Effect of Microsilica and fly ash on the strength of concrete

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Abstract— In present study, concrete has been partially replaced with micro-silica which acts as a by-product in electric furnace and fly-ash which is a by-product in thermal power plants. Both these materials have been partially replaced with cement to economize the production of concrete as well as to have high strength. Apart from economization, this will also help in reducing the environmental losses. This replacement was made by considering water-cement ratio as 0.45 and it has been observed that about 5% replacement of cement by microsilica cement improves compressive strength and flexural strength of the concrete specimens.

Index Terms — Fly-ash, Slag, Micro-Silica, Concrete, Compressive strength, Cement, Coarse Aggregate, Pozzolanic, Cementitious

1 Introduction

In today's world, almost all the structures have been found to have concrete as an important building material which is a mixture of sand, cement, coarse aggregate and water. In order to construct bridges, dams, retaining walls, high rise building and chimneys, concrete has been an important building material. Cement is an important material in concrete, manufacture of which is expensive and a cumbersome process. Moreover, certain materials which have properties similar to cement like fly-ash, slag, micro-silica etc are emitted as a waste product from industries and power plants. These materials can be successfully applied as a replacement to cement and reduce the cost of production to a great extent. These materials also tend to produce huge environmental problems if left exposed and unattended. Therefore, their utilization in making of concrete mix is not only cost effective, but also eco-friendly in nature. In present study, effectiveness of these materials in improvising the strength of concrete has been tested after 7, 14 and 28 days respectively. The porosity and fineness of fly-ash and micro-silica have been found to develop similar compressive strength as in case of cement with a much lower cost. When water is added to the cement paste, chemical reaction takes place as a result, of which hydration lime is generated. This lime has been found to be susceptible to deterioration of strength and weathering effects. These pozzolanic material produce cementitious properties which on reaction to lime, convert to calcium silicate hydrate thereby, providing sufficient strength and durability.

2 Method and Materials

2.1 Cement: Cement is prepared by heating limestone with certain small quantity of materials like clay to a temperature of about 1500°C. This process is called as calcination where one molecule of CO_2 or quicklime is blended with other materials that have been included as a part of the mix.

In order to make ordinary Portland cement, the above mix called as Clinker is blended with a small amount of gypsum to delay the setting time to a much greater extent. In large number of grout or filler operations, this ordinary Portland cement is used. This OPC has also been an important ingredient in concrete and mortar. This cement helps in providing appropriate strength to concrete mix as well which is a blended mixture of small aggregate, coarse aggregate and water. Concrete contains composite material which consists of gravel and sand. Following table indicates important components and their respective percentage compositions:

Table1: Components of cement

Component	Composition
Fe_2O_3	0.6-0.7%
SO_3	1.2-3.2%
CaO	60-65%
MgO	0.2-4.5%
Na_2+K_2O	0.3-1.5%
IR	0.5-1.5%
SiO_2	15-30%
Al_2O_3	5-10%

2.2 Fly ash: Fly ash is a residue of combustion processes taking place in power plants and the fine particles are caused due to rise in flue gas. This fly ash due to small size and density is found to increase the tensile strength and durability to a greater extent and also has binding properties. Usage of fly ash not only improves the strength, but is also eco-friendly to a much greater extent. This usage of fly ash has also made manufacture of concrete much economical as large part of cement can be partially replaced with fly ash. Fly ash is found to exist in two classes namely Class F and class C. Class F is obtain from the combustion of older anthracite and bituminous coal whereas, class C is obtained from the combustion of lignite coal. These classes are found to have pozzolanic and cementitious properties respectively.

2.3 Microsilica: Microsilica is a mineral admixture composedof SiO_2 of very fine and solid glassy spheres of Silicon di oxide. Microsilica comes as a by-product in many industries manufacturing ferro silicon and metallic silicon in a very high temperature, especially in electric furnaces.This silicon produced is obtained fron the

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bottom in a slag form. Further processing of this yields microsilica after intense cooling and condensation. This byproduct can be eventually used to strengthen concrete.

Fig 1: Microsilica in crude state ready to for a condensed product

Table2: Components of concrete

Content	Quantity
Cement	350 kg/m^3
Fly ash	43% of cement
Micro silica	5% of cement
Fine aggregate	700.3kg/m^3
Coarse Aggregate	1056.98kg/m^3
w/c	0.45

Aggregates: The fine and coarse aggregates which have been used are depicted in the table below.

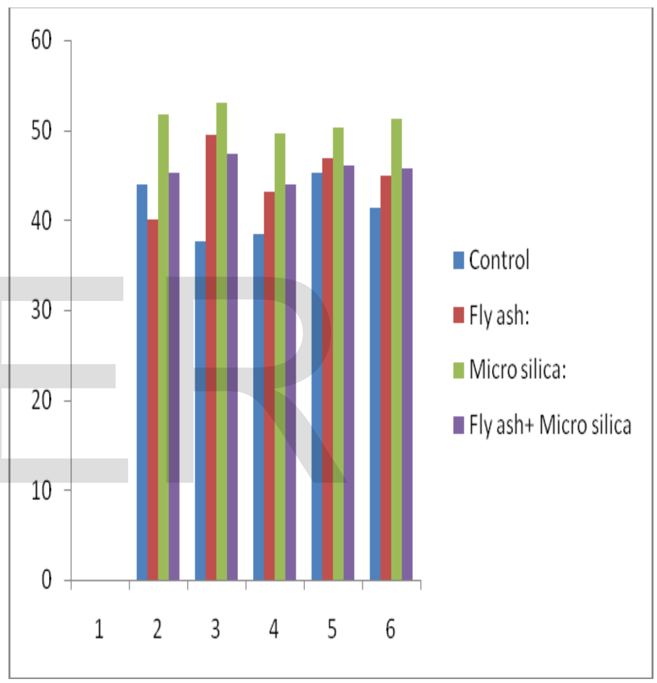
Material	Specific Gravity	Bulk density Kg/m^3	Fineness modulus
Fine Aggregate	2.48	1765	3.54
Coarse aggregate	2.97	1870	7.67

3 Results and Discussion:

The results and discussions in these tables include the strength of concrete in presence of different admixtures in 7, 14, 28 days and determine the strength of different concrete blocks in a bar chart.

Table 3: Compressive strength of concrete after 7 days (N/mm^2)

S.No.	Control	Fly ash: 43% of cement	Micro silica: 5% of cement	Fly ash+ Micro silica
1	23.8	33.4	40.3	34.9
2	39.5	34.2	42.4	35.1
3	34.5	33.6	38.1	35.9
4	32.4	34.5	39.9	36.5
AVG:	**32.55**	**33.92**	**40.17**	**35.5**



Graph1: Compressive strength of concrete after 7 days

Table 4: Compressive strength of concrete after 14 days (N/mm^2)

S.No.	Control	Fly ash: 43% of cement	Micro silica: 5% of cement	Flyash+ Micro silica
1	33.2	39.2	45.2	38.4
2	41.3	35.3	44.6	33.5
3	39.2	37.2	48.3	42.3
4	36.7	39.6	49.1	35.9
AVG:	**37.6**	**37.82**	**46.8**	**37.52**

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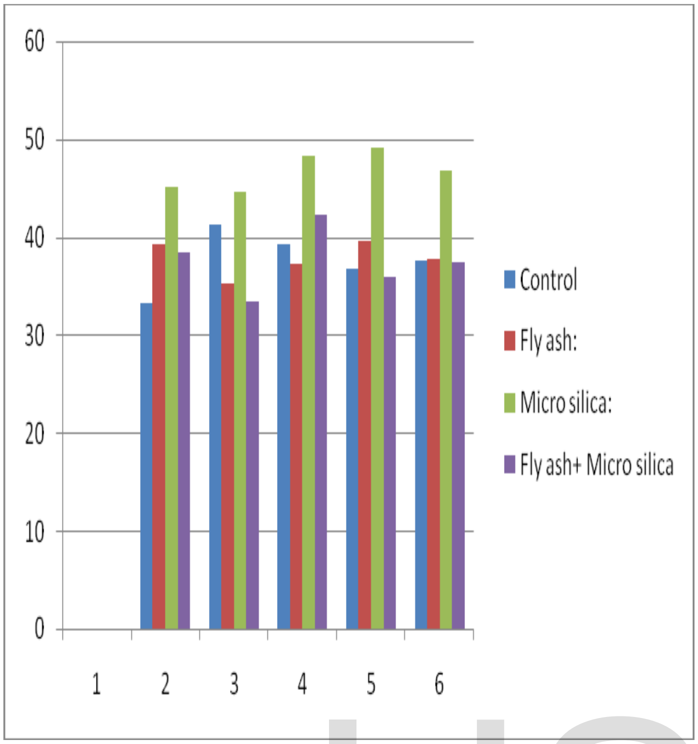


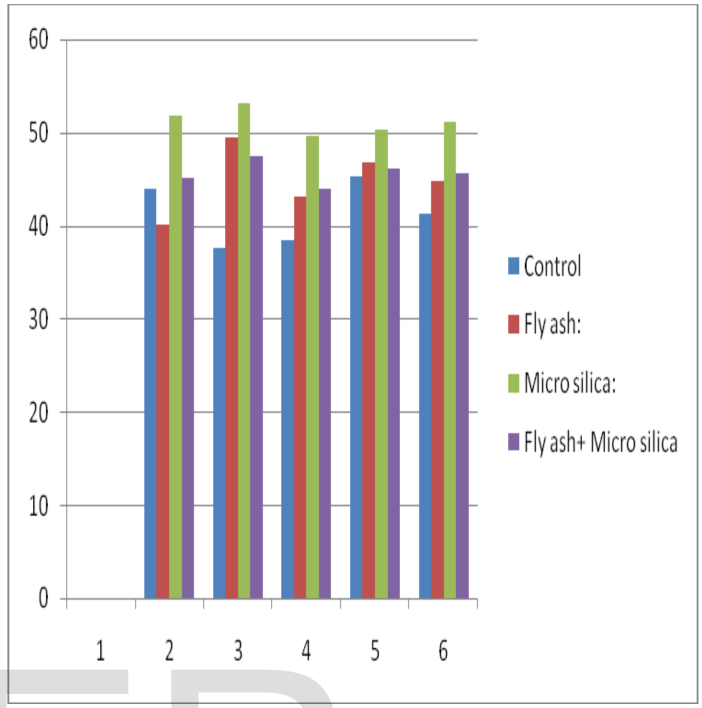
Graph2: Compressive strength of concrete after 14 days

Table 5: Compressive strength of concrete after 28 days (N/mm^2)

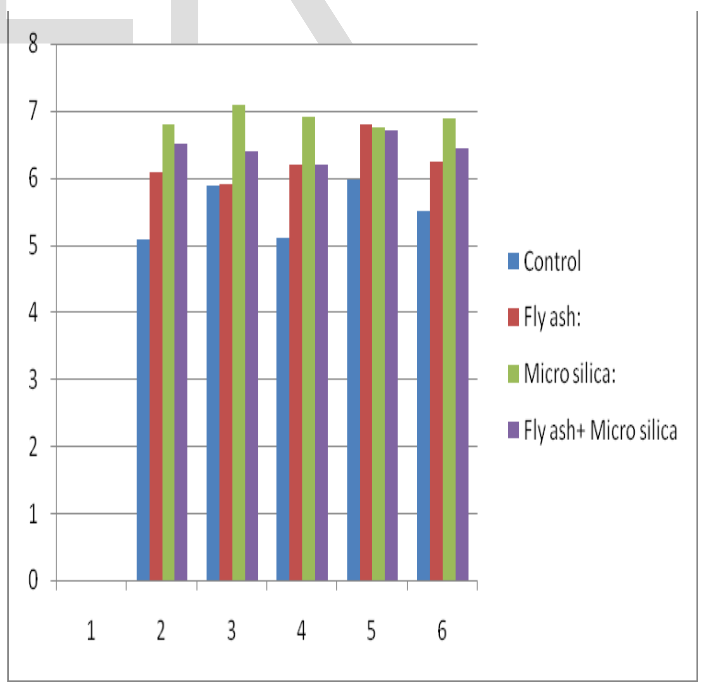
S.No.	Control	Fly ash: 43% of cement	Micro silica: 5% of cement	Fly ash+ Micro silica
1	43.9	40.1	51.8	45.2
2	37.6	49.4	53.1	47.4
3	38.4	43.2	49.6	43.9
4	45.3	46.8	50.3	46.1
AVG:	**41.3**	**44.87**	**51.2**	**45.65**

Table 5: Flexural strength of concrete after 28 days (N/mm^2)

S.No.	Control	Fly ash: 43% of cement	Micro silica: 5% of cement	Fly ash+ Micro silica
1	5.09	6.09	6.8	6.5
2	5.89	5.9	7.09	6.4
3	5.1	6.2	6.9	6.2
4	5.98	6.8	6.76	6.7
AVG:	**5.51**	**6.24**	**6.88**	**6.45**



Graph3: Compressive strength of concrete after 28 days



Graph4: Flexural strength of concrete after 28 days

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3 CONCLUSION:

In the study, the cement content has been reduced by 48% with 43% fly ash and 5% microsilica. These materials have been substantially reduced the cement content and added strength much more that the prior situation. Moreover, it has made cement manufacture cheap and more eco-friendly. The present analysis suggests that the cement content has certainly enhanced the compressive strength of concrete in all the three situations of testing including strength after 7, 14, 28 days respectively which has been taken into account. Final strength comes out to be 45.65(N/mm^2) which ensure that these admixtures have worked and enhanced the strength to a great extent. In the above experiment, a brief summary can be made regarding the overall results obtained. The normal strength comes out to be 41.3 N/mm^2 whereas it was 44.87 N/mm^2 after adding 43% fly ash and 51.2 N/mm^2 after adding 5% microsilica. This is the entire summary which depicts the enhancement in the strength form the rest of the days. Although, in these experiments all the these permutations have been followed, yet it can be hereby concluded that, the overall strength of mere presence of microsilica is more that the addition of both fly-ash and microsilica.

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