

INFLUENCE OF SILICA FUME ON COMPRESSIVE STRENGTH OF FLY ASH CONCRETE



Engineering

KEYWORDS: fly ash, concrete, silica fume, compressive strength, cement, cementitious material, curing

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ABSTRACT

This paper presents an experimental investigation on the properties of fly ash concrete incorporating silica fume to improve the early strength of concrete by cement replacements up to 35%. The results indicate that, the addition of higher the percentage of fly ash lead to decrease in values of concrete compressive strength in early age of concrete and silica fume improved the early age compressive strength of fly ash concrete. The cement replacements percentage for combination of fly ash and silica fumes is 20% of fly ash and 15% of silica fumes gain same strength that of normal concrete after 28 days curing with similar strength gaining early age of concrete, that save the cost of cementitious material more than 18%.

INTRODUCTION

Currently, India is taking major initiatives to improve and develop its infrastructure by constructing express highways, power projects and industrial structures to emerge as a major economic power. To meet out this rapid infrastructure development a huge quantity of concrete is required. Unfortunately, India is not self-sufficient in the production of cement; the main ingredient of concrete and the demand for exceeds the supply and makes the construction activities very costlier. Hence, currently, the entire construction industry is in search of a suitable and effective the waste product that would considerably minimize the use of cement and ultimately reduces the construction cost. Few of such products have already been identified like Rice Husk Ash (RHA), Fly Ash, Silica Fumes, etc. Now a day to reduce the cost of construction cement is partially replaced by fly ash. In India, a large amount of fly ash is produced but out of this only 4% fly ash is used for replacing cement. This utilization increasing steadily but the problem occurs more water cement ratio up to 0.45% .if we reduce 50% of cement by fly ash. This will reduce the strength of concrete automatically. Hence to achieve the high strength and workability fly ash is mixed with silica fumes up to 25%.Then it is possible to produce high strength concrete by lowering up to 0.28.

LITERATURE REVIEW

The principle advantage of fly ash is reduced permeability at a low cost, but fly ash of poor quality can actually increase permeability. Careful attention to the mix design and water content is always necessary to obtain proper set and early strength development. In all the concrete mixes, the compressive strength decreases with the increase in replacement level of fly ash for cement (30% and 40%) in comparison to normal mixes at all the ages. The rate of development of compressive strength of fly ash concrete is more during the period from 28 days to 90 days than the corresponding values for the initial period up to 28 days (Vanita Aggarwal, 2012). Replacement of cement with high lime fly ash reduces the rate of strength development/ gain, beyond the optimal limits obtained for 25 - 35 % fly ash mixes (Carolyn Namagga, 2009). Although use of fly ash improve the workability of concrete, the reduction in the strength of concrete with increasing fly ash content. This reduction is more at earlier ages as compared to later ages. This is expected, as the secondary hydration due to pozzolanic action is slower at initial stage for fly ash concrete. Rate of strength development at various ages is related to the water / cement ratio and percentage of fly ash in the concrete mix. Modulus of elasticity of fly ash concrete also reduces with increase in fly percentage for a given water / cement ratio. Reduction in modulus of elasticity value is much lower as compared to compressive strength (Amit Mittal, 2007).

The result of experimental investigation on the properties of fly ash concrete incorporating either hydrated limes or silica fumes to improve the early strength of concrete indicated that addition of lime and silica fumes improved the early age of compressive strength of fly ash concrete. The inclusion of silica fumes was also found to increase that 28 days strength significantly. The air permeability of concrete containing lime and silica fume either decreased or remained silica fume also improved the sorptivity of concrete almost the same when

compare to the concrete without these (S. A. Barbhuiya, 2009).

FLY ASH CONCRETE USING SILICA FUME

One of the ultimate aims of studying the various properties of the materials of concrete, plastic concrete and hardened concrete is to enable a concrete technologist to design a concrete mix for a particular strength and durability. The design of concrete mix is not a simple task on account of the widely varying properties of the constituent materials, the conditions that prevail at the site of work, in particular the exposure condition, and the conditions that are demanded for a particular work for which the mix is designed. Concrete Mix Design done by using Indian standard method IS 10262-2009 for M40 grade concrete. The Experimental program was designed to investigate fly ash as partial replacement of cement along with micro silica in concrete. The replacement levels of cement by fly ash are selected as 5 %, 10%, 15% & 20% and for various proportion of silica are 5%, 10% & 15%. Following are different mix proportions of replacement of cement by Fly-Ash and Silica Fume as shown in Table 1.

Table 1 MIX PROPORTION FOR REPLACEMENT OF CEMENT BY FLY-ASH AND SILICA FUME

Mix No.	Cement	Fly Ash	Silica Fumes
M11	100%	0%	0%
M12	95%	5%	0%
M13	90%	10%	0%
M14	85%	15%	0%
M15	80%	20%	0%
M21	95%	0%	5%
M22	90%	5%	5%
M23	85%	10%	5%
M24	80%	15%	5%
M25	75%	20%	5%
M31	90%	0%	10%
M32	85%	5%	10%
M33	80%	10%	10%
M34	75%	15%	10%
M35	70%	20%	10%
M41	85%	0%	15%
M42	80%	5%	15%
M43	75%	10%	15%
M44	70%	15%	15%
M45	65%	20%	15%

RESULT AND DISCUSSION

Throughout the world, the waste disposal costs have escalated greatly. At the same time, the concrete construction industry has realized that coal fly ash is relatively inexpensive and widely available by-product that can be used for partial cement replacement to achieve excellent workability in fresh concrete mixtures. Consequently, in the modern construction practice 15% - 20% of fly

ash by mass of the cementitious material is now commonly used. Such high proportions of fly ash are not readily accepted by the construction industry due to a slower rate of strength development at early age. Figure 1 shows slower rate of strength development at early age on concrete due to presence of fly ash. The replacement of fly ash up to 15% dose not varies the strength but from 15 - 20% the strength reduces for early age on concrete.

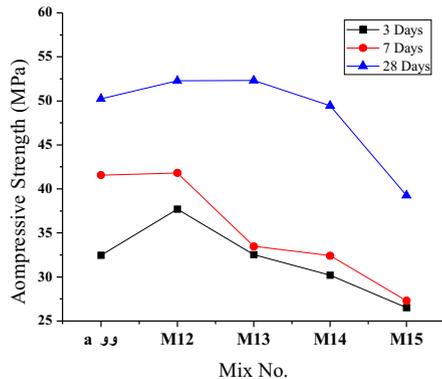


Figure 1: Compressive Strength Concrete mixes for replacement of cement by Fly-Ash (from 0% to 20%)

The results of the present investigation indicate that, other mix design parameters remaining constant, silica fume incorporation in concrete results in significant improvements in the compressive strengths of concrete. The optimum silica fume replacement percentages for compressive strengths have been found to be a function of w/c ratio of the mix. The optimum 28-day compressive strength has been obtained in the range of 5–15% silica fume replacement level. The replacement of Silica Fume up to 15% increase the strength from 10 - 30% as shown in Figure 2 which overcome limitation of replacement of fly ash.

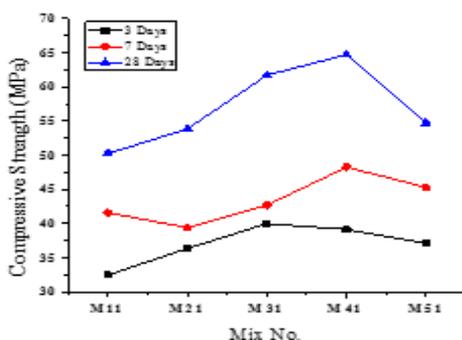


Figure 2: Compressive Strength Concrete mixes for replacement of cement by Silica Fume (0% to 20%)

The obtained values of concrete compressive strength according to the different used percentage of FA and SF for replacement of cement content are shown Figure 1 and 2. These figures indicate that, the higher the percentage of FA the higher the values of compressive strength until 15% of FA, after that the increase in the percentage of FA lead to decrease in values of concrete compressive strength. However, SF the highest value of concrete compressive strength is obtained from 15% of SF. It can be noticed with 15% of SF as replacement cement content gives higher values of concrete compressive strength with 20% of FA by about 40%. The results show that the best percentage for combination of FA and SF is 5% of FA and 10% of SF (Mix M32), where the values of concrete compressive strength in this case higher than the values in case of 10% FA and 15%

SF (Mix M43) by about 17% and 12% respectively as shown in Table 4.3 show that the percentage for combination of FA and SF is 20% of FA and 15% of SF (Mix M45) gain same strength that of normal concrete (Mix M11) after 28 days curing with similar strength gaining early age of concrete, that save the cost of cementitious material more than 18%.

CONCLUSIONS

1. Although use of fly ash improves, the reduction in the strength is more at earlier ages of concrete with increasing fly ash content. Such high proportions of fly ash are not readily accepted by the construction industry due to a slower rate of strength development at early age.

2. Cement replacement up to 15% with silica fume leads to increase in compressive strength from 20% to 25%. Whereas from 20% replacement of cement by silica fume is a decrease in compressive strength with decreasing the workability of concrete

3. The result of experimental investigation on the properties of fly ash concrete incorporating silica fumes to improve the early strength of concrete indicated that addition of silica fumes improved the early age of compressive strength of fly ash concrete. The inclusion of silica fumes was also found to increase that 28 days strength significantly. The rate of gain of compressive strength decreases but maintains its strength value above the desired design strength for higher percentage of fly ash and silica fume.

4. The cement replacements percentage for combination of fly ash and silica fumes is 20% of fly ash and 15% of silica fumes gain same strength that of normal concrete after 28 days curing with similar strength gaining early age of concrete, that save the cost of cementitious material more than 18%.

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