EFFECT OF SILICA FUME ON SOME PROPERTIES OF CONCRETE

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Abstract

In the present paper, experimental results on workability, compressive strength and permeability of concrete with various mixture proportions have been presented to study the effect of silica fume on concrete mixes. It has been found that microsilica increases the workability of the fresh concrete upto a certain limit of microsilica addition (upto 20%) as cement replacement. Compressive strength was also increased on addition of microsilica. The Ultrasonic Pulse Velocity results showed that during initial compression the UPV was increased slightly but on further increasing the compressive load the UPV was decreased. When the load was about 75-80 percent of ultimate strength, an abrupt reduction in UPV was observed. It has been found from the study that addition of micro silica (upto 20%) in concrete reduces the permeability by 35%-50%.

Keywords: Workability, compressive strength, permeability, microsilica, ultrasound pulse velocity.

1.INTRODUCTION

Silica fume or Micro silica is co-product of the ferrosilicon and silicon alloy industry which is very rich in amorphous silicin dioxide nearly 90%. Realizing the pozzolanic potential of the materials, this has been used successfully as an admixture in producing concrete. Initially, the use of microsilica was as a cement replacement, due to its very high pozzolanic reactivity, but as more data came from laboratory and field, the material becomes as additional cementitious component giving increased performance in both fresh and hardened states. In the recent times, use high performance concrete is in demand in the construction industry. For improved strength and durability, the use of silica fume as the replacement of cement has been tried with success. Some of the notable researches in making concrete using silica fume as admixture includes the works of

Yogendran et.al (1982), Khedr and Abou-Zeid (1994), Sabir (1995) and Bayasi and Zhou (1993). The mechanical property especially compressive strength of the concrete was investigated with aim to find optimum silica fume replacement percentage. Different researchers have arrived at different optimum value. Bhanja and Sengupta (2005) investigated influence of silica fume on the tensile strength of concrete. The important finding was strength increases with silica fume addition but optimum replacement level was not constant which depends on the water-cementious material ratio of the mix. Mazloom et.al. (2003) presented experimental results on the workability, strength and autogeneous shrinkage with different percentage of silica fume. Gonen and Yazicioglu (2006) presented a laboratory study on the performance of concrete by adding mineral admixtures, silica fumes or/and fly ash. The test results, in general, showed that mineral admixtures improved the performance of concretes. Silicafume contributed to both short and long-term properties of concrete, whereas flyash shows its beneficial effect in a relatively longer time. Silica fume is also found to enhance durability of concrete in terms of its increased resistance to chemical attacks, combating alkali silica reaction (Thomas, 2001). Microsilica is also found to improve the corrosion protection and strength of concrete by reducing the permeability of the concrete and forming more calcium silicate hydrate (CSH) which provides strength and durability to concrete (Asrar et. al, 1999). In view of increased use of silica fume in high performance concrete, the present investigation aims at obtaining the workability, strength and permeability of concrete of two different mixes with varying level of cement replacement by silica fume. The ultrasonic pulse velocity during compression of silica fume concrete specimen is also reported which may be useful to anticipate failure of the specimen by means of non destructive technique.

2.EXPERMENTAL PROGRAMME

Two grades of concrete mix M25 and M30 have been considered in the present investigation with different percentage replacement of cement with silica fume. The principal properties of the materials used in concrete mix have been evaluated and given below:

2.1 Material Properties

Cement: Cement used was of Shakti brand (OPC-53). Standard consistency: 28%, Initial setting time: 180 minutes; Final setting time: 600 hours; Specific Gravity: 3.14, Compressive strength at 28 days: 50 N/mm^2.

Fine Aggregate: Specific Gravity: 2.82; Fineness Modulus: 3.14; Zone-III (IS 383: 1970)

Coarse Aggregate: Nominal size: 20 mm; Specific gravity: 2.82

Silica Fume: Elkem micro silica has been used in concrete mixes to replace cement. Specific gravity= 2.24. The amount of various ingredients is: SiO_2 = 85%; Carbon= 3.5%; LOI= 4%;

2.2 Mixture Proportion

The concrete mixes were proportioned following IS 10262: 1982. The mixes were prepared with the same type of aggregate. The concrete mixes (M25 & M30) were designed with various percentages of micro silica (0%, 10% and 20% respectively). Plasticizer at 0.2 percent of the weight of cement was added to the concrete made. The quantities of ingredients per cubic meter or two types of concrete mixes are shown in Table1.

2.3 Preparation of Test Specimen

Under laboratory conditions 150mm concrete cubes were prepared. The mixing was done in a tilting type mixer machine; cubes were cast and compacted by using a vibrating rod. The slump was noted for each of the mixes. The concrete cubes, six for each type of mix, were cured in water. The cubes were tested under nominal conditions. Each water-cured cube was taken from water at each of the test age and then rubbed with a clean dry cloth until a saturated surface dry sample was obtained.

2.4 Test Conducted

Following tests were conducted on hardened concrete to examine the influence of cement replacement by silica fume.

- Workability Test
- Compressive strength test
- UPV test during compressive loading to examine the progressive failure
- Permeability Test

The conventional slump test on fresh concrete mixes was carried out to determine workability in terms of slump. Compressive strength tests on cured cube specimen at 28 days were performed in a compression testing machine of 200 tonnes capacity. Each of two opposite faces of cubes was prepared for UPV test according to IS: 13311 (Part-1) and then center of each surface was determined. The cubes are fitted in compression testing machine and a very small load was applied to keep the cube in position. The transmitter and receiver of the UPV tester (make TICO) were used on each pair of the opposite faces. The pulse velocity was recorded at the zero stress level. The load was then slowly applied to the tested cube until failure. At each load increment, the pulse

velocity was recorded. Concrete permeability is measured by Torrent Permeability Test kit developed by Holderbank Management and Consulting Limited, Switzerland. The particular features of the Torrent permeability method are a two-chamber vacuum cell and a pressure regulator, which ensure that the airflow at right angles to the surface is directed towards the inner chamber. This permits the calculation of the permeability coefficient kT (m^2) on the basis of a simple theoretical model. The unit has a user-friendly menu technique and measures the pressure increase as a function of time according to a specific sequence. The associated data is automatically collected by the display unit and the permeability coefficient kT and the depth of penetration L if the vacuum is calculated. The measurement takes 2-12 minutes, depending on the permeability of the concrete.

3. RESULTS AND DISCUSSIONS

3.1 Effect of silica fume on workability of concrete

All the fresh concrete mixes were observed under standard slump cone apparatus and the slump values were measured. Low to medium slump values was obtained. In both grades of the concrete the slump values observed to be gradually increasing upto 10% of microsilica content and thereafter gradually decreasing pattern were observed due to increase in the microsilica content. This is due to finer size of microsilica and high water absorption of silica particles. A constant difference in slump value were observed for different percentage of microsilica content for both of the M 25 and M 30 concrete. This is depicted in Fig. 1.

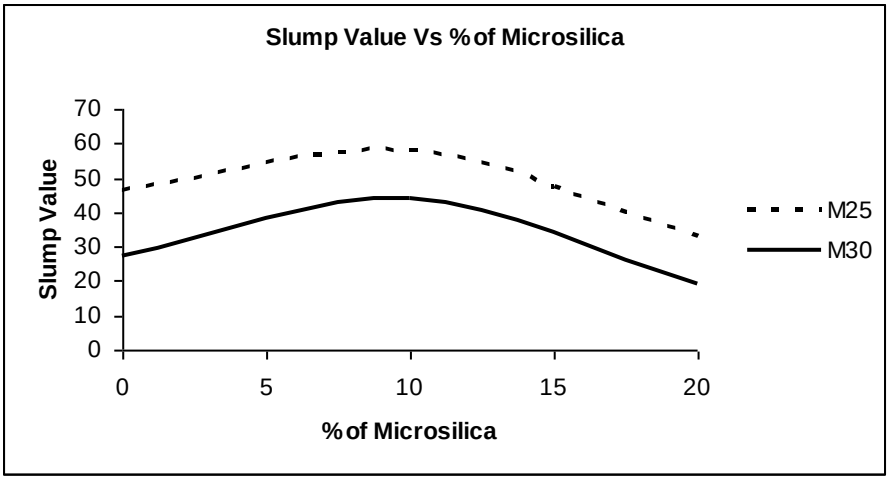

Fig.1 Slump Value Vs % of Silica Fume

3.2 Effect of silica fume on compressive strength of concrete

The compressive strengths have been evaluated from the peak load obtained by crushing the specimen. Slightly higher 28 days compressive strengths have been observed for both the concrete grades with 10% microsilica replacement.

Fig.2 and Fig.3 shows the variation of UPV with progressive compressive loading for M25 and M35 concrete. Ultrasonic Pulse Velocities (UPV) were slightly increasing during initial compression but decreasing on further increase in compressive load. The UPVs were observed to be abruptly decreasing on compressive load about 70-80 percent of ultimate strength.

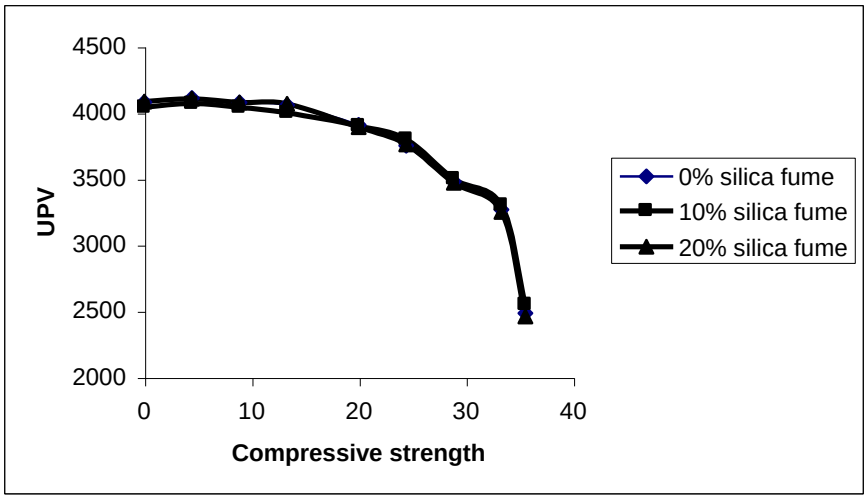

Fig.2 Compressive Strength (N/mm^2) Vs UPV (m/sec) for M 25 grade of concrete

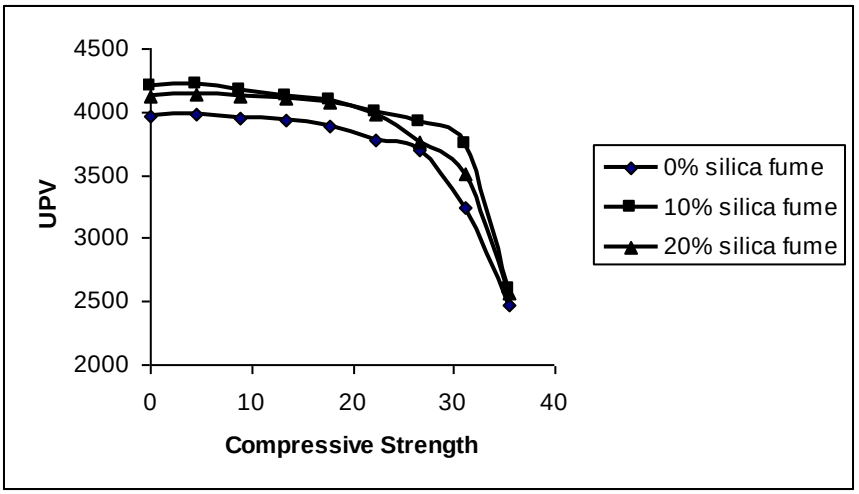

Fig.3 Compressive Strength (N/mm^2) Vs UPV (m/sec) for M 30 grade of concrete

3.3 Effect of silica fume on permeability of concrete

The quality of concrete with respect to permeability may be bad, normal and good. Permeability with (0.01-0.10) $x10^{-16}$ m^2 said to be good, (0.1-1) $x10^{-16}$ m^2 is said to be normal and (1-10) $x10^{-16}$ m^2 is said to be bad. The length from where the machine sucks air and make vacuum is L mm. L is the shortest distance of a surface parallel to the concrete surface where the instrument is placed. Concretes with 20% silica fume content for both the grades have lower values of L. Variation of permeability of concrete with increasing silica fume content has been shown in Fig.4 and Fig.5 respectively.

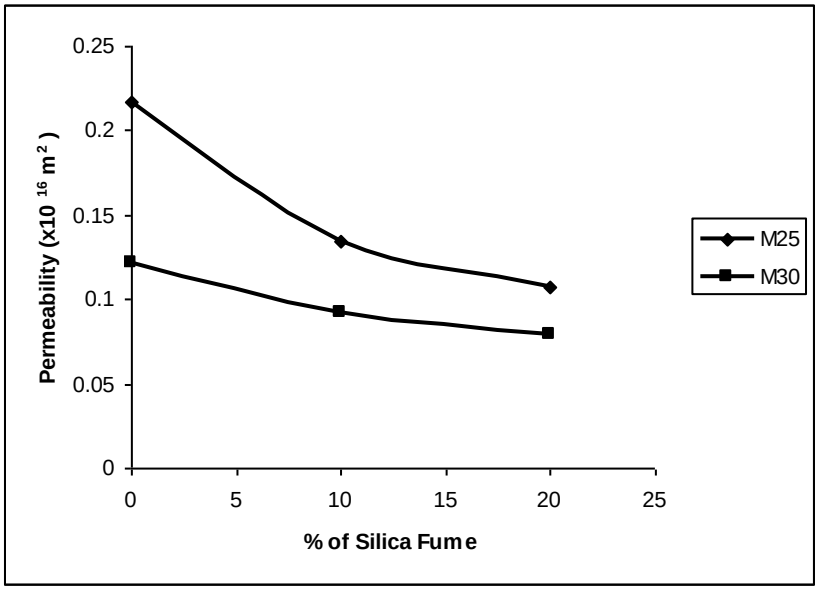

Fig.4 Permeability Vs % of Silica Fume

For both the grades concrete the permeability shows improvement with contents of silica fume i.e less permeability with higher content of silica fume.

4. CONCLUSION

Various parameters of both fresh and hardened concrete are getting changed due to silica fume content. Following conclusions can be made.

1. Workability of concrete improves with addition of silica fume up to certain limit.
2. Ultimate compressive strength of concrete increases with replacement of cement by silica at certain specified limit.
3. UPV increases with increase in compressive load initially and the decreases with increase in compressive load due development of micro cracks in concrete. Abrupt decrease in UPV occurs at 70-80% of failure load.

4. Permeability decreases with increase in percentage of silica fume content to a level after which addition of silica fume has negligible effect on the concrete permeability.

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