EFFECT OF SILICA FUME ON HIGH STRENGTH CONCRETE

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Abstract

The compressive strength for high strength concrete HSC has been studied and tested in this article. The high strength has made by replacing / adding silica fume with ordinary cement. The ratio was 7%, 10%, 12%, and 15% as replacement and as addition with cement. An admixture has been also used to increase workability and reduced water-cement ratio to obtain high strength concrete. Many trials have been made to find optimum compressive strength for 7 and 28 days, then they were investigated and studied. In General, the experimental results show that the replace or adding silica fume to concrete has significant effect and increase compressive strength at both 7 and 28 days. The dosage of silica fume that uses as addition in concrete mixture increases compressive strength more than by replacement. While it reduces the workability of fresh concrete which needs to use of admixture to ensure workability. The study also shows that applying the dosage of silica fume and admixture to produce high strength concrete based on ACI committee 211 recommendation.

Keywords: Silica fume, high strength concrete, compressive strength

1. Experimental Work

To produce high strength concrete HSC, well garde aggregate (crushed is more prefered ruther than rounded), ordinary proland cement (450-550) Kg/m^3, Silica fume (generally 5% to 15% by mass of total cementitious materials), with always superplasterizer, and very low water cement ratio (below 0.35 and aften around 0.25) based on Neville(1) recommednation.

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Silica fume is an extremely effective material for producing very high strength concrete with low permeability. Because of its chemical and physical composition, silica fume is highly effective for achieving high strength at both early and later ages. The silica fume content in concrete generally rages from 5 to 20 percentage of the total cementitious materials content (as a partial replacement by weight of cement) [2].

Table (1) and Figure (1) show the details of concrete mixes (1.0:1.19:1.80 with HRWRA 3% by weight of cement) that contain different dosages of silica fume as partial replacement by weight of cement. It can be noted that the compressive strength is continuously increases as the dosage of silica fume increases; the optimum dosage of silica fume that can be replaced partially by weight of cement is 15%, which produces a compressive strength of about 84 MPa. This dosage causes an increase in compressive strength of about 14% in comparison to concrete mix not containing silica fume. This increase in compressive strength is due to the formation of additional calcium silicate hydrate (CSH) binder, through the reaction of the silica fume (SiO_2) with the free lime $Ca(OH)_2$ preset in the cement [2, 3].

$$Cement + H_2O \longrightarrow CSH\ (Cementing\ gel) + Ca(OH)_2$$

$$Ca(OH)_2 + SiO_2 \longrightarrow CSH\ (Additional\ cementing\ gel)$$

Table (1) Details of trail mixes for various dosages of silica fume as partial replacement by weight of cement

Mix proportions by weight	Mix Symbol	W/C ratio	HRWRA (% by weight of cement)	SF (% as a replacement by weight of cement)	Slump (mm)	Compressive Strength (Mpa)		Increase in strength with respect to Mix ($M_{H3\text{-}RSF0}$)	
						7 days	28 days	7 days	28 days
1:1.19:1.80	$M_{H3\text{-}RSF0}$	0.30	3	0	75	64.2	73.9		
	$M_{H3\text{-}RSF7}$	0.30	3	7	85	71.3	78.4	11.1%	6.1%
	$M_{H3\text{-}RSF10}$	0.29	3	10	80	77.6	83.8	20.9%	13.4%
	$M_{H3\text{-}RSF12}$	0.29	3	12	85	74.3	81.7	15.7%	10.6%
	$M_{H3\text{-}RSF15}$	0.29	3	15	75	74.0	84.4	15.3%	14.2%

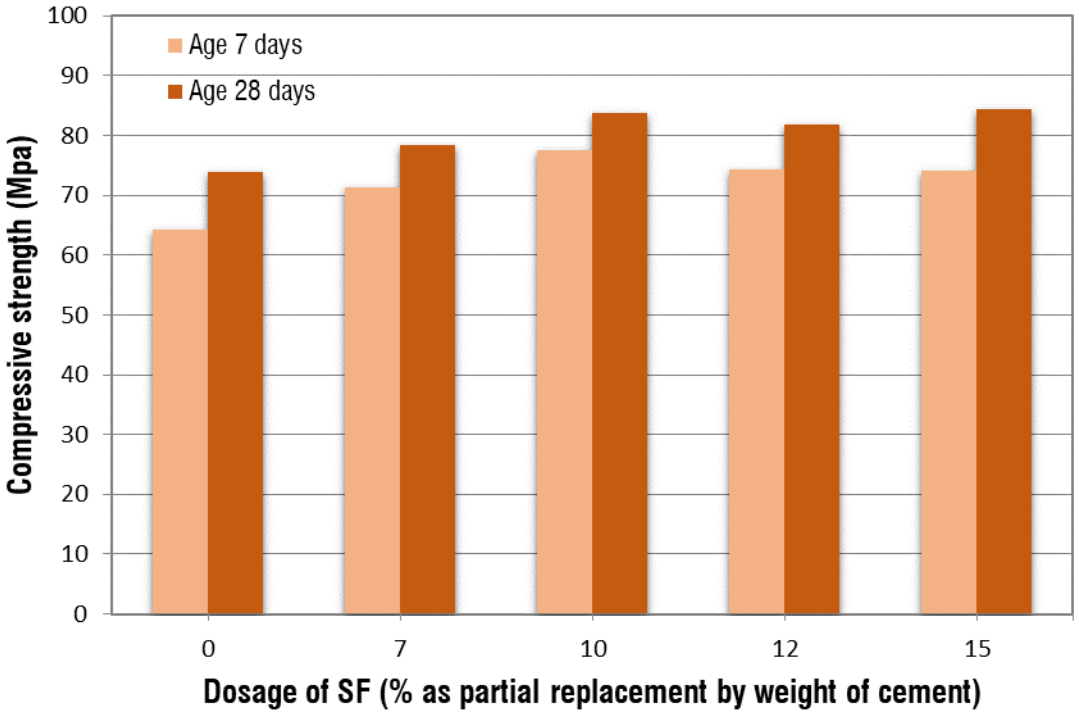

Figure (1) ffect of dosage of silica fume as partial replacement by weight of cement on compressive strength of concrete mix *

*(Mix proportion 1:1.19:1.80 by weight, HRWRA 3% by weight of cement).

Many researchers [4] used silica fume as a percent addition by weight of cement. It was reported [5] that the normal addition rates of silica fume ranges between 6-10% by weight of the cementitious content of the mix, this percentage can be increased to 12-15% to make the mix even more cohesive. It is recommended [5] that the silica fume be added in addition to the existing cement in very highly aggressive environments, in order to substantially increase the chemical resistance and durability of the concrete. Even though addition is more expensive than cement replacement, the improvement in the long term performance of the concrete structures will far outweigh the slightly higher initial expenditure on cementitious materials. So many trial mixes were carried out in this investigation using silica fume as addition by weight of cement in different dosages (7%, 10%, 12% and 15%).

The results of concrete mixes (1:1.19:1.80 by weight with HRWRA 3% by weight of cement) containing different dosages of silica fume as addition by weight of cement are shown in Table (2) and Figure (2). It is clear that the compressive strength is continuously increases as the dosage of silica fume increases. The results also show that the optimum dosage of silica fume that can be added by weight of cement is 15% to obtain maximum compressive strength of about 93 MPa. The percentage increase in compressive strength is about 26% relative to the reference mix (not containing silica fume).

Figure (3) shows the effect of different dosages of silica fume as replacement and as addition by weight of cement on the compressive strength of concrete at 28 days. From the results indicated, it can be noted that using silica fume as addition by weight of cement increases the compressive strength more than that as a replacement by weight of cement. The percentages increase in compressive strength of concrete containing 15% silica fume as a replacement and as addition by weight of cement are about 14% and 26% respectively. It can be concluded that the optimum dosage of silica fume is 15% as addition by weight of cement.

Table (2) Details of trail mixes for various dosages of silica fume as addition by weight of cement

Mix proportions by weight	Mix Symbol	W/C ratio	HRWRA (% by weight of cement)	SF (%as addition by weight of cement)	Slump (mm)	Compressive Strength (Mpa)		Increase in strength with respect to Mix ($M_{H3-ASF0}$)	
						7 days	28 days	7 days	28 days
1:1.19:1.80	$M_{H3-ASF0}$	0.30	3	0	75	64.2	73.9		
	$M_{H3-ASF7}$	0.30	3	7	85	66.2	80.1	3.1%	8.4%
	$M_{H3-ASF10}$	0.29	3	10	85	71.1	85.3	10.7%	15.4%
	$M_{H3-ASF12}$	0.29	3	12	80	72.7	81.3	13.2%	10.0%
	$M_{H3-ASF15}$	0.29	3	15	80	75.4	93.3	17.4%	26.3%

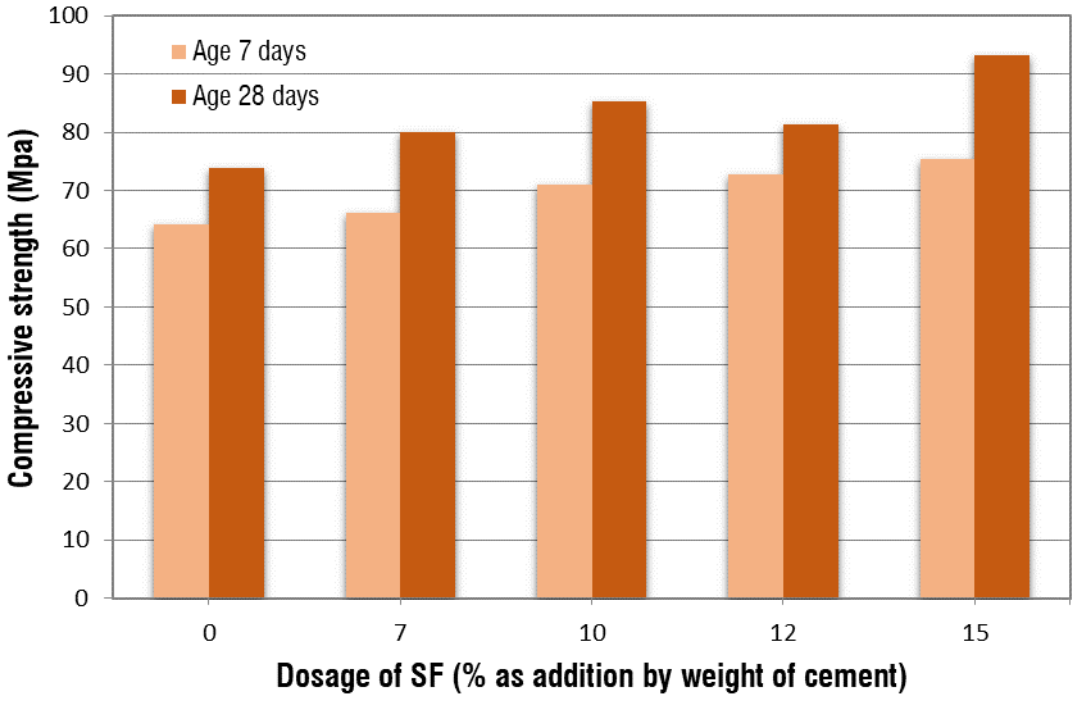

Figure (2) Effect of dosage of silica fume as addition by weight of cement on compressive strength of concrete mix *

*(Mix proportion 1:1.19:1.80 by weight, HRWRA 3% by weight of cement).

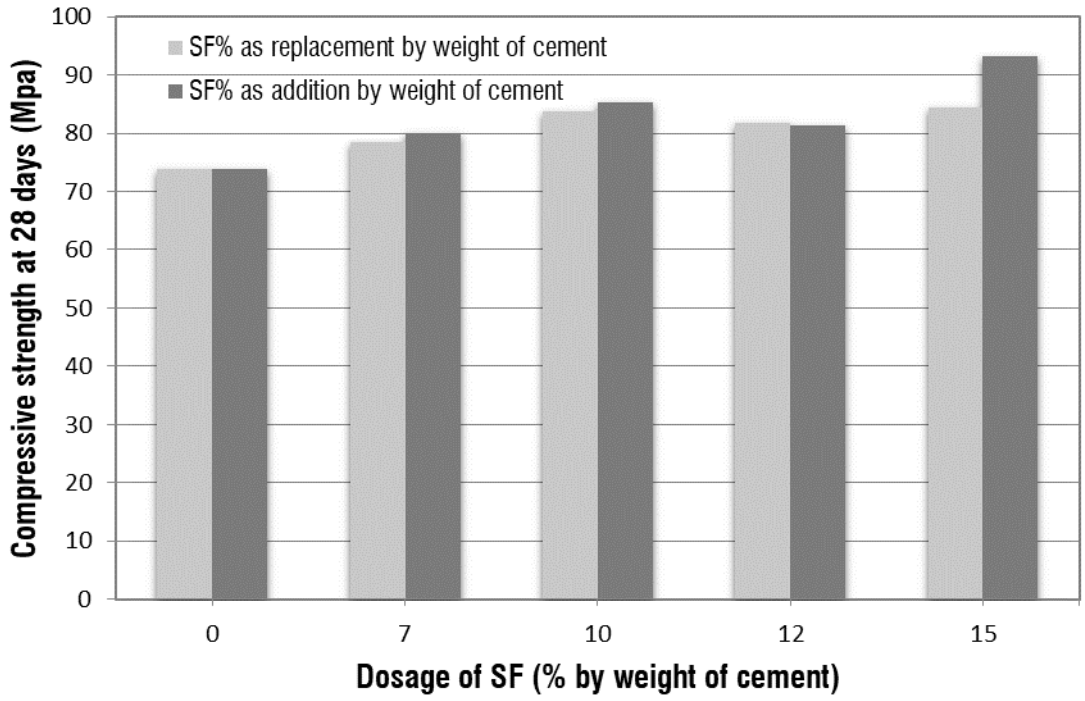

Figure (3) Effect of different dosages of silica fume on compressive strength of concrete mix *

*(Mix proportion 1:1.19:1.80 by weight, HRWRA 3% by weight of cement).

2. Conclusions

1. Addining silica fume increases compressive strength of concrete
2. The recommended silica fume dosage is between 5% to 15%
3. Addining silica fume in concrete decreases workability
4. It is recommedned to use High Range Water Reducung Admixture (HRWRA) with silica fume
5. Addining silica fume increases compressive strength rather than replacing by weight of cement
6. Silica fume reduces concrete permability which is it conveinent to use for submerged structures
7. It is recomended to use high strength coarse aggregate with silica fume so as to resist high stress

3. References

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