International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 03 | Mar-2016 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL INVESTIGATION ON STRENGTH CHARACTERISTICS OF CONCRETE WITH PHOSPHOGYPSUM AND FRP BARS

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ABSTRACT - *In India, about 6 million tons of waste gypsum such as phosphogypsum, flourogypsum etc., are being generated annually. 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 disposal of phosphogypsum is a serious environmental problem. This problem along with scarcity of cement, environmental pollution associated with the manufacture of cement and its increased cost can be solved to some extent by replacing certain quantity of cement in concrete with phosphogypsum. This project deals with the experimental investigation on compressive strength, and splitting tensile strength of phosphogypsum concrete. The study aims to determine the optimum amount of phosphogypsum that can give maximum strength to concrete. The experiment consists of testing partially replaced phosphogypsum concrete using 0%, 10%, 20% and 30% replacement of cement with phosphogypsum at two different water cement ratios (0.4 &0.5) and to increase the strength of optimum phosphogypsum content in concrete with replacement of steel reinforcement with FRP bars. Based on the experimental investigation conducted and the subsequent analysis of test results, the following conclusions are drawn. With 10% replacement of cement with phosphogypsum, the compressive strength and splitting tensile strength at 28 days increased commendably. However, further replacement of cement with phosphogypsum lead to drastic reduction not only in the compressive strength but also the split-tensile strength. Even though an industrial waste like phosphogypsum impairs the strength development of calcined products, it can be used as a partial replacement of cement in concrete, to achieve economy. Thus the method is important in engineering, environmental and economic point of view.*

Keywords: Phosphogypsum concrete, FRP bars, Compressive Strength, Split Tensile, and Flexural Strength.

1. INTRODUCTION

Difficulty in disposing waste is one of the serious problems faced by our country. A large amount of money is being used for waste disposal. Today, it is a new trend to study the potential utilization of the different waste materials in various fields. If the addition of these materials can make any positive changes in the field in which it is applied, it is an added advantage along with the waste disposal. In the field of concrete technology, various researches are frequently done to improve its properties. This includes the research on utilizing the materials like rice husk ash, fly ash, etc., in concrete. Though a large amount of waste gypsum is generated in India, it is not used effectively. This is a serious matter of concern. As we give more emphasis to sustainable development, effective utilization of waste materials like phosphogypsum deserves importance. Scarcity of cement leads to its increased cost, which causes problems in the construction sector. At the same time, reduction in the cement production and usage has environmental benefits also. Thus utilization of phosphogypsum in concrete gives multiple advantages, as it leads to a solution to problems related to waste disposal and reduction in the usage of cement in concrete, thereby reducing its cost. With the advancement of technology and increased field application of concrete and mortars, the strength, workability, durability and other characteristics of the ordinary concrete is continually undergoing modifications to make it more suitable for any situation. 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, rise husk, etc. in manufacture of cement concrete. However, the literature on the use of phosphogypsum in construction industry is in the budding stage. This paper tries to focus on the use of phosphogypsum in partial replacement of cement in concrete and to increase the strength using FRP bars.

Objectives of this project:

To experimentally investigate the effect of replacing 10%, 20%, 30% replacement of cement by Phosphogypsum at two different water cement ratios (0.4 & 0.5) on strength characteristics namely compressive strength, split tensile strength and flexural strength of beam using FRP bars as reinforcement.

2. MATERIALS USED

Cement

Ordinary Portland cement-53 grade have used in the investigation. The cement was tested according to IS 4031:1988. It confirmed to IS 12269:1987. Its Properties is given in Table I

S.no	Property of cement	Values	As per is:12269-1987
1	Specific gravity	3.15	3.15
2	Normal Consistency	32.5%	30%-35%
3	Initial setting time	40min	>30
4	Final setting time	490min	<600

Fine aggregate

Clean and dry river sand available locally was used. Sand passing through IS 4.75 mm sieve was used for casting all the specimens. Specific gravity and fineness modulus is 2.64 and 2.29 respectively.

Coarse aggregate

Coarse aggregate passing through 12.5 mm sieve as given in IS 383 – 1970 was used for all the specimens. In addition to cement paste- aggregate ratio, aggregate type has a great influence on concrete dimensional stability. Specific gravity and fineness modulus is 2.89 and 5.23 respectively.

Phosphogypsum

Phosphogypsum refers to the gypsum formed as a by-product of processing phosphate ore into fertilizer with sulphuric acid. Phosphogypsum is produced from the fabrication of Phosphoric acid by reacting Phosphate ore with Sulphuric acid. Phosphogypsum can be gainfully utilized in cement and building materials industries.

Chemical properties	Compounds (%) Phosphogypsum
CaO	31.2
SiO_2	3.92
SO_3	42.3
R_2O_3	3.6
MgO	0.49
Phosphate, Fluoride etc.	18.49

FRP bars

It is a structural reinforcing bar made from filaments or fibers held in a polymeric resin matrix binder. There are different types of FRP bars available in market. In this project GFRP bar is used.

3. MIX DESIGN

In this investigation concrete mix design M40 was designed based on IS 10262 – 2009. This code presents a generally applicable method for selecting mixture proportion. Mix Design are given below in table 1. The quantity of material used in this study details are given below in table 2.

Mix proportions

Cement	Fine Aggregate	Coarse Aggregate	W/C
1	1.7	2.4	0.4
1	2.1	2.7	0.5

Notations of specimens

Notations	Phosphogysum %	W/C
NA1	0	0.4
PH1	10	0.4
PH2	20	0.4
PH3	30	0.4
NA2	0	0.5
PH4	10	0.5
PH5	20	0.5
PH6	30	0.5

Mix proportions *all values are in kg/m3

CRL	Cement	Phosphogypsum	Fine aggregate	Coarse aggregate
NA1	493	0	862	1203
PH1	490.9	2.1	862	1203
PH2	488.9	4.1	862	1203
PH3	486.9	6.1	862	1203
NH2	394	0	824	1059
PH4	391.5	2.5	824	1059
PH5	388.9	5.1	824	1059
PH6	386.4	7.6	824	1059

4. METHOD OF EXPERIMENT

It is important that the constituent material of concrete remain uniformly distributed within the concrete mass during the various stages of handling and that full compaction is achieved, and making sure that the characteristics of concrete which affect full compaction like consistency, mobility and compatibility are in conformity with relevant codes of practice. The tests were carried out in accordance with relevant IS Standards. The aggregates were tested for physical properties such as specific gravity and particle distribution test. All the mixes were prepared by mixing the concrete in laboratory mixer with water. For compressive strength 72 NOS cube specimens of size 150 mm x 150 mm x 150 mm, for flexural strength studies, 72 NOS prism specimens of size 100 mm x 100 mm x 500 mm and 72 NOS cylinder specimens of size 300 mm height and 150 mm diameter for split tensile strength studies were prepared. For durability properties

specimens were cast and cured for 28 days as per standard curing methods.

5. ANALYSIS AND TEST RESULT:

Compressive Strength Test

The results of the compressive tests of various concrete mixes at the age of 7, 14, 28 days are given in Table

Tensile Strength Test

The split tensile test is a method of determining the tensile strength of the results of the split tensile tests of various concrete mixes at the age of 28 days are given in Table.

Replacement of cement with phosphogypsum, %	Water-cement ratio	Split tensile strength, N/mm^2
0%	0.4	2.263
	0.5	2.348
10%	0.4	2.475
	0.5	2.178
20%	0.4	2.065
	0.5	1.839
30%	0.4	1.641
	0.5	1.697

Mix	Compressive strength in N/mm^2		
	7 days	14 days	28 days
NH1	19.6	30	36.88
PH1	20.31	31.10	38.22
PH2	11.21	17.17	21.11
PH3	9.91	15.17	18.66
NH2	18.5	29.3	36
PH4	18.3	28.91	35.55
PH5	11.5	18.07	22.22
PH6	10.3	16.30	20

6. CONCLUSION

- Compressive strength and splitting tensile strength has its maximum value at 10% replacement of cement with phosphogypsum, it reduces if the percentage replacement is more than 10%.Thus the optimum amount of phosphogypsum to be added to concrete is 10%.
- There will be significant reduction in the cost of concrete if phosphogypsum is added to it. The scarcity of cement and its increased cost are serious problems faced by construction industry. Use of phosphogypsum in concrete will be an appropriate solution to these problems
- The stack of phosphogypsum dumped by the fertilizer plants is a serious waste disposal problem. Effective utilization of phosphogypsum in concrete reduces the intensity of problems caused by its dumping.
- Thus phosphogypsum which is a by-product of fertilizer plant and chemical industries can be effectively utilized by partial replacement of cement in concrete with phosphogypsum. This method is surely a step toward sustainable development and is important in engineering, environmental and economic point of view.

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