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EFFECTS OF SUPPLEMENTARY CEMENTITIOUS MATERIALS ON PHYSICO-MECHANICAL PROPERTIES OF CEMENT PASTE

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ABSTRACT

This paper presents the results of an experimental study performed to investigate effect of supplementary cementitious materials (SCM) in cement pastes. SCMs used were fly ash, silica fume and rice husk ash. Replacement of cement was made at 20% for all the specimens. Physical properties like water absorption, apparent porosity and sorptivity were compared for different SCMs along with mechanical properties like Compressive Strength, Split tensile strength .Generally it was found that among the SCMs studied, silica fume gives the better results in terms of the physico-mechanical properties of the cement paste.

Keywords: Fly ash, Silica fume, Rice husk Ash ,compressive strength

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1. INTRODUCTION

Concrete, being the most versatile construction material, is consumed second only to water in the world [1]. It is estimated that more than 10 billion tons of concrete is produced annually [2]. It has been projected that by 2050 approximately 18 billion tons of concrete annually to meet the growing demands of world population [3]. Subsequently, cement production were expected to raise from 3.6 billion tons of cement in 2011 [3], to 5.8 billion tons by 2050 [4].

However, sustainability issues of raw materials and environmental issues of CO_2 emissions are cause of concern to the cement industry. It is estimated to be responsible for about 7% of all the CO_2 generated worldwide [5]. It has been found that every ton of Portland cement produced releases approximately one ton of CO_2 into the atmosphere [6]. One of the optimistic step taken to address these issues in cement industry is the utilization of supplementary cementitious materials (SCMs).

SCMs, including fly ash, ground granulated blast furnace slag, silica fume, calcined clays and Rice Husk Ash, are commonly mixed with clinker to make Blended Portland Cement or used as a replacement for a portion of Ordinary Portland Cement (OPC) in concrete. Increased used of SCMs have decrease the world average percent clinker of cement from 85% in 2003 to 77% in 2010, and expected to decrease further up to 71% in the future [7].

The objective of the present experimental investigation is to study the effect of addition of three different SCMs namely Fly Ash (FA), Silica Fume (SF) and Rice Husk Ash (RHA) on the physico-mechanical properties of cement paste. 20% of each type of SCMs has been added to the OPC while manufacturing cement paste. Porosity, compressive strength, water absorption, water sorptivity, modulus of elasticity has been performed for the comparative study.

2. EXPERIMENTAL

2.1. Materials

OPC Grade 33 conforming to IS: 269-1989, was chosen as the binding material. Silica fume was sourced from Mohta Microfilers Pvt.Ltd.Kolkata. With specific gravity 2.4 and passing on 40 ***µm*** sieves. Low calcium class F fly ash was procured from Kolaghat Thermal Power Plant, Kolaghat, West Bengal, India. Rice husks ash (RHA) were also source from Kolkata, West Bengal, India. The chemical composition of the OPC, FA, SF and RHA is shown in Table1.

Table 1 Chemical Composition of OPC and SCMs

Chemical Analysis (%)	Cement	Fly Ash	Silica Fume	Rice Husk Ash
SiO_2	20.15	56.01	98.5	90.00
Al_2O_3	4.20	29.8	0.2	0.39
Fe_2O_3	3.20	3.58	0.1	0.37
CaO	63	2.36	1.3	0.46
MgO	2.4	0.30	0.5	0.88
K_20	0.67	0.73	0.2	3.10
Na_20	1.1	0.61	0.3	0.07
$S0_3$	1.5	-	0.1	-

2.2. Preparation of specimens and testing

Paste samples are made with cement replaced with a fixed quantity of fly ash, silica fume, rice husk ash as the substitute material. The water-binder ratio is maintained comparatively same for all the specimens except in the paste with RHA as the demand of water was much higher in this mix. The nomenclature od the specimens were given with alphanumeric system where the alphabet denotes constituents and numerical denotes the percentage of each constituents. The mix proportions of all the specimens are listed in Table 2.

Table 2 Details of Paste specimens

Nomenclature of Samples	Percentage of the Constituents				Water-cement Ratio
	Cement	Fly Ash	Silica Fume	Rice Husk Ash	
CP	100	-	-	-	0.31
80C20F	80	20	-	-	0.31
80C20S	80	-	20	-	0.31
80C20R	80	-	-	20	0.60

3. RESULT AND DISCUSSION

3.1. Bulk Density

The average values of bulk density of the specimen were recorded and shown in Fig.1 It can be observed that the bulk density of cement paste specimen (CP) is maximum with 19.68 kN/m^3 and the bulk density of 80C20R with RHA replacement is minimum at 14.72 kN/m^3.

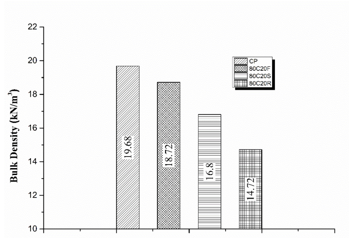

Figure 1 Bulk Density of specimens

Though the bulk density of 80C20F paste and CP paste specimen are reported to be comparable, bulk density of cement paste is higher due to better hydration in the specimen.

3.2. Apparent porosity

A simple test to represent porosity of specimens is by way of determining the apparent porosity. The value of apparent porosity is graphically presented in Figure 2. From the results, it can be noticed that 80C20S specimen has the lowest porosity of only 18.51%.80C20R has the highest porosity of 26.78%. 80C20S has low porosity because silica fume is very fine and acts as a good filler material. Porosity of 80C20R is relatively very high as rice husk particles are very coarse as compared to cement.

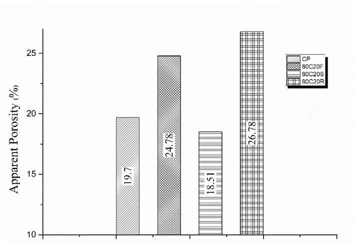

Figure 2 Apparent Porosity of specimens

3.3. Water Absorption

Water absorption test is simple test but has a lot of significance. Figure 3 presents the water absorption value of the specimens. It can be observed that paste specimen of 80C20S has lowest water absorption of 12.33% whereas paste specimen 80C20R shows very high water absorption of 22.57%. Silica fume replaced specimen 80C20S recorded low water absorption as similar to its lower porosity.

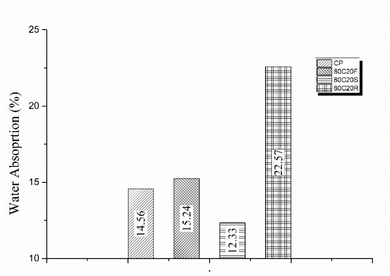

Figure 3 Water Absorption of specimen

2.4. Water Sorptivity

Water sorptivity is properties which indirectly indicate the durability of a specimen. Water sorptivity is determined for all test specimens and presented in Table 3. For finding the sorptivity, the slope of the initial straight portion of the curves are found out which gives the value of sorptivity . 80C20R specimen has highest sorptivity of all due to its high porosity.

Table 3 Water Sorptivity of specimen

Specimen	Water sorptivity (g/mm2/min.0.5)
CP	2.27×10-3
80C20F	3.731×10-3
80C20S	3.478×10-3
80C20R	4.075×10-3

2.5. Compressive Strength

For measuring the compressive strength of specimens, the cement paste blended with SCMs was tested at the age of 28 days. The values recorded for compressive strength are the average of 3-samples. Fig. 4 shows the result of compressive test conducted on different specimens. From the result obtained in the test; it is found that 80C20S has the highest compressive strength of 41.07 MPa and 80C20R gives the lowest compressive strength of 16.78 MPa. The compressive strength of CP specimen is 36.78 MPa.

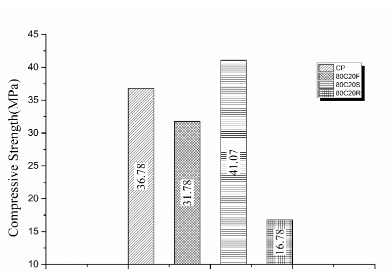

Figure 4 Compressive Strength of specimen

2.6. Split Tensile Strength

The split tensile strength for all the specimens are determined and presented Fig. 5. From the figure it is observed that 80C20S specimen gives highest value of split tensile strength. Also 80C20S recorded the highest compressive strength of cylinder among the four specimens. 80C20F specimen made by replacing 20% of cement by fly ash also gives slightly higher value of split tensile strength when compared to CP specimen. It shows that replacement of cement by silica fume and fly ash improves the tensile strength.

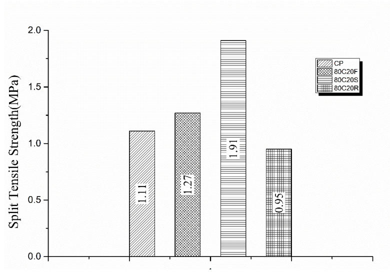

Figure 5 Spilt Tensile Strength of specimen

4. CONCLUSION

Generally, replacement of cement by silica fume is found to give better physico-mechanical properties than other specimens. The bulk density of CP is higher than the other specimens and geopolymer specimen studied in the present work. Apparent porosity of specimen made by replacement of cement by rice husks ash is higher in comparison to those of other specimen. Among the specimens in the present study, water absorption of rice husk ash replacement specimen is higher which can be attributed to its higher porosity. Compressive strength of specimen prepared by replacement of cement by silica flume in the present work is comparatively higher than those of other specimens. The replacement of cement by silica fume gives highest split tensile strength among the specimen tested.

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