Expremental Study on Strength Characteristics of Partial Replacement of Cement and Sand by Phosphogypsum and Granite Powder

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***Abstract*- The research has shown that every one ton of cement produce releases half ton of carbon dioxide, so there is an instantaneous need to manage the usage of cement. The rapid increase in construction activities leads to massive shortage of conventional construction materials such as cement, fine aggregate and coarse aggregate. Phosphogypsum is a by-product while of phosphate fertilizer plant and chemical industries. It can be used as partial replacement of cement. The partially cement replaced Phosphogypsum concrete using 10%, 20% & 30% replacement with M20 grade concrete with water binder ratio of 0.55. Granite powder is a by-product produced in granite factories while cutting huge granite rocks to the desired shapes. Granite fines are used as a filter material in the concrete, partial replacement of fine aggregate, which will helps in filling up the pores in the concrete. Filling up of the pores by granite fines will increases the strength of the concrete. The partially sand replaced granite powder concrete using 25% with M20 grade. This study revealed that there is an improvement in compressive strength.**

***Index terms*- Phosphogypsum; partial replacement; water-binder ratio; compressive strength**

1. INTRODUCTION

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 growth in infrastructure sector led to scarcity of cement because of which the cost of cement increased incrementally. In India, the cost of cement during 1995 was around Rs. 1.25/kg and in 2005 the price increased approximately three times. In order to combat the scarcity of cement and the increase in cost of concrete under these circumstances the use of recycled solid wastes, agricultural wastes, and industrial by-products like fly ash, blast furnace slag, silica fume, rise husk, phosphogypsum, etc. came into use. The use of above mentioned waste products with concrete in partial amounts replacing cement paved a role for

a. Modifying the properties of the concrete,
b. Controlling the concrete production cost,
c. To overcome the scarcity of cement, and finally
d. 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, 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.

2. LITERATURE REVIEW

In this content we explain about some literature review related to our project.

Y.Yaswanth Kumar. Et.al. examined the usage of granite powder as a partial replacement of cement in concrete. Cement was replaced with granite powder in steps of 0%, 5%, 10%, 15% and 20%. The compressive strength and of the samples was recorded at the curing age of 7 and 28 days. The results indicated that the compressive strength of concrete increased with additional of granite powder up to 10% replaced by weight of cement further addition of granite powder was found that the compressive strength will be decreasing from 10% replacement of cement.

Ong, Metcalf, Seals and Taha (2014)
They are studied unconfined compressive strength of various cement stabilized Phosphogypsum (CSPG) and it was shown that the mix behaves like cement-stabilized soil. The strength and its relation between parameters were studied for different curing conditions. It was concluded Phosphogypsum could be stabilized with cement to produce an adequate material for road base construction to the requirement of the local codes.

YUN YAN (2013)
In order to make clear the role of Phosphogypsum in cement– PG–slag–lime system, the following scheme was established: kept the proportion of cement–slag–lime invariant, added Phosphogypsum whose content was 0–50% multiply by the total amount of cement, slag and lime, at the same time, the ratio of water to raw materials was also consistent. Effect of Phosphogypsum content on compressive strength increases with increasing Phosphogypsum content from 0% to 10%, however, which decreases when Phosphogypsum content exceeds 10%. This shows that a part of Phosphogypsum plays the role of activator in the system, besides; redundant Phosphogypsum plays the role of filler. When Phosphogypsum content exceeds 10%, the compressive strength goes down due to the relative volume of binder reduce with Phosphogypsum content increasing.

Sarbjeet Singh, Ravindra Nagar, Vinay Agrawal
Granite dust is a waste produced during cutting and grinding process of granite stone. The waste generation from granite stone industry is in the form of non-biodegradable fine powder, the utilization of this waste in concrete will help in sustainable and greener development Published literature shows huge potential of granite dust as a replacement of natural fine aggregate. The depletion of reserves of sand and stricter mining laws have made the need for substitution of natural sand in concrete an absolute necessity. A comprehensive overview of the published literature on the use of granite dust in concrete is being presented. Effect of granite dust on the properties of concrete such as workability, setting times, compressive strength, split tensile strength; flexural strength, shrinkage, durability & microstructure of concrete have been presented.

3. EXPERIMENTAL PROGRAMME

MATERIALS USED

Cement
Grade 53 Ultratech cement was used for casting cubes for all concrete mixes. The cement is free from lumps and colour is uniform, Results of various tests on cement conducted are summarized in table 1.

Sand
The sand used for this experimental investigation was locally obtained and confirmed to Indian standard specifications IS: 383-1970. The sand was primarily sieved through 4.75 mm sieve to separate any particles greater than 4.75 mm. the sand is free from clay matter, silt and organic impurities.

Aggregates
Machine crushed 20 mm normal size angular metal from local sources conforming to IS 383-1990 is use as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter, etc. The properties of fine and coarse aggregates are shown in table 2.

Tables 1 Properties of cement

S. No.	Characteristics	Values obtained	Standard values
1	Normal consistency	32%	-
2	Initial setting time	48mm	Not less than 30 min
3	Final setting time	240mm	Not greater than 600 min
4	fineness	4%	Less than 10%
5	Specific gravity	3.12	3.1-3.15

Table 2 Properties of Fine Aggregate and Coarse Aggregate

S. No	Characteristics	Fine Aggregate	Coarse Aggregate
1	Specific gravity	2.65	2.72
2	Fineness modulus	2.31	4.20

Phosphogypsum (PG)
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. It is produced by various processes such as dehydrate, hemihydrates or anhydrite processes. In India the majority of phosphogypsum is produced by the dehydrate process due to its simplicity in operation and lower maintenance as compared to other processes. The other sources of phosphogypsum are by-products of hydrofluoric acid and boric acid industries. Current worldwide production of phosphoric acid yields over 100 million tons of phosphogypsum per year. While most of the rest of the world looked at phosphogypsum as a valuable raw material and developed process to utilize it in chemical manufacture and building products, India blessed with abundant low-cost natural gypsum piled the phosphogypsum up rather than bear the additional expense of utilizing it as a raw material. It should be noted that during most of this time period the primary reason phosphogypsum was not used for construction products in India was because it contained small quantities of silica, fluorine and phosphate (P205) as impurities and fuel was required to dry it before it could be processed for some applications as a substitute for natural gypsum, which is a material of higher purity. However, these impurities impair the strength development of calcined products. It has only been in recent years that the question of radioactivity has been raised and this question now influences every decision relative to potential use in building products in this country.

Fig .1.Phosphogypsum

APPLICATIONS OF PHOSPHOGYPSUM

The phosphogypsum for different applications which include

1 For use as soil conditioning(for alkaline soil) or as fertilizer in agriculture
2 In cement manufacturing to control the setting time of cement(as a retardant) and
3 Small quantity used in the production of plaster, plaster boards, gypsum fiber boards, and gypsum blocks.

The utilization of phosphogypsum depends on the degree of impurities such as fluoride, phosphoric acid and radioactivity which depends on type of raw material used process or pro-treatment giving to phosphogypsum.

Granite Powder

Granit waste was obtained from granite industry at Srikakulam district in Andhra Pradesh, India. The specific gravity of granite waste was 2.98 respectively and its size was less than 90 microns. The fineness modulus of granite waste was 2.83 respectively.

FIG.2. Granite powder

Water

The locally available potable water, which was free from concentrated of acid and organic substances, was used for mixing the concrete.

Preparation and casting of specimens

The phosphogypsum collected from the industry we should dried it in sunlight for evaporating additional water content in it. As per the mix proportions, given in table-3 the quantities of various ingredients were weighed. Initially cement and phosphogypsum, fine aggregate and granite powder were mixed thoroughly and then coarse aggregate were added to the mix. Once all the materials were mixed well, water added to the dry mix with water cement ratio 0.55 to the mix to form concrete. Cubes of size 150mm*150mm*150mm are used to determine compressive strength. All the inner surfaces and base plates of mould were coated with oil for easy removal of form and smooth finish. At-most care was taken while batching, mixing and casting operations were done. The specimens were de-moulded after 24 hours

and kept in water for curing for 7, 14 and 28 days respectively.

Experimental procedure

Experimental investigation was carried out with reference to the nominal concrete mix M20, Phosphogypsum, Grade 53 Ultratech cement, fine aggregates, granite powder and coarse aggregates are the materials used as replacement of cement and fine aggregate in this study.

Mix Proportions of Concrete (kg/m^3)

Mix	Cement	Fine Aggregate	Coarse Aggregate	Water (ml)
M 20	1.534	2.301	4.602	771.5

4. EXPERIMENTAL WORK

Slump cone test:

This test is used extensively in site all over the world. The slump test does not measure the workability of concrete, but the test is very useful in detecting variations in the uniformity of a mix of given nominal proportions. The slump test is done as prescribed by IS: 516. The apparatus for conducting the slump test essential consists of a metallic mould in the form of a cone having the internal dimensions as under

Bottom diameter: 200 mm

Top diameter: 100 mm

Compression test:

Compression test was conducted on 150mm × 150mm × 150mm cubes. Concrete specimens were removed from curing tank and cleaned. In the testing machine, the cube is placed with the cast faces at right angles to that of compressive faces, then load is applied at a constant rate of 1.4 kg/cm2/minute up to failure and the ultimate load is noted. The load is increased until the specimen fails and the maximum load is recorded. The compression tests were carried out at 7 days, 28 days and 90 days. For strength computation, the average load of three specimens is considered for each mix. The average of three specimens was reported as the cube compressive of strength.

Fig.4. Compressive strength

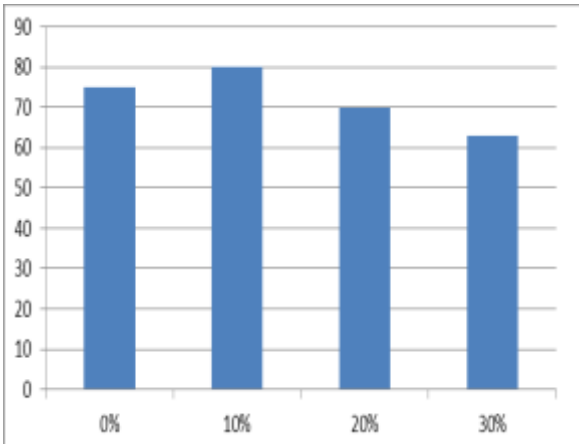
5. EXPERIMENTAL RESLUTS

SLUMP CONE:

Table -3 test result of slump cone

Grade of concrete	%of phosphogypsum	% of granite powder	Slump cone values in mm
M20	0%	0%	70
M20	10%	25%	80
M20	20%	25%	75
M20	30%	25%	63

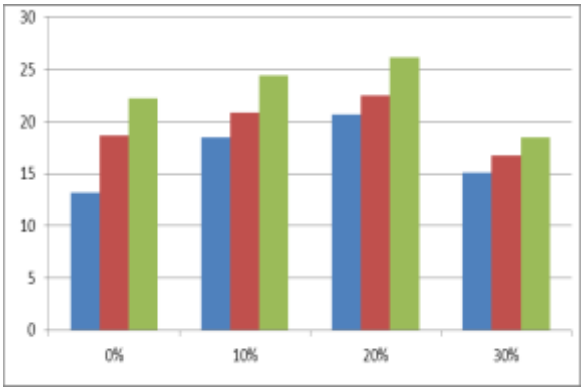
GRAPH OF SLUMP CONE VALUES:



COMPRASSIVE STRENGTH:

Phosphogypsum in percentage (%)	% of granite powder	Compressive strength values in N/mm^2		
		For 7 days	For 14 days	For 28 days
0%	0%	13.77	18.66	22.22
10%	25%	18.51	20.88	24.44
20%	25%	20.68	22.44	26.13
30%	25%	15.11	16.75	18.52

GRAPH OF COMPRESSIVE STRENGTH VALUES:



6. CONCLUSION

Based on the experimental investigation the following conclusion are drawn

1 The partially replaced phosphogypsum to cement and granite powder as fine aggregate leads to increase in workability and setting time.
2 Compressive strength of concrete is increased from 0-10% of phosphogypsum and 25% of granite powder is added in cement and fine aggregate compared to 0% of phosphogypsum and also increased when compared to conventional concrete.
3 Compressive strength of concrete is also increased from 10-20% of phosphogypsum and 25% of granite powder is added in cement and fine aggregate when compared to 10% of phosphogypsum.
4 But from 20-30% compressive strength is decreased when compared to 20% of phosphogypsum and 25% of granite powder in cement and fine aggregate in concrete.
5 The phosphogypsum as a use full material instead of a waste material (harm to the environment) that they were hurled in many hundred tons annually had been use in an engineering application.
6 After studying all these papers it is observed that, phosphogypsum can be used as a cement replacing material in the concrete. Mostly cases, phosphogypsum are replaced with cement in range of 0-30%.
7 It is found that, 10-20% replacement is optimum for compressive strength of concrete.
8 In some of the cases it is observed that, setting time of cement is increased due to use of phosphogypsum.
9 This experimental investigation will help to new researchers and user how and where the waste phosphogypsum can be used as building and construction material in glance.
10 10) Based on experimental investigation to addition phosphogypsum in concrete affects durability strength characteristic of concrete.

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