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Investigating the Consequences of Replacing Cement with GGBFS and RHA on Properties of Concrete Mixture

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Abstract

Objective: As concrete is most generally used man-made construction material. So far it is not possible to get a material like this. So an effort has been made to investigating the consequences of replacing cement with GGBFS and RHA on properties of concrete mixture.

Methods/Analysis: Here cement has been replaced with different percentages of GGBFS and RHA. Different concrete specimens were prepared with GGBFS replaces 0, 5, 10, 15,20,25,30,35,40,45 and 50% of cement and RHA replaces 0,5,10,15,20,25,30,35,40 of cement. Curing period was taken to be 3, 7 and 14 days. Concrete slump test and UCS (Uniaxial compression strength test) were performed to measure the consistency and compressive strength of the specimen.

Findings: It is evident from results that there is a considerable effect on the consistency as GGBFS percentage goes on increasing and the finally it is found to be satisfactory. In case of RHA, consistency percentage increases quickly and seems too favorable at all percentages as we are increasing the percentage of RHA in the mixture. On increasing the GGBFS percentage from 0% to 5% then the 3 days, 7 days and 14 days strength shows reductions of 5.2%, 11.2% and 4.3% respectively. The further increase in GGBFS percentage indicates a spiky reduction in the compressive strength. The effects of RHA also found to be decreasing the compressive strength of concrete mixture. There is a decrease of 84.6%, 86.66% and 86.31% in compressive strength for 3 days, 7 days and 14 days.

Improvement: By considering different proportions of GGBFS and RHA and simultaneously some additive we can get different results. Curing period can be increased upto 21 and 28 days for more deep analysis of characteristic properties of GGBFS and RHA.

Keywords: *Ground Granulated Blast Furnace Slag (GGBFS), Rice Husk Ash (RHA), Cement and Concrete.*

1. Introduction

At present time, the utilization of waste materials is increasing at par. This feature has also taken a new trend in the ever-growing construction industry where different supplementary cementitious materials have entered the arena. Among this category, GGBFS from blast furnace and RHA from agriculture by-products are playing safe in the building and construction field as per latest reports worldwide. Being commonly used material in construction at present, these products in combination with some mixing binder and aggregates form a large part of concrete. The hardness of concrete is mainly because of the chemical reaction taken place between water and cement. The presented study is focusing on replacing cement GGBFS and RHA for finding their existence in the business.

Glanville et al. stated that due to more surface area, very fine sands needs more water for a given workability **[1]**. Malhotra and Carette reported in his study that GGBFS concrete is better at both resisting chloride ingress and alkali-silica reactions than PC concrete **[2]**. Berry and Malhotra emphasized that percentage of GGBFS influences the reduction in water content **[3]**. Zhang and Malhotra elaborated that ompressive strength of concrete was investigated after replacement of 10% of cement with RHA and results were compared with the concrete containing 10% silica fume for the same **[4]**. Aiqin et al. studied that RHA affects the physical properties of fresh concrete by improving the workability which is necessary for mixing and forming **[5]**. Waswa-Sabuni et al. reported that for making lime, RHA and concrete cubes, the pozzolanic activity of RHA was measured. Results reported high pozzolanic activity in the blended mixture **[6]**. Wachira et al. suggested that while examining the relation between lime and RHA it is noted that lime in a ratio of 2:1 with RHA incorporates best results gave the best results **[7]**. Zahran et al. emphasized that a controlled experimental program was conducted to investigate the effects of RHA replacing cement on the workability and compressive strength of concrete **[8]**. Wang et al. reported that GGBFS, fly ash and silica fume helps in achieving the high performance, sustainable concrete and reduction of CO_2 **[9]**. Rodriguez in his study suggested that RHA plays a keen role in incorporating compressive strength to concrete in addition with retard in permeability [10]. Saraswathy and Song in their research ratified that for finding the effect of RHA on porosity and water absorption on concrete, the cement replaced with 0, 5, 10, 15, 20, 25, and 30% RHA [11]. Mulick suggested that for achieving a reasonable durability, GGBFS in a blend with ordinary Portland cement are useful [12]. Sheng et al. in their study stated that at 15% replacement level of cement with GGBFS, compressive strength reaches highest value [13]. Gastaldini et al. reported that electrical resistivity in addition to high strength is resulted from addition of RHA [14]. Kartini in his research suggested that RHA incorporates in improving the durability index and comprehensive strength while replacing it with ordinary Portland cement [15]. Harald emphasized that industrial by-products on replacing cement can leads to a sustainable concrete [16]. Sajedi et al. examined that RHA plays as safeguard in attaining resistance to corrosion [17]. Lopez et al. find in their research that slag cements deals with lower early age strengths than ordinary portland cement but finally have higher ultimate strengths [18].

2. Experimental Investigation

After preparing different compositions of concrete mixture on replacing it with GGBFS and RHA, the effect of these materials on consistency and compressive strength of concrete mixture are tabulated and drawn below for better representation.

Table 1: Effect of GGBFS on Consistency of Cement

Amount of Cement replaced by GGBFS (%)	0	5	10	15	20	25	30	35	40	45	50
Consistency (%)	30.3	30.8	31.3	31.7	32.5	33.2	33.9	34.7	35.6	35.9	36.1

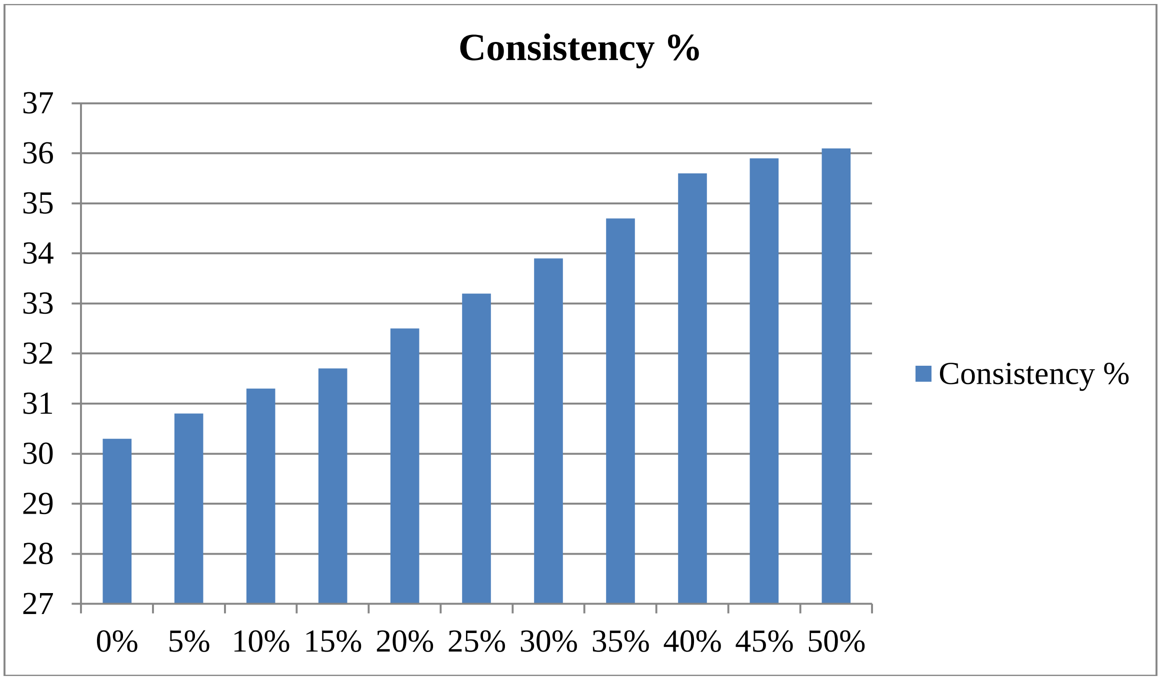

Figure 1: Effects on consistency (%) w.r.t amount of cement replaced by GGBFS (%)

Table 2: Effect of GGBFS on Compressive Strength of Cement

Amount of Cement replaced by GGBFS (%)	0	5	10	15	20	25	30	35	40	45	50
3 Days Strength (MPa)	11.14	10.56	9.63	8.52	7.25	6.81	6.19	5.45	4.98	4.04	3.25
7 Days Strength (MPa)	24.95	22.15	18.32	15.43	12.08	11.09	10.22	9.63	8.34	7.27	6.24
14 Days Strength (MPa)	33.41	31.95	29.03	26.79	23.46	20.07	17.88	14.54	12.03	10.39	8.72

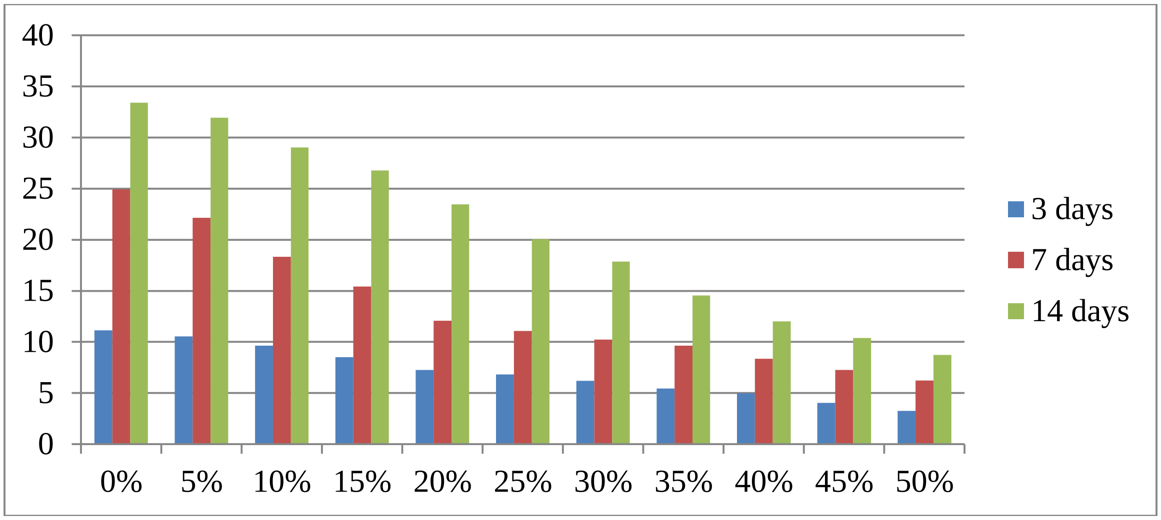

Figure 2: Effects on different day's compressive strength (MPa) w.r.t amount of cement replaced by GGBFS (%)

Table 3: Effect of RHA on Normal Consistency of Cement

Amount of Cement replaced by GGBFS (%)	0	5	10	15	20	25	30	35	40
Consistency (%)	32.03	36.83	42.88	45.06	48.21	49.77	51.29	53.15	55.16

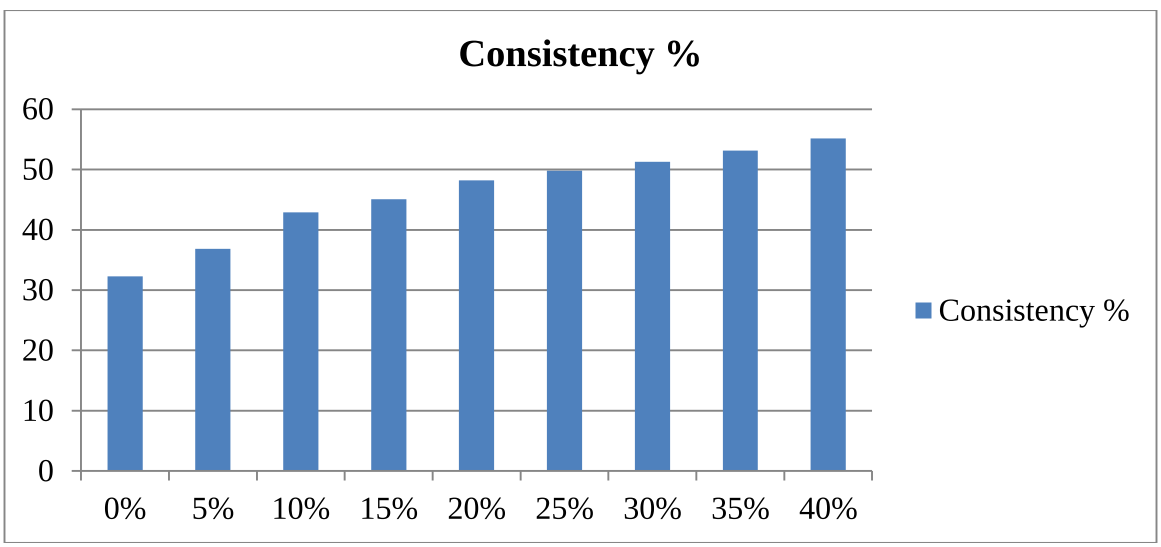

Figure 3: Effects on consistency (%) w.r.t amount of cement replaced by RHA (%)

Table 4: Effect of RHA on Compressive Strength of Cement

Amount of Cement replaced by GGBFS (%)	0	5	10	15	20	25	30	35	40
3 Days Strength (MPa)	11.23	9.12	7.94	6.32	4.78	3.59	2.90	2.27	1.79
7 Days Strength (MPa)	24.75	20.32	14.67	11.77	8.48	6.77	5.66	4.21	3.30
14 Days Strength (MPa)	27.76	22.38	17.51	13.09	9.02	7.31	5.85	4.78	3.80

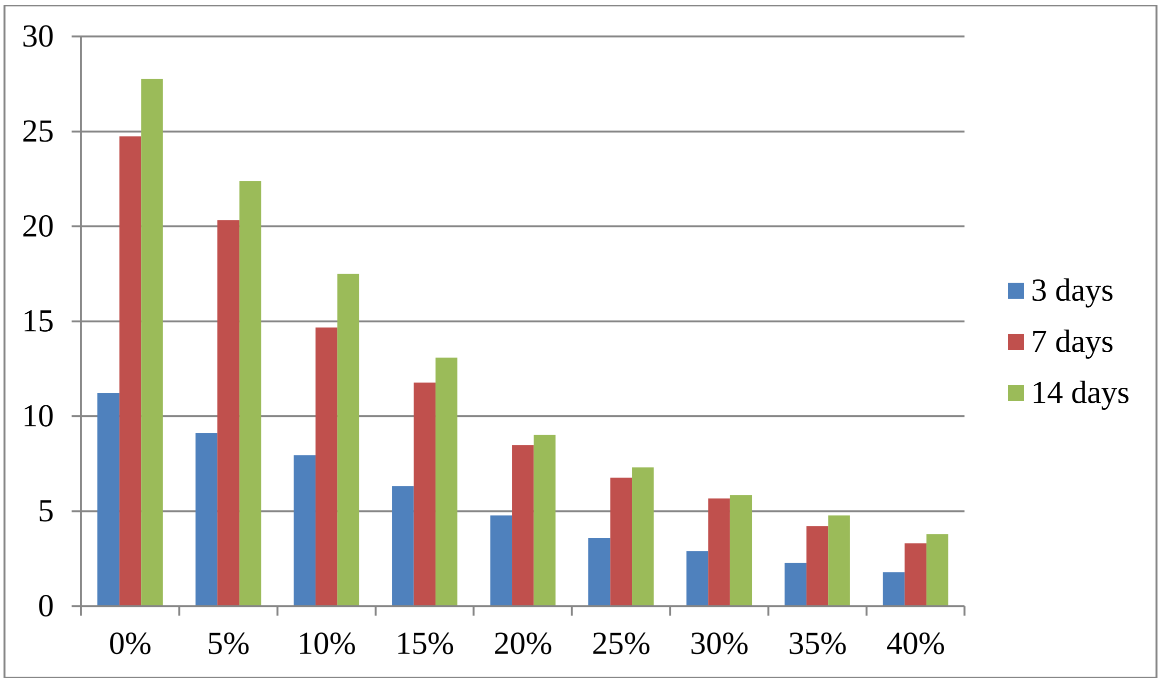

Figure 4: Effects on different day's compressive strength (MPa) w.r.t amount of cement replaced by RHA (%)

3. Result Discussion

The test results shows that there is a considerable effect on the consistency as GGBFS percentage goes on increasing and the finally it is found to be satisfactory at all. On the other side, consistency percentage increases quickly as we are increasing the percentage of RHA in the mixture. It seems too favorable at all percentages. On increasing the GGBFS percentage from 0% to 5% then the 3 days, 7 days and 14 days strength shows reductions of 5.2%, 11.2% and 4.3% respectively. The further increase in GGBFS percentage indicates a spiky reduction in the compressive strength. Finally a decrease of 70.8%, 74.98% and 73.9% is found for 3 days, 7 days and 14 days compressive strength from its initial value. So inclusion of GGBFS in place cement leads towards decrease in strength of concrete mixture. The effects of RHA also found to be decreasing the compressive strength of concrete mixture. There is a decrease of 84.6%, 86.66% and 86.31% in compressive strength for 3 days, 7 days and 14 days.

4. Conclusion

So the present study concludes that:

(i) There is a satisfactory increase in the consistency of concrete mixture on replacing cement with GGBFS but GGBFS diminish the strength of concrete mixture.

(ii) Rapid and demanding effects have come on the consistency of concrete mixture on replacing cement with RHA. The compressive goes on decreasing with an increase in the percentage of RHA.

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