, condenses and is collected in cloth bags. Silica fume also exhibits large reduction in bleeding and concrete with micro silica could be handled and transported without segregation. I have obtained the silica fume from the ultratech cements Chandigarh India Manufactured by ELKEM INDIA PVT LTD.

3.2 Physical and Chemical properties of silica fume

Properties	**Approximate Value**
Surface Area	150000-200000 (cm2/gm)
Specific Gravity	2.21
Particle size	<1μ
SiO_2	90.2%
Al_2O_3	1.7%
Fe_2O_3	0.4%
MgO	1.7%
SO_3	0.5%
Na_2O	0.7%
CaO	2.1%
K_2O	0.7%

3.3Cement

Elephant OPC 53 grade cement is used in this study. It is tested for physical properties as per IS : 12269:1981.

Physical Requirements for ordinary Portland cement of 53-Grade

Characteristic	Requirement	Test Method
Fineness (Min)	225 m^2 /Kg	IS 4031 (Part 2)
Soundness	10mm	IS 4031 (Part 3)
Initial Setting Time	30 minutes	IS 4031 (Part 5)
Final Setting Time	600 minutes	IS 4031 (Part 5)
Normal Consistency	5-7 mm	IS 4031 (Part 4)
Specific Gravity	3.15	-

3.4 Fine Aggregate

Manufactured Sand was collected from NearbyPvt. Ltd.Bhud, India and the bulk density is 1748 kg/m3 . It has specific gravity and fineness modulus of 2.65 and 2.86 respectively. The test results from sieve analysis are presented in table. Which lies in the zone II confirming to IS-383-2016.

3.5 Coarse Aggregate

Crushed stones that confirms to IS: 383-2016 have used. Aggregates which passes through 20 mmsieve and retained at 12 mm sieve were used having specific gravity 2.86 and fineness modulus 7.28 for 20 mm and 6.30 for 10 mm were used.

3.6 Water

Water plays a vital role in concrete construction. The requirement of water should be reduced to that required for chemical reaction of un-hydrated cement as the excess water would end up in only formation of undesirable voids in the hardened cement paste in concrete.

3.7 Admixtures

Conplast SP430 confirming IS: 9103:1979 and BS: 5075 Part 3 andASTM-C-494 as a high range water reducing admixture. Conplast SP430 is based on Sulphonated Naphthalene Polymers and is supplied as brown liquid instantly dispersible in water and specially formulated to give high water reduction up to 25%without loss of workability, Specific gravity 1.22 to 1.225 at 30°C.

4. Concrete Mix Design – M60 Grade Of Concrete (OPC 53 Grade)

Design Stipulation

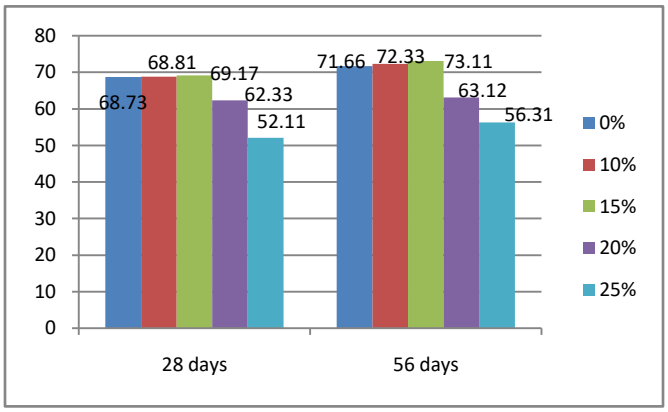
Characteristic comprehensive Strength @ 28 days = 68.25 N/mm^2
Maximum size of aggregate = 20 mm
Degree of workability = Collapsible
Degree of quality control = Good
Type of exposure = Severe

Minimum cement content as per is 456-2000

Test data for concrete ingredients
Specific gravity of cement = 3.15
Specific gravity of silica fume = 2.21
Setting time of cement initial = 30 min, final = 600 min
cube compressive strength
46.55 N/mm^2 @ 7 days
68.25 N/mm^2 @ 28 days

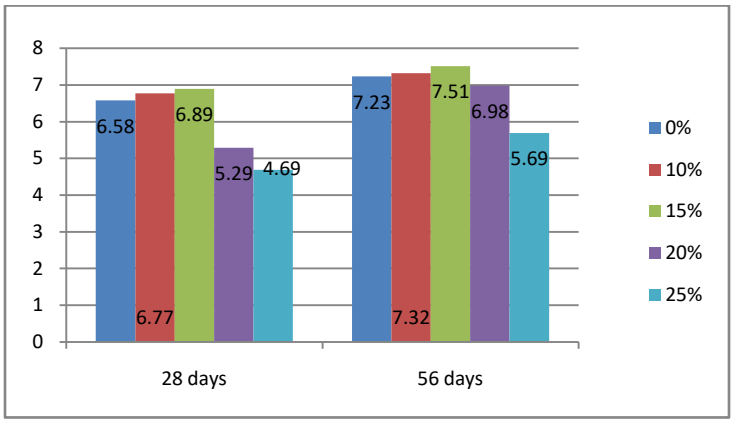
4.1 Compressive Strength

For each set six standard cubes were cast to determine 7-days,28 day and 56 days compressive strength after curing. Also nine number of cubes was casted to know the compressive strength of concrete. The size of the cube 150 x 150 x 150 mm.



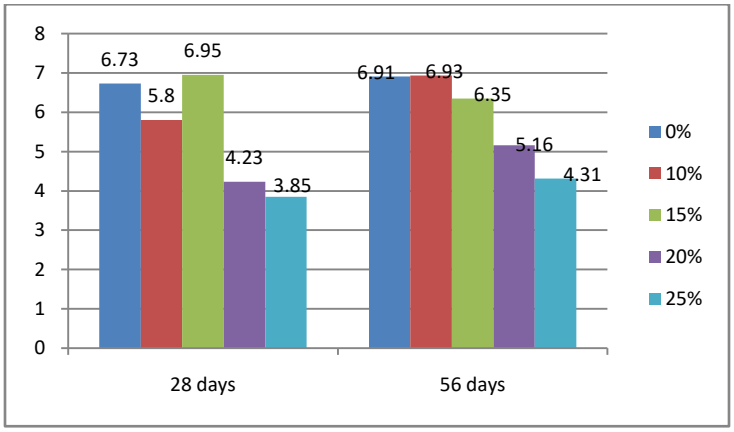
4.2 Flexural Strength

It is the ability of a beam or slab to resist failure in bending. The flexural strength of concrete is 12 to 20 percent of compressive strength. Flexural strength is useful for field control and acceptance for pavement but now a days flexural strength is not used to determine field control only compressive strength is easy to judge the quality of concrete.



4.3 Splitting Tensile Strength

Tensile Strength is one of the important property of the concrete as we know that concrete is weak in tension. Tensile strength is done on the cylinders casted by the concrete. After casting of cylinders the cylinders are the put in splitting tensile strength machine after 7,14,28,56 days and tested separately in order to get maximum tensile strength. The results are shown in the following chart.



5. Conclusion

1. A mix design procedure for High Performance Concrete using silica fume and super plasticizer is formulated by ACI method of mix design and available literature on HPC
2. Maximum compressive strength observed in M60 grade was 73.11 N/mm^2(when 15% silica fume was replaced by weight of OPC) which was greater than control mix M60
3. Maximum flexural strength observed in M60 grade was 7.51 N/mm2(when 15% silica fume was replaced by weight of OPC) which was greater than control mix M60
4. Maximum split tensile strength observed in M60 grade was 5.35 N/mm2(when 15% silica fume was replaced by weight of OPC) which was greater than control mix M60
5. In short as we increase the percentage of silica fume the strength of the cubes increases upto 15% and then decreases so the optimum value is 15%
6. The 28 days and 56 days cube compressive strength ratio of HPC is 0.93 to 0.95
7. The percentage replacement of cement by silica fume increases, the workability decreases.
8. The success of High Performance Concrete requires more attention on proper Mix Design, Production, Placing and Curing of Concrete.

6. Refrences

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