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A Comparative Study on Flexural Strength of Concrete Containing Different Mineral Admixtures as Replacement of Cement

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***Abstract* – Concrete is the most widely used material in the world today. This paper is about the comparative study of the flexural strength of concrete when different admixtures are used as partial replacement of cement in the concrete mix. The mineral admixtures that are used here are Silica Fume, Rice Husk Ash and Iron slag as partial replacement of cement. All these materials are industrial waste products and are abundantly available nowadays. These materials have high silica content and can be effectively used as a replacement of cement during the formation of High Performance Concrete. Flexural strength is the most important characteristic of concrete and is calculated for the hardened concrete to analyse the load bearing capacity for design purposes. Thus for the effective judgement of type of mineral admixtures to be used a comparative study is very useful.**

Keywords- Silica Fume; Rice Husk Ash (RHA); Iron Slag; flexural strength; High Performance Concrete

I. INTRODUCTION

Cement is the most widely used material in today's world. It is used in all the construction works. But the formation of cement is not a sustainable process as it releases a large amount of CO_2 gas in the environment which is the main component of the greenhouse gases. Thus it is inevitable to find suitable material for the partial replacement of cement in concrete mix design. Silica Fume, Rice Husk Ash and Iron Slag are highly siliceous materials and have good pozzolanic properties. Thus these materials can be effectively used as a partial replacement of cement to impart improved properties to the concrete. Also all these materials are industrial waste products that are abundantly available in India. Their disposal is also a problem and if filled in a land fill, it have many deleterious effects on the environment. Researches have been done to analyse the properties imparted to the hardened concrete due to use of these materials.

Flexural strength is one of the most important properties of the hardened concrete that signifies its load bearing capacity. Also as concrete is weak in tension thus it is important to calculate the bending load the concrete beam can carry before failure. In this research a comparative study is conducted to calculate and compare the flexural strength that is imparted to any concrete when Silica Fume, RHA and Iron Slag are used separately as a partial replacement of cement. For this purpose 5%, 10%, 15% and 20% replacement of cement was done by the mineral admixtures one at a time and the flexural strength of the beams were calculated by Centre Point Loading method of flexural strength testing according to IS:516-1959 and ASTM C293. Then a comparative result is shown with a table and the variation of the flexural strength comparatively according to the replacement of cement with mineral admixtures is also shown graphically. This research work can provide a guideline for the priority of use of any particular type of admixture in construction and also gives the values of the flexural strength provided by these materials to the concrete.

II. MATERIALS USED

The various materials that are used in this research are as follow:-

A. Cement:- Cement of grade OPC43 is used that is commercially available in Indian market. The properties of the cement are confirming to IS: 8112-1989.

B. Fine Aggregate:- Yellow sand of grading Zone II confirming to IS:383-1970 is used that is available commercially. The specific gravity of the sand is calculated as 2.59.

C. Coarse Aggregate:- Crushed angular coarse aggregates of 10mm and 20mm nominal sizes are used in the ratio of 40:60 respectively. The specific gravity of the aggregate is 2.74.

D. Chemical Admixture: - A concrete super plasticizer was used from the Roorkee Construction Chemicals to reduce the water Cement ratio.

E. Silica Fume: - Silica fume is a by-product of the manufacture of silicon metal and ferro-silicon alloys. The process involves the reduction of high purity quartz (SiO2) in electric arc furnaces at temperatures in excess of 2,000°C. Silica fume is a very fine powder consisting mainly of spherical particles or microspheres of mean diameter about 0.15 microns, with a very high specific surface area (15,000–25,000 m2/kg). For the project silica fume was obtained that is commercially available in Delhi market(Fig.1).The specific gravity of silica fume is 2.22.

Fig. 1. Silica fume in concrete mix

F. Rice Husk Ash:- Rice Husk Ash is a waste product obtained from Rice Husk boilers. For this project the RHA was obtained from Sardar nagar Distillery, Gorakhpur (fig.2). The specific gravity of RHA is calculated as 2.0.

Fig. 2. Rice husk ash in concrete mix

G. Iron Slag:- Iron slag is the granular material formed when molten iron blast furnace slag is rapidly chilled by immersion in water. It is a granular product with very limited crystal formation, is highly cementitious in nature and, ground to cement fines, and hydrates like Portland cement. For this project iron slag was obtained from Gallant Industries, Gorakhpur. The specific gravity of Iron Slag was calculated as 3.03.

H. Concrete Mix:- The concrete mix designed was of M35 grade confirming to IS:10262- 2009. The proportion of various components per m^3 of concrete is shown in Table 1.

TABLE 1:-

Weight of component per m^3 of concrete

Type of component of mix	**Weight per m^3 (kg)**
Cement	354
Fine aggregate	815
Coarse aggregate	1217
Water	148
Super plasticizer	1% by weight of cement

*Concrete mix design

The water cement ratio is kept as 0.42:1 and the ratio of cement: fine aggregate: coarse aggregate is kept as 1: 2.31: 3.46. the concrete mix was prepared by hand operations .

I. Water:- Fresh water was used for preparation of concrete mix as well as for the curing of the samples created during the project.

III. EXPERIMENTAL PROCEDURE

The concrete mix was designed confirming to IS: 10262-2009 and concrete beams were cast for different replacement percentages of cement by Silica fume, Rice Husk Ash and Iron Slag. The cement was replaced by 5%, 10%, 15% and 20% by weight by Silica Fume, RHA and Iron slag respectively using one at a time. The beams casted were of the dimensions of 700mm*150mm*150 mm and were cured in fresh water for 7, 14 and 28 days. Then the beams were tested to calculate the flexural strength by using manual Centre Point loading method confirming to IS:516-1959 and ASTM C293 and a comparative graph showing the values of flexural strength for different mineral admixtures as partial replacement of cement was drawn. The load was applied on the topmost surface of the beam as it was casted in the mould.

IV. RESULT AND DISCUSSIONS

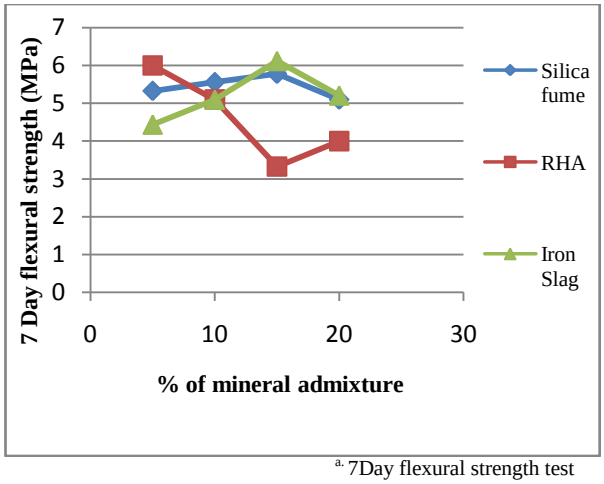
A. *7 Day test:-* The samples were on the 7 day after casting and the flexural strength obtained are given in the table II. And the variation is given by graph I.

TABLE II.

Sl. No.	**% replacement of cement by Mineral admixture**	**7 DAY FLEXURAL STRENGTH (MPa)**		
		Silica fume	***RHA***	***Iron Slag***
1	5	5.33	6	4.44
2	10	5.56	5.1	5.1
3	15	5.78	3.33	6.123
4	20	5.1	4	5.21

[a.]7 day flexural strength

GRAPH I



[a.] 7Day flexural strength test

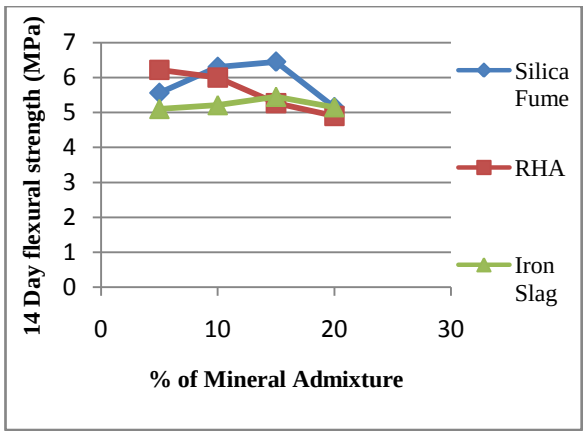
B. 14 day test :- 14 day test was conducted 14 days after casting . The results obtained for the 14 day test and comparative variation is shown by Table III and and the comparative variation in shown in Graph II.

TABLE III

Sl. No.	% replacement of cement by Mineral admixture	14 DAY FLEXURAL STRENGTH (MPa)		
		Silica fume	*RHA*	*Iron Slag*
1	5	5.56	6.22	5.1
2	10	6.3	6	5.21
3	15	6.45	5.27	5.45
4	20	5.15	4.9	5.15

[b.]14 day flexural strength test

GRAPH II.



[b.]14 day flexural strength test

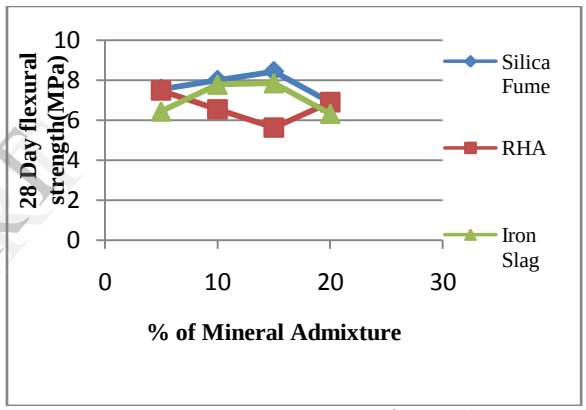
C. 28 Day Test:- 28 day test was conducted on the beam specimens 28 days after casting and the values obtained are given in table IV and comparative variation is shown by Graph III.

TABLE IV.

Sl. No.	% replacement of cement by Mineral admixture	14 DAY FLEXURAL STRENGTH (MPa)		
		Silica fume	*RHA*	*Iron Slag*
1	5	7.56	7.48	6.44
2	10	8	6.54	7.78
3	15	8.44	5.63	7.85
4	20	6.9	6.9	6.32

[c.]28 dayflexural strength test

GRAPH III.



[c.] 28 day flexural strength test

V. CONCLUSIONS

- Silica Fume gives the highest values of flexural strength as compared to Rice Husk Ash and Iron Slag.
- The values obtained for Silica fume and Iron slag are maximum for 15% replacement of cement after which the value decreases.
- For Rice Husk Ash the value of flexural strength is the minimum and it is lower than the M35 beam formed with 0% replacement.
- The value of flexural strength for replacement with Iron Slag is the minimum after 7 days but it increases significantly during 14 day and 28 day tests.
- The flexural strength of the beam specimen goes on decreasing as the percentage of RHA increases.
- The highest flexural strength obtained was 8.44 MPa that was obtained for 15% replacement of cement by Silica Fume.
- The value of flexural strength for 20% replacement by RHA increase in comparison to 15% replacement during 7 day and 28 day tests.

- Both RHA and Iron Slag are abundantly available industrial wastes in India and can be effectively used as partial replacement of cement in concrete mix.
- Silica Fume can impart very high strength and can be used to form High Performance Concrete.

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