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Durability Properties on Concrete with Phosphogypsum and Fly ash as a Partial Replacement for Cement

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ABSTRACT: The utilization of these industrial by-product materials is important in terms of environmental and economic issues are concerned. In my project cement is partially replaced by varying proportions such as 0%, 5%, 10%, 15% of phosphogypsum and 0%, 10%, 15% of fly ash. The material Properties of fly ash and phosphogypsum were studied. The durability studies such as acid resistance, water absorption, carbonation are studied.

KEYWORDS: Fly Ash, Phosphogypsum, Acid resistance, water absorption, Carbonation.

I. INTRODUCTION

Demand of cement leads to its increased cost, which causes problems in the construction area. The cost of cement during 1995 was around Rs.1.25/kg and in 2005 the price increased approximately three times. The shortage of conventional building materials in developing countries and abundantly available industrial waste products has promoted the development of new building materials. The aim of this research is to investigate the potential to use by-product materials, especially Phosphogypsum and fly ash as construction raw materials. Phosphogypsum is a by-product in the wet process for manufacture of phosphoric acid in the phosphate fertilizer plant and chemical industries. It is mainly composed of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Fly ash is a byproduct from burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. As the fused material rises, it cools and solidifies into spherical glassy particles called fly ash. Fly ash is collected from the exhaust gases by bag filters. The focus of the research concentrated on developing and maximizing cementitious reactions of waste Phosphogypsum by mixing it with other by-product fly ash, to create some cementitious binders for cement replacement. The use of above mentioned waste products with concrete in partial amounts replacing cement acted a role for (i) modifying the properties of the concrete, (ii) controlling the concrete production cost, (iii) to overcome the scarcity of cement, and finally (iv) the advantageous disposal of industrial wastes. The use of particular waste product will be economically advantageous usually at the place of abundant availability and production. Much of the literature is available on the use of fly ash, blast furnace slag, silica fume, rice husk, etc. in manufacture of cement concrete. This experiment tries to focus the chemical reaction take place between phosphogypsum fly ash and conventional cement content and their suitability in construction industry.

II. EXPERIMENTAL PROGRAMME

PHOSPHOGYPSUM

Phosphogypsum is a by-product in the wet process for manufacture of phosphoric acid (ammonium phosphate fertilizer) by the action of sulphuric acid on the rock phosphate. In India the majority of phosphogypsum is produced by the

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dehydrate process due to its simplicity in operation and lower maintenance as compared to other processes. Specific gravity of phosphogypsum is 2.8. Some of the advantages are:

- 1 Controlling the concrete production cost.
- 2 To overcome the scarcity of cement.
- 3 The advantageous disposal of industrial wastes.



Fig. 1. Phosphogypsum

FLY ASH

Class F fly ash was used. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Specific gravity of fly ash is 2.08. Some of the benefits are:

- 1 Produces various set times
- 2 Cold weather resistance
- 3 Great workability
- 4 Can be used as an admixture
- 5 Reduces heat of hydration
- 6 Reduces crack problems



Fig. 2. Fly ash

CEMENT

The cement is tested for its various properties as per IS 4031-1988. The different properties of cement are: specific gravity- 3.12, normal consistency- 29%, fineness – 4 %, initial setting time – 50 minutes, and final setting time- 320 minutes

FINE AGGREGATE

The available sand conforming to IS 383:1970 is used as fine aggregate in the present investigation. The sand has a specific gravity- 2.76, fineness modulus- 2.34, Water absorption- 0.5%, Minimum density- 1578.61 kg/m³, Maximum density- 1758.60 kg/m³.

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COARSE AGGREGATE

The maximum nominal size of aggregate is 20 mm conforming to IS 383:1970. The coarse aggregate has specific gravity- 2.83, fineness modulus- 7.04, Water absorption- 0.1%, impact value- 12.6%, crushing value- 11.3%, and Density- 1772.40 kg³.

III. EXPERIMENTAL RESULTS

WATER ABSORPTION

For water absorption test the cylinder size of 100mm dia and 50mm as per (ASTM 1585) height was used. After De moulding the cubes are immersed in a water for 28 days. After 28 days of curing the cubes were taken out to measure saturated weight (w₁). Thus the specimen were dried in oven at a temperature of 105 0c for 72 hours and taken it as an oven dried weight. Next the specimens were submerged for 30 min inside a tank filled with portable water and free water was removed thoroughly by wiping with a cloth and taken as (w₂). The water absorption was calculated as:

$$(w_1 - w_2) / w_1 \times 100$$

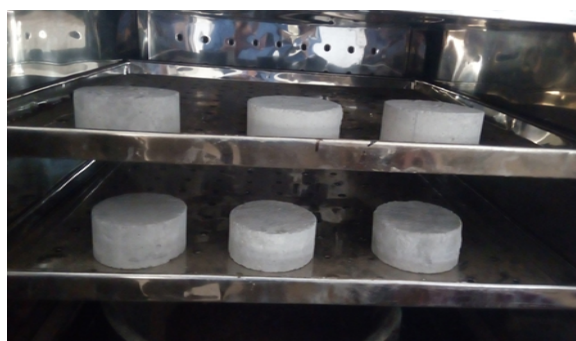


Fig. 3. Specimen in oven curing

TABLE 1. WATER ABSORPTION TABULATION

Mix	Oven dried weight (g)	Saturated weight (g)	% of water absorption
Conventional mix	933	895	4.07
95% C+05% Pg	924	892	3.46
90% C+10% Pg	935	874	6.52
85% C+15% Pg	919	855	6.96
05% Pg+10% Fa	916	858	6.63
10% Pg+10% Fa	938	891	5.01
15% Pg+10% Fa	920	879	4.45
05% Pg+15% Fa	923	868	5.95
10% Pg+15% Fa	930	880	5.68
15% Pg+15% Fa	921	875	5.25

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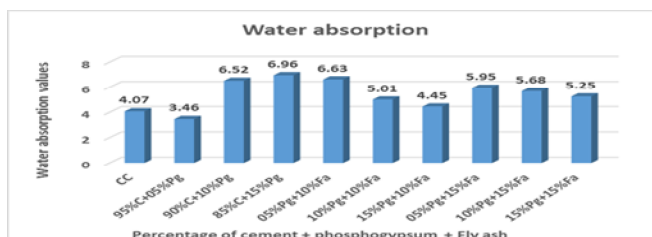


Fig. 3. Graph for water absorption

ACID RESISTANCE

Acid resistance test was performed on Concrete cubes of size 50mm × 50mm × 50mm as per (ASTM C 267) were cast and stored in a place at room temperature for 24 hours and then the specimens were demoulded and kept for curing in water for 28 days and Specimen were taken out placed in room temperature and weight was taken as (w1). After 28 days of acid curing, the specimens were taken out and allowed to dry for one day. Weights of the cubes were taken as (w2). Sulphuric acid solutions with 0.3 normality per liter were prepared in acid-resistant tanks. The 0.3 Normality H2SO4 water solution (8.24 mL/liter) the percentage of weight loss were calculated. The acid resistance is calculated as

$$(w1-w2)/w1 \times 100$$



Fig. 4. Specimens in acid curing



Fig. 5. Specimens after acid curing

Table 2. Acid resistance tabulation

Mix	Oven dried weight (g)	Saturated weight (g)	% of water absorption
Conventional mix	933	895	4.07
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CARBONATION

Carbonation of the concrete occurs when the carbon dioxide in the atmosphere in the presence of moisture, reacts with hydrated cement minerals to produce carbonates. This test is to determine the depth of concrete affected due to combined attack of atmospheric carbon dioxide and moisture causing a reduction in level of alkalinity of concrete. Phenolphthalein spray is sprayed on a concrete after 56 days which is placed in an open exposure. It is noted that the colour of concrete is changed to pink. The change of colour of concrete to pink indicates that the concrete is in the good health. Cylinder dimensions of 300mm height and 150 mm dia was used.

IV. CONCLUSION

From the experimental work carried out and the analysis of the results following conclusions seem to be valid with respect to the utilization of Fly Ash and Phosphogypsum.

i) From water absorption test results it seems that 15 % replacement of phosphogypsum with cement has higher water absorption value compared to the conventional concrete.

ii) Proportion like 5% replacement of phosphogypsum with cement gives good result when compared to the conventional concrete.

iii) From acid resistance test results it's observed that the proportion like 5%Pg + 15%Fa gives more weight loss and 5% Pg gives low weight loss when compared to the conventional concrete.

iv) For carbonation test results there is no carbonates formed in the cylinder due to the absence of co₂ in the surrounding area.

v) The chances of forming carbonates in the specimen by placing that in an open exposure period may get extended.

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