

Studies on Strength and Durability Properties of Concrete with Partial Replacement of Cement in Phosphogypsum

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Abstract - In this experimental research is focused on the utilization of phosphogypsum as a partial replacement of cement in concrete. The main aim was to experimentally analyze the strength and durability characteristics of concrete with the addition of phosphogypsum and comparing it with the conventional concrete mix. In this phosphogypsum is added to a 0%, 5%, 10%, 15% and 20% by partial replacement of cement with M25 grade of concrete with water cement ratio 0.45. The fresh and harden concrete properties was tested for slump test , compaction factor test, while the hardened concrete for compressive strength, split tensile, flexural strength and water absorption test different replacement levels at the age of 7 and 28 days obtained. The experimental results shows that the maximum replacement level of 15% with weight of cement. Beyond limits of increasing replacement level of cement strength will be reduced.

Keywords: compressive, strength split tensile, water absorption.

I. INTRODUCTION

Cement Concrete is one of the most important and universally adopted very largest building materials used by the different construction industries. Cement Concrete is a composite materials for mainly cement, fine aggregate, coarse aggregate and addition of water. Usually there are additives and reinforcements included to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with variety of uses to the structural work.

The utilization of phosphogypsum materials in concrete comes from the conservation of environmental pollution prevention and the safe disposal of byproducts of phosphate fertilizer chemical industries. Big attention is being focused on the environment and safeguarding of natural resources and recycling of wastes materials. Actually many industries are producing a significant number of products which incorporate scrap (residues). In the past two decades, a lot of works

concerning the use of different kinds of rural and urban wastes building materials from industrial process have been generated. Many research works have been extended to study new varieties of wastes to experimentally investigate the specific wastes. The addition of wastes of by product to the construction works and reduces the construction cost and also environmental benefits to safe guard of natural resources.

In our country more than 6 million tons of waste gypsum such as phosphogypsum, flourgypsum etc., are being generated every year. 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. The other sources of phosphogypsum are by-products of hydrofluoric acid and boric acid industries.

The main objectives of the present research are:

- To analyse fresh concrete properties like slump and compaction factor of concrete.
- To study the strength and durability properties of concrete in hardened state.

II. EXPERIMENTAL DETAILS

2.1 Materials used

2.1.1 Cement

Ordinary Portland cement used 53 grades conforming to Indian standards Code – IS 12269 (1987) was used for the present experimental research. Its specific gravity is 3.02. The cement was tested as per the procedure given in Indian standards IS 4031 (1988).

TABLE-1
Chemical Composition of Phosphogypsum

Sl.No	Details of description	% in values
1	CaO	31.2%
2	SiO ₂	3.92%,
3	SO ₃	42.3%,
4	R ₂ O ₃	3.6%,
5	MgO	1.50
6	Phosphate,fluoride	17.48

2.1.2 Fine aggregate

The river sand used for (fine aggregate) and retained on 600µm sieve, conforming to Zone II as per the river sand, passing through 4.75 mm sieve IS 383-1970 was used as fine aggregate in the present study. The river sand is free from unwanted impurities. The fine aggregate was tested for its physical standards such as gradation fineness modulus, specific gravity in as per Indian standard: 2386 – 1963.

2.1.3 Coarse aggregate

Hard granite broken stone 20mm nominal size from the local available materials with free from unwanted impurities like dust, clay particle and organic matter.

2.1.4 Water

The present research work water used for the tap water from concrete and highway laboratory. The water was clean and free from unwanted impurities. The pH value should not be less than 6 as per IS456 - 2000.

2.1.5 Phosphosypsum

The Phosphosypsum was obtained from the production fertilizer from phosphate rock. From the fertilizer industry in producing the phosphoric acid from phosphate rock deposition by the by product of 5-6 tons of phosphogypsum for every ton of phosphoric acid produced.

2.1.6 Design mix procedure

The design mix procedure for M25 grade of concrete using IS: 10262 -2009. The mix proportions of materials required for M25grade of concrete 1: 1.47:2.39 with water cement ratio 0.45.

III. EXPERIMENTAL PROGRAM

The compressive strength, split tensile strength, flexural strength and water absorption properties of M25 grade concrete with experimentally analyzed. The concrete cube size for 150mm x 150mm x 150mm for compressive strength, 150mm diameter with 300 height cylinder for split tensile, 100mm x 100 mm x 500 mm size prism for flexural strength and 100mm diameter with 50mm thick cylindrical disc for water absorption test was carried out. The test should be carried out as per codal provision IS 516: 1959.

3.1 Mechanical Strength properties Test

Compressive strength, split tensile and flexural test was carried out on the concrete specimens after 7 and 28 days of curing by universal testing machine. The test should be carried

out as per codal provisions. IS: 516-1959. Totally 30 cubes for compressive strength, 30 cylinders for split tensile, 30 prisms for flexural strength and 30 discs for casted water absorption studies. The experimental test results are shown in Table – 2 for mechanical properties of concrete specimens.

TABLE-2
Strength Properties of Concrete

Sl No	% replacement of cement	Average compressive strength in N/mm ²		Average split tensile strength in N/mm ²		Average flexural strength in N/mm ²	
		7 days	28 days	7 days	28 days	7 days	28 days
1	0	18.67	34.48	1.82	2.67	1.98	2.97
2	5	21.16	36.37	2.34	3.45	2.89	3.76
3	10	24.06	40.67	2.80	3.70	3.02	3.92
4	15	25.30	41.67	2.97	3.96	3.47	4.02
5	20	16.45	37.58	1.85	3.29	2.87	3.05

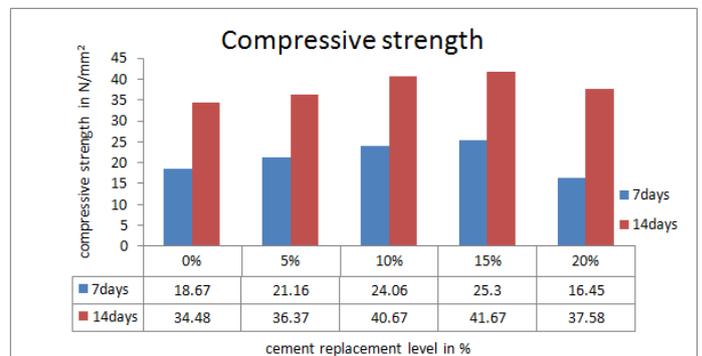


Figure 1: Compressive strength of phospho gypsum concrete

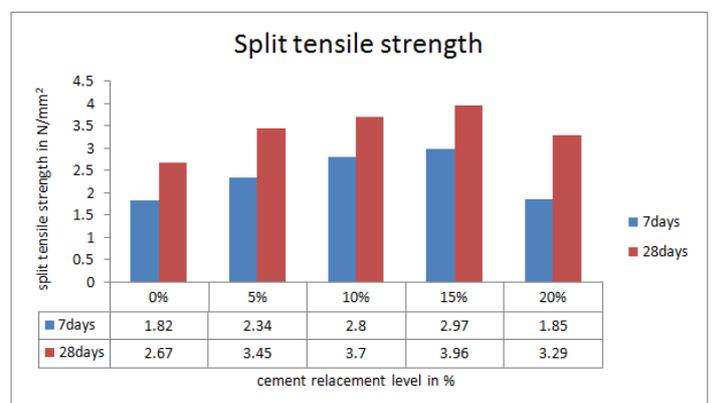


Figure 2: Split tensile strength of phospho gypsum concrete

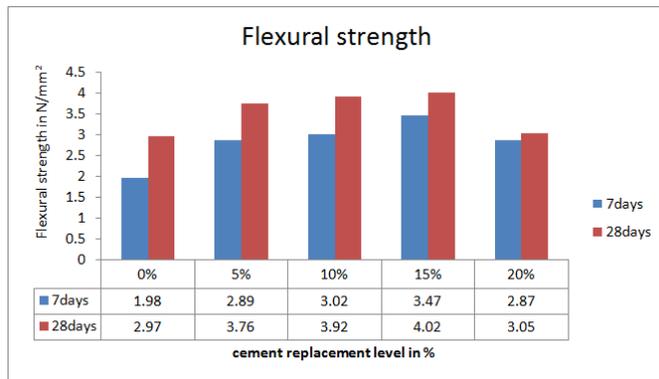


Figure 3: Flexural strength on phospho gypsum concrete

3.2 Water Absorption Test

For water absorption 100mm diameter with 50mm thick cylindrical disc was casted and tested after 28 days and 60 days curing period. Then after cube specimen were dried for 24 hours at open atmosphere. This weight should be measured in Kg (W1). Then after specimens were kept in water for 24 hours, this wet weight noted is (W2). The experimental test results are shown in table-3.

TABLE-3
Water absorption for phospho gypsum concrete

Sl No	% replacement of cement	Average water absorption in %	
		28 days	60 days
1	0%	1.25	1.22
2	5%	1.16	1.10
3	10%	1.10	1.02
4	15%	0.97	0.90
5	20%	0.85	0.80
6	25%	0.98	1.05

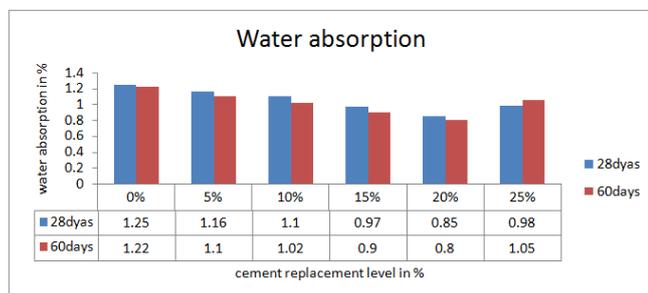


Figure 4: Water absorption for phospho gypsum concrete

IV. RESULTS AND DISCUSSION

4.1 Mechanical Properties Test

The Mechanical properties of concrete strength test such as Compressive strength split tensile and flexure test results after 7 days and 28days are shown in given Table – 2. The

experimental test results show that in the strength increases at 15% replacement by phosphogypsum. There is an increase in strength of concrete up to 15% replacement of cement by phosphogypsum because after the replacement of 20% the potassium oxide content in phosphogypsum gets increases which disrupt the concrete, thereby decreases its strength. This is illustrated in Figures.1,2,3.

4.2 Water Absorption Test

The Figure 4 and Table 3 shows that water absorption for conventional concrete is more than optimum mix because the phosphogypsum is a fineness material, it may block the pores in the concrete there by decreases its water absorption capacity.

V. CONCLUSION

The experimental test results shows that the phosphogypsum in blended concrete had significantly higher compressive strength, split tensile strength, flexural strength and lower water absorption properties compare to that of the concrete without phosphogypsum. It is determined that the cement could be advantageously replaced with phosphogypsum up to maximum limit of 15%. The strength of concrete decreases with increase in phosphogypsum content, low weight concrete produced in the society with waste materials of phosphogypsum.

- The compressive strength of 15% replacement of phosphogypsum shows an increase of 26.20% and 15.81% for 7days and 28days.
- The split tensile strength of 15% replacement of phosphogypsum shows an increase of 38.72% and 25% for 7days and 28days.
- The flexural strength of 15% replacement of phosphogypsum shows an increase of 42.93% and 26.12% for 7days and 28days.
- Test conducted on water absorption showed that the optimum mix with phosphogypsum absorbs only less amount of water when compared to Conventional mix. This may be attributed to the fineness of phosphogypsum that blocks the pores thereby reducing its water absorption capacity.

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Citation of this Article:

P.Ramesh, K.Pandi, S.Ganeshammal@Gomathi, “Studies on Strength and Durability Properties of Concrete with Partial Replacement of Cement in Phosphogypsum” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 4, Issue 3, pp 41-44, March 2020.
