RESEARCH ARTICLE OPEN ACCESS

A Comparative Study on Compressive and Flexural Strength of Concrete Containing Different Admixtures as Partial 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 and compressive 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 pozzolanic properties and can be effectively used as a replacement of cement during the formation of High Performance Concrete. Compressive and Flexural strength are the two most important characteristic of concrete and are calculated for the hardened concrete to analyze the load bearing capacity for design purposes. Thus for the effective judgment of type of mineral admixtures to be used a comparative study is very useful.
Keywords – Compressive strength, flexural strength, High Performance Concrete, Iron slag, Rice Husk Ash (RHA), Silica fume

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. (S.A Khedr et al., 1994) studied the effect of use of silica fume to obtain High Performance Concrete. (G.A Rama Rao et al, 1989) studied the nature and reactivity of silica available in Rice Husk Ash (RHA). The effect of use of RHA in concrete was studied by Sandesh D Deshmukh et al, (2011). Iron slag is a waste product from iron and Steel Manufacturing Industries. The use of iron slag in concrete was studied by (S.S Sun et al, 2007) and the effect of use of iron slag in concrete was studied by (C.H Huang et al,2004). 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, these have many deleterious effects on the environment. Compressive and Flexural strengths are 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 compressive and 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 using one at a time and the flexural strength and compressive strengths were calculated. Compressive and Flexural strength testing was done according to IS: 516-1959. Then a comparative result is shown with a table and the variation of the compressive and 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 compressive and flexural strength provided by these materials to the concrete.

II. MATERIALS USED

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

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

2.2 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.

2.3 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.

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

2.5 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. The specific gravity of silica fume is 2.22.

2.6 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. The specific gravity of RHA is calculated as 2.0.

2.7 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.

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

2.9 Concrete Mix:- The concrete mix designed was of M30 grade confirming to IS:10262- 2009. The proportion of various components per m^3 of concrete is shown in Table 1. 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.

Table1. Concrete Mix design

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

III. EXPERIMENTAL PROCEDURE

The concrete mix was designed confirming to IS: 10262-2009 and concrete beams cubes 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 the dimension of the cubes was 150mm* 150mm* 150mm. The samples were cured in fresh water for 7, 14 and 28 days. Then the beams were tested to calculate the flexural strength and the cubes were tested for compressive strength at 7 and 28 days confirming to IS:516-1959 and comparative graphs showing the values of flexural strength and compressive strength for different mineral admixtures as partial replacement of cement were drawn.

IV. RESULT AND DISCUSSION

4.1. Flexural strength test:- The flexural strength test was conducted on beam specimens by manual flexural strength testing machine. The beams were tested on 7, 14 and 28 days after curing in fresh water at 27 ^{0}C. Separate graphs were drawn for 7,14 and 28 days to show the variation of flexural strength with different amount of replacement of cement by different admixtures. The value of flexural strength for different level of replacement of cement is given in Table2 and the graphs for 7 ,14 and 28 days are given in fig.1 ,fig.2 and fig.3 respectively.

Table 2. Flexural strength of concrete with different admixtures

Sl. No.	% replacement of cement by Mineral admixture	FLEXURAL STRENGTH(M Pa)								
		7 Days			14 Days			28 Days		
		Silica fume	RHA	Iron Slag	Silica fume	RHA	Iron Slag	Silica fume	RHA	Iron Slag
1	0	3.56	3.56	3.56	4	4	4	4.3	4.3	4.3
2	5	3.56	4	2.96	3.71	4.15	3.4	5.04	5	4.3
3	10	3.71	3.4	3.4	4.2	4	3.48	5.34	4.36	5.19
4	15	3.86	2.67	4.082	4.3	3.67	4.12	5.63	4	5.24
5	20	3.4	2.22	3.48	3.44	3.44	3.52	4.6	3.74	4.22

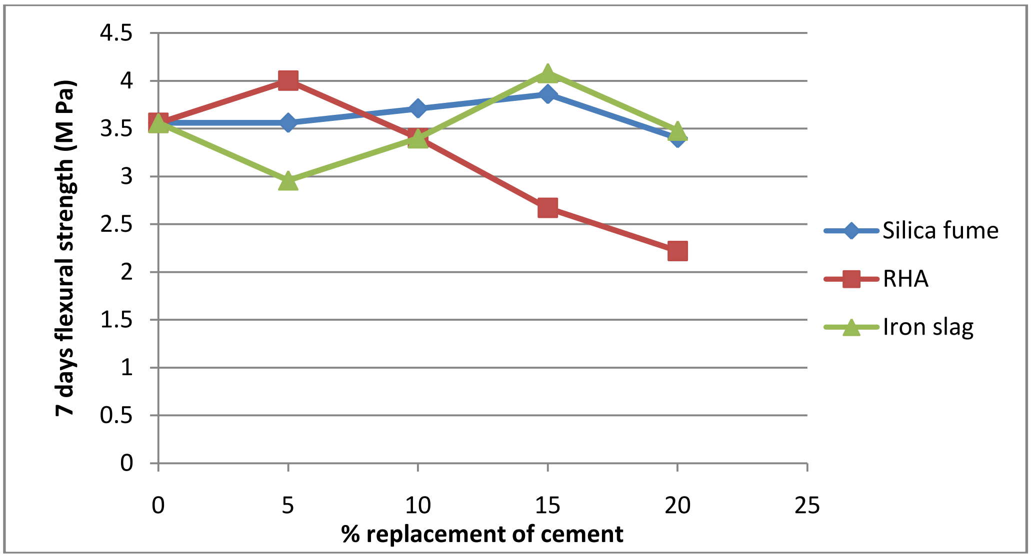

Figure . 1 Variation of 7 days flexural strength for different admixtures

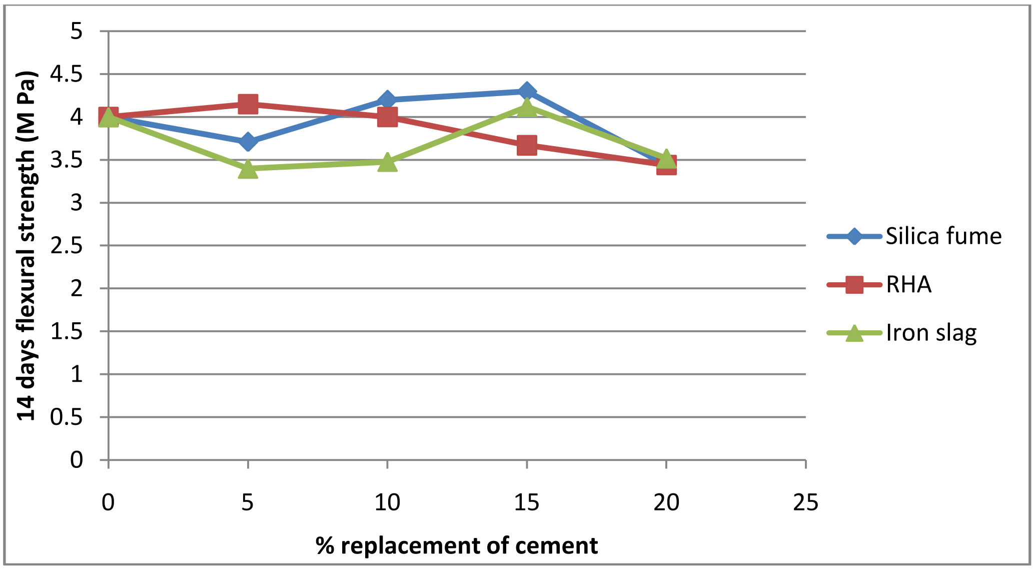

Figure.2 Variation of 14 days flexural strength for different admixtures

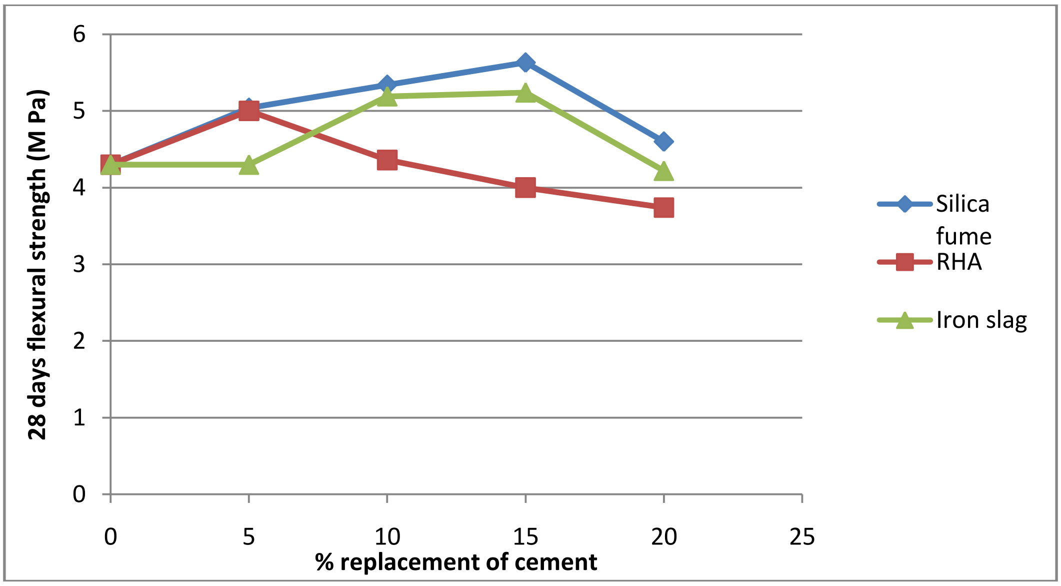

Figure.3 Variation of 28 days flexural strength for different admixtures

4.2 Compressive strength test:- The compressive strength test was conducted on concrete cubes by automatic compressive strength testing machine by applying the load gradually. The cubes were tested after 7 days and 28 days curing period and separate graphs were drawn to show the variation of compressive strength for different amount of replacement of cement by different admixtures. The values of compressive strengths for different mineral admixtures are given in Table 3 and the variation of compressive strength for different proportion of replacement of cement with admixtures at 7 days is given in fig.4 and the variation of compressive strength at 28 days is given in fig.5.

Table 3. Compressive strength of concrete with different admixtures

S. No.	**% of mineral admixture as replacement of cement**	**Compressive Strength(M Pa)**					
		7 days compressive strength			**28 days compressive strength**		
		Silica Fume	**RHA**	**Iron slag**	**Silica fume**	**RHA**	**Iron slag**
1	0	23.6	23.6	23.6	38.2	38.2	38.2
1	5	24.5	22.3	26.3	40.2	32	31.2
2	10	27.2	21.4	23.6	41.1	31	35
3	15	27.6	17.4	22.3	42	29.1	37
4	20	22.2	16	21.4	37.4	27.5	34

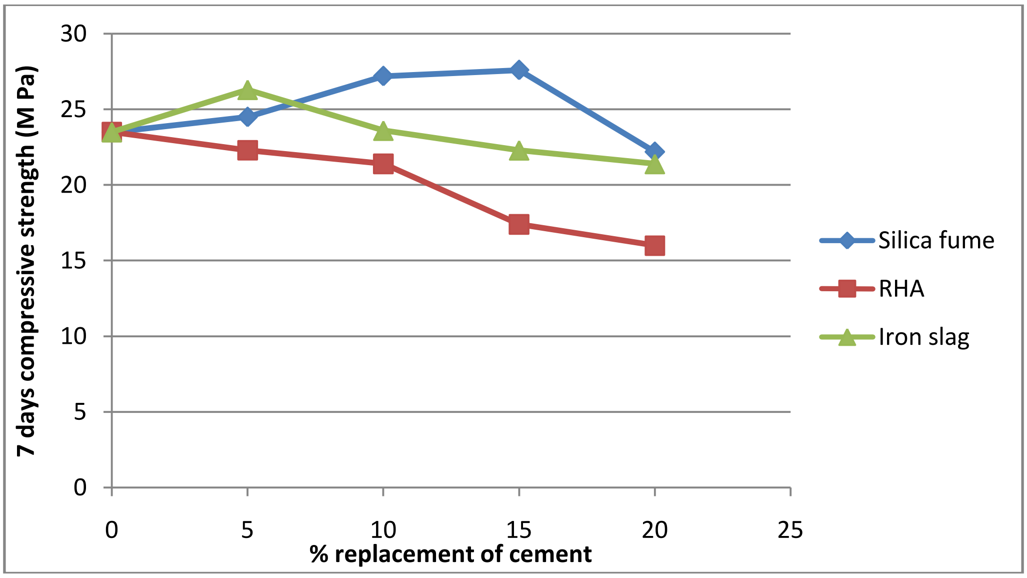

Figure 4. Variation of 7 days compressive strength of concrete for different admixtures

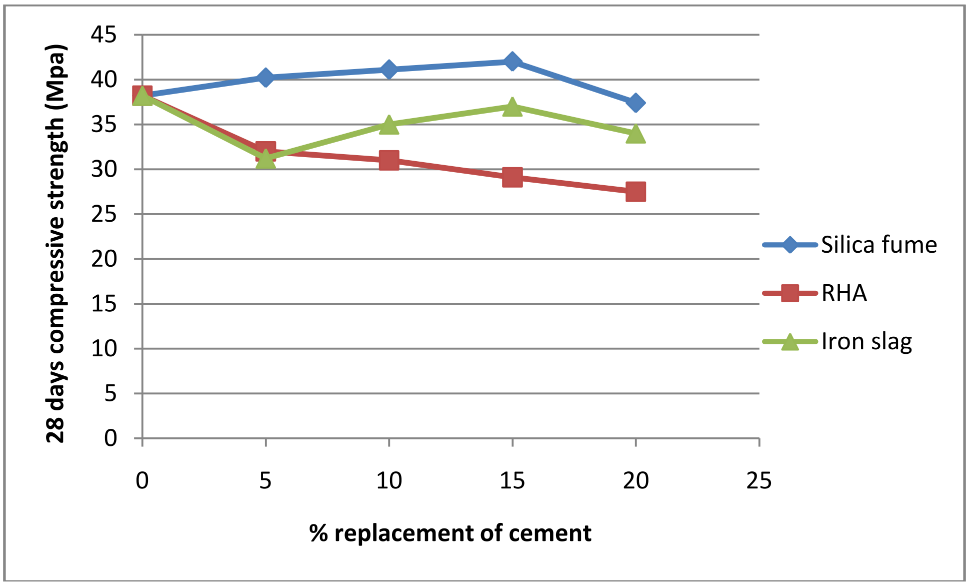

Figure .5 Variation of 28 days compressive strength for different admixturtes

V. CONCLUSIONS

- Silica Fume gives the highest values of flexural strength and compressive 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 and compressive strength is the minimum and it is lower than the values for M30 specimen formed with 0% replacement.
- The compressive and flexural strength of the specimen goes on decreasing as the percentage of RHA increases.
- The highest value of flexural strength obtained was 5.63 M Pa that was obtained for 15% replacement of cement by Silica Fume.
- The highest compressive strength achieved was 42 M Pa for 15% replacement of cement by Silica Fume.
- 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.
- 28 days compressive strength for RHA and Iron slag is lower than that of concrete without any admixture.

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