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PREVENTION OF AIR POLLUTION BY USING SILICA FUME AS CEMENTITIOUS MATERIAL

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ABSTRACT

In recent years significant attention has been given to the use of pozzolan silica fume as a concrete property-enhancing material, as a partial replacement for portland cement, or both. The initial interest in the use of silica fume was mainly caused by the strict enforcement of air pollution control measures in various countries to stop release of the material into the atmosphere. More recently, the availability of high range water-reducing admixtures (HRWRA) has opened up new possibilities for the use of silica fume as part of the cementing material in concrete to produce very high strength or very high levels of durability or both. In this study effective use of silica fume as cementitious material in making high performance concrete has been studied as a result of which the air pollution due to silica fume can be minimized. It is vital to minimize air pollution and to enjoy the pollution free environment because air is one of the important resources for the sustenance of life on terrestrial organisms.

INTRODUCTION

Initial interest in the use of silica fume sprung from air pollution enforcement placed on the silicon metal production industry. Silica fume is a by-product of the manufacture of silicon, ferro-silicon and other silicon alloys. It is produced by reducing high quality quartz with coal, iron and wood chips at very high temperature around 1800°C in electric process. The silica fume reaches top of the furnace with other combustion gases, where it becomes oxidized to silica by the air and then condenses as submicroscopic particles and agglomerated particles of amorphous silica (Rajkumar 2001). Today silica fume is perhaps the material of choice in designing to withstand aggressive exposure conditions. In India silica fume is a relatively new material. The interest in the silica fume started with the strict enforcement of air pollution controls in many countries which implies that the industry has to stop releasing silica fume along with other fine gases into the atmosphere. To find a solution to this problem studies were initiated and after some investigations, it was found that silica fume could be used as a very reactive pozzolanic material in concrete (Tiwari et al. 2000).

Adverse effects of different pollutants on human health have been well documented in all parts of the world. These include many diseases, and an estimated reduction in life expectancy of a year or more for people living in the world. There is also evidence of increased infant mortality in highly polluted areas. Concerns about these health effects have led to the implementation of regulations to reduce emissions of harmful air pollutants and their precursors at International, national and regional level.

MATERIALS AND METHODS

Totanji et al. (1995) inferred that replacing 25 % of cement in composites with silica fume had no adverse effect on strength and that percentage should be considered optimum for maximizing strength. Yogendran et al. (1987). investigated the strength of silica fume concrete at a constant water binder ratio of 0.34 and replacement percentage of 0 to 25 with varying dosages of high range water reducing admixtures. The maximum 28 days compressive strength was obtained at 15% replacement level. The chemical composition of silica fume, supplied by M/s Elkem India Pvt. Ltd., is given in Table 1.

The mixes adopted in this study M1, M_2, M_3 and M_4 were obtained by replacing 0.5, 7.5 and 10% of the mass of cement by silica fume. Mix proportioning details are given in Table 2. The water/binder ratio of 0.32 for all mixes was maintained (Santanu Bhanja & Sengupta 2003). Chemical admixture was used is sulphonated naphthalene type super plasticizer.

All the test specimens such as cubes (100 mm) and cylinders (100 mm × 200 mm) were cast using steel moulds. The specimens were removed from the mould after 24 hours and cured in water. The cube specimens were used for compressive strength test and durability study, whereas cylinder specimens were used to study split tensile strength and stress-strain behaviour. 100 mm × 200 mm × 2000 mm beam specimens were used to study the flexural behaviour.

RESULTS AND DISCUSSION

The tested compressive strengths for various mixes M_1 to M_3 at the age of 3, 7, 28 and 56 days are given in Table 3. When silica fume is added as addition admixture, there is a significant improvement in the strength of concrete because of high pozzolanic action to form more calcium silicate hydrate gel (Tiwari et al. 2000). The maximum compressive strength is obtained for Mix M_3 with 7.5% of silica fume and its 28 days compressive strength is 68 MPa. The increased strength is due to high reactive silica present in silica fume concrete.

It is observed that M_3 mix has the maximum compressive strength. For M_3 mix with 7.5 % silica fume, the 28 days and 56 days compressive strength is 68 MPa and 72 MPa respectively. The compressive strength depends mainly on silica fume because of excellent pozzolanic properties to produce high strength concrete.

The compressive strength of high performance concrete containing 7.5% of silica fume is 11% higher than the normal concrete. As the age of concrete increases, the compressive strength also increases.

Table 1: Chemical composition of silica fume.

Constituent	%
SiO_2	90-96
Al_2O_3	0.5-0.8
MgO	0.5-1.5
Fe_2O_3	0.2-0.8
CaO	0.1-0.5
Na_2O	0.2-0.7
K_2O	0.4-1
C	0.5-1.4
S	0.1-0.4
Loss on ignition (C+S)	0.7-2.5

Table 2: Mix proportioning details.

Mix	Cement (kg/m^3)	Silica fume (kg/m^3)	F.A (kg/m^3)	C.A (kg/m^3)	SP (L/m^3)	W/b
M_1	500	0	716.916	1046.7	4.16	0.32
M_2	476.190	23.8	716.916	1046.7	6.25	0.32
M_3	465.116	34.88	716.916	1046.7	7.3	0.32

Table 3: Compressive strength results.

Mix	% silica fume	3 days (MPa)	7 days (MPa)	28 days (MPa)	56 days (MPa)
M_1	0	43	50.5	60.5	65
M_2	5	42	52	64	70
M_3	7.5	43	53	68	72

Table 4: Flexural test results.

Description of test specimens	% of silica fume	First crack load (kN)	Ultimate load (kN)	Deflection at ultimate load (mm)
CB	0	30	72	15.65
SFB1	5	30	90	20.9
SFB2	7.5	35	95	23.6

A total of 4 reinforced concrete beams were cast for flexural test. All the beams were tested up to failure. Table 4 gives the flexural test results.

The ultimate load carrying capacity of the beam with silica fume was 24.2% higher than that of control beam in flexural test.

CONCLUSION

The effective use of silica fume in the manufacture of high performance concrete for present and future use minimizes the disposal of silica fume. Hence, by effectively using the silica fume we can enjoy the pollution free environment. The complete usage of silica fume in concreting works double the benefit by giving pollutionless environment and rich concrete mixes.

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