

Effect of superplasticizer and silica fume on properties of concrete

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Abstract— Nowadays high strength and high performance concrete are widely used in many civil engineering constructions. To produce them it is required to reduce the water/powder ratio and increase the binder content. Superplasticizers are commonly used to achieve the workability. Silica fume is one of the popular pozzolanas used in concrete to get improved properties. The use of silica fume in conjunction with superplasticizers has become the backbone of high strength and high performance concrete. An experimental program has been carried out to study the effect of superplasticizer alone and in conjunction with silica fume on some of the properties of fresh and hardened concrete.

Index Terms—high strength concrete, high performance concrete, superplasticizer, silica fume.

1. Introduction

Concrete is the most widely used building material because of its versatile nature. It can be used for construction of dams, water tanks and canal linings. The reinforced cement concrete (RCC) are used for constructions of buildings, roads, bridges, factories etc. The RCC can resist forces due to natural and manmade calamities like cyclones, earthquakes, blasts and fires much better than other materials. The material has been well accepted by the society in this age and present era can be termed as “Concrete age” in history of mankind.

The deterioration and premature failure of concrete structures such as marine structures, concrete bridge deck etc. has leads to development of high performance concrete. The high performance concrete is defined as the high-tech concrete whose properties have been made to meet specific engineering properties such as high workability, very high strength, high toughness and high durability to exposure condition. However, it is possible to produce high performance concrete that shows high workability, high ultimate strength and high durability by partial replacement of cement with silica fume.

Silica fume is among one of the most recent pozzolanic materials currently used in concrete. It was first used in 1969 in Norway but only began to be systematically employed in North America and Europe in the early 1980s. Since then, the use of silica fume in concrete has been increasing rapidly, it has been used either as a partial replacement for cement or as an additive when

special properties are desired. The rapid increase in the use of silica fume is attributed to its positive effect on the mechanical properties of the cementitious composites. Though added strength and low permeability are the two reasons that silica fume is added to concrete, there are other properties that are favorably affected by the addition of silica fume, including: modulus of elasticity, drying shrinkage, bonding, and resistance to reinforcing steel corrosion and sodium sulphate attack due to low permeability to water and chloride ions. However, some unfavorable properties are associated with the addition of silica fume to concrete, such as loss of slump and reduction in ductility. The use of fly ash and silica fume in concrete has been reported [1-9].

2. Materials used

The cementitious materials used are ordinary Portland slag cement (PSC) and silica fume. As the ordinary Portland cement are not available locally, the Portland slag cement has been used in the present study. The physical properties of PSC obtained from the experimental investigation are presented in table 1. The the physical properties of the silica fume used in this study are given in table 2.

Table 1 Physical properties of Portland slag cement

Physical test	Results
Fineness (retained on 90mm sieve) %	4.5
Soundness(by Le-Chartilier method) (mm)	2
Initial setting time (s)	110
Final setting time (s)	300
Compressive strength (Mpa)	
3 day	21.5
7 days	32.0
28 days	41.5

Table 2 Physical properties of silica fume

Physical characteristics	Typical values
Specific gravity	2.2
Average partical size	0.1 micron
Bulk density	240kg/m ³

Specific surface	16000m ² /kg
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Natural river sand has been collected from Koel River near Koel Nagar, Rourkela, Orissa with its maximum size as 4.75 mm. The fine aggregate is conforming to the zone-III as per IS-383-1970. The coarse aggregate used was 20 mm down graded and collected from Quarry near Rourkela. The gradation curves of fine and coarse aggregate are shown in Fig.1 and Fig. 2. The other physical properties of the fine and coarse aggregates are given in Table 3.

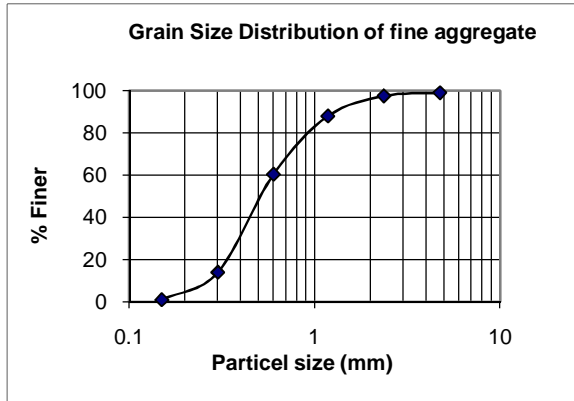


Fig. 1 Grain Size Distribution of fine aggregate

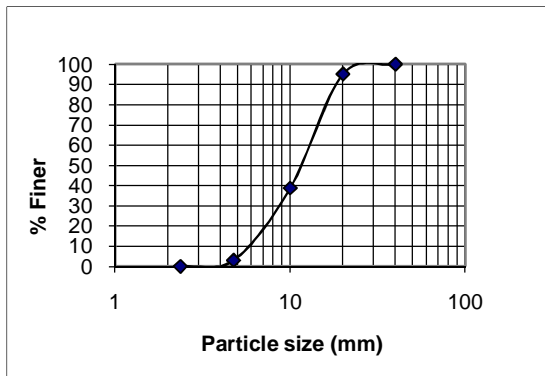


Fig. 2 Grain size distribution Curve for Coarse aggregate

Table 3.Physical properties of aggregates

Property	Aggregates	
	F.A	C.A
Specific gravity	2.65	2.72
Fineness modulus	2.40	6.63
Water absorption	0.85 %	0.40 %
Free surface	0.90 %	Nil

moisture		
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3. Results and discussion.

3.1 Workability of fresh concrete

The water cement ratio for constant range of slump (80mm to 85mm) are 0.45, and 0.35 for control mix and control mix with superplasticizer respectively. The variation of water cement ratio with superplasticizer is shown in Fig. 3. It is observed that the water cement ratio decreases by using superplasticizer . The variation of water cement ratio with silica fume is given in Fig. 4. It is seen that the water cement ratio increases with the increase of silica fume for constant slump range.

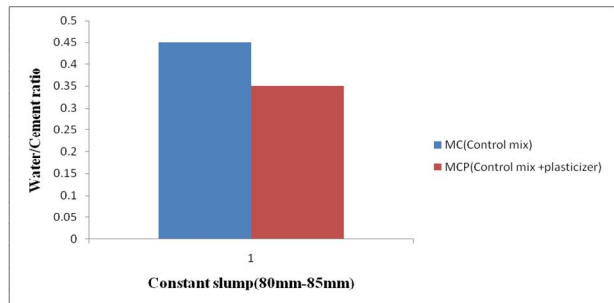


Fig. 3 Variation of water cement ratio with superplasticizer of fresh concrete

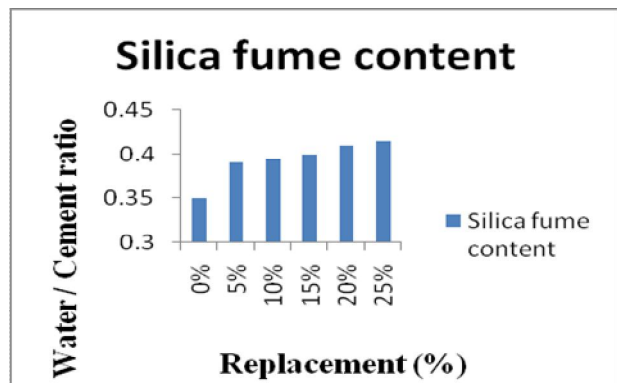


Fig. 4 Variation of water cement ratio with replacement of Silica fume

Table 4 Compressive strength (MPa) of concrete

3.2 Compressive strength

The results of compressive strength of cubes for 7, 28 and 56 days curing are shown in Table 4. It can also be seen that the compressive strength of concrete increases with an increase in the replacement percentage up to 20% of silica fume content then decreases for all days of curing. It can be observed that the compressive strength of cubes at 28 days curing for control mixture with superplasticizer (M_{CP}) is 35.6 MPa and the strength increases by 6.23 %, 12.0 %, 16.82%, 18.39% and 13.39 % for M_{S5} (5% silica fume replacement), M_{S10} (10% silica fume replacement), M_{S15} (15% silica fume replacement), M_{S20} (20% silica fume replacement), and M_{S25} (25% silica fume replacement) mixes respectively, in comparison with the control mixture with superplasticizer(M_{CP}). The increase in strength from 7 to 28 days curing was in the range of 26% to 38 %. The increase in strength from 28 to 56 days was 4% to 9%. The above results are also presented graphically in Fig. 5.

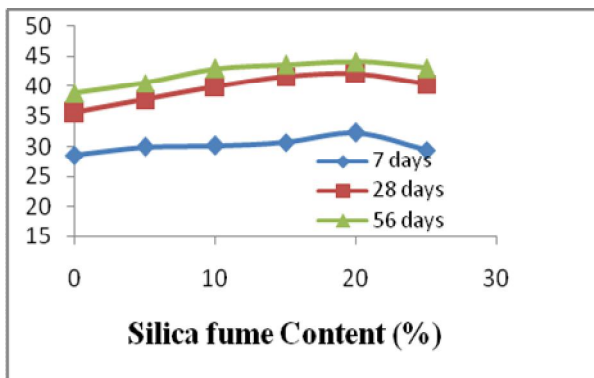
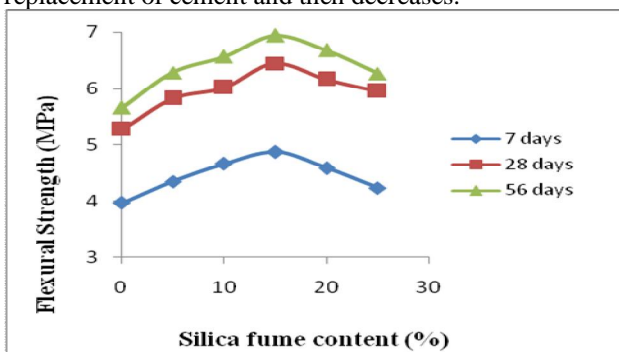


Fig.5 Variation of compressive strength with silica fume percentage

3.2 Flexural strength

The flexural strength of concrete with different percentage of cement replacement with silica fume is shown in figure 6 for constant slump range of 80 to 85 mm. It is observed that the flexural strength of concrete will increase with increase in silica content up to 15 % replacement of cement and then decreases.



Mix. identification	Compressive strength (MPa) of concrete cubes		
	7 days	28 days	56 days
M_{CP} (control mix with plasticizer)	28.57	35.6	38.87
M_{S5} (5% silica fume)	29.97	37.82	40.57
M_{S10} (10% silica fume)	30.25	39.87	42.95
M_{S15} (15% silica fume)	30.78	41.59	43.68
M_{S20} (20% silica fume)	32.37	42.15	44.12
M_{S25} (25% silica fume)	29.45	40.37	43.05

Fig 6. Variation of flexural strength with silica fume

Conclusion:

The following conclusions may be made from the present investigation of the replacement of cement silica fume and use of superplasticizer on fresh and harden concrete properties.

1. The water cement ratio reduces by 23% in concrete by using superplasticizer (1% by weight of cement) for a constant range of slump 80mm to 85mm.
2. The compressive of concrete is increased by use of silica fume up to 20% replacement of cement.
3. The flexural strength of concrete is increased by use of silica fume up to 15% replacement of cement.

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