RESEARCH ARTICLE OPEN ACCESS

An Experimental Investigation of Partial Replacement of Cement by Various Percentage of Phosphogypsum And Flyash In Cement Concrete

Suchita R Saikhede*, S. R. Satone**.
*(Department of Civil Engineering, RTMN University, Nagpur, INDIA)
** (Department of Civil Engineering, RTMN University, Nagpur, INDIA)

ABSTRACT
Over 15 million tons of fly ash (FA) and 3 million tons of phospho-gypsum (PG) are produced every year. The utilization of these industrial by-product materials is important in terms of environmental and economical issues are concerned. The main purpose of this study is to evaluate the technical possibilities of incorporating FA and PG in production of concrete .In this study Combination of FA and PG is use as a mineral admixture with, phosphogypsum 0%., 5%,10%, 15% and fly ash is constant as 20% , Last proportion was taken PG- 5% and FA-25%. . The compressive, tensile and flexural strength are studied by casting and testing specimens for 7, 14 and 28 days. It is shown that a part of ordinary Portland cement can be replaced with PG and FA to develop a good and hardened concrete to achieve economy; above 10% replacement of phosphogypsum and 20% replacement of F in concrete lead to drastic reduction not only in the compressive strength but also in Flexural and split tensile strength of concrete.
Keywords: Phosphogypsum, Fly ash, Flexural Strength, Compressive Strength, Split Tensile Strength

I. INTRODUCTION

Rapid industrialization in developing countries continues to attract growth in urbanized areas. New construction to support urbanization, such as buildings for housing and industries, mass transit for moving people, and facilities for handling water and sewage all require construction activities. The shortage of conventional building materials in developing countries and abundantly available industrial waste products has promoted the development of new building materials (Kumar 2002). The aim of this research was to investigate the potential to use by-product materials, especially Phosphogypsum and fly ash as construction raw materials. 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 abovementioned waste products with concrete in partial amounts replacing cement paved 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, rise husk, etc. in manufacture of cement concrete.. This paper tries to focus on the use of phosphogypsum and flyash in partial replacement of cement in concrete.

II. EXPERIMENTAL MATERIALS:

2.1. Phosphogypsum

Phosphogypsum was tested according to IS: 12679-1989 and found to satisfy the requirement. The specific gravity obtained was 2.89. The phosphogypsum know to have some of the chemical impurities like phosphates and World wide for most of the application as a binder or cements, etc.

Table–1 Chemical Property of Phosphogypsum

Chemical	Constituents Percentage (%)
CaO	31.2
SiO2	3.92
SO3	42.3
R2O3	3.6
MgO	0.49
Phosphate, Fluoride	18.49

2.2. Fly ash

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. 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. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can lead to the formation of a geopolymer. Flyash for use in portland cement concrete shall conform to the requirements of ASTM C 618, Standard Specification for Flyash and Raw or Calcined Natural Pozzolan Class C Flyash for use as a Mineral Admixture in Portland Cement.

Table 2: Chemical composition of the pulverised fuel ash used

Compound	Content, % wt
Sio2	59
Al2O3	21
Fe3O3	3.7
Cao	6.9
Mgo	1.4
So3	1.0
K2o	1.9
Lo1	4.62

2.3. Cement

The cement used was Ordinary Portland cement (53 Grade) with a specific gravity of 3.15. Initial setting time of the cement was 48 min,conforming to I.S-8112- 1989. Chemical Composition of ordinary portland cement

Table 3: Chemical properties of cement (OPC)

Analysis	Ordinary Portland cement
CaO	65.9
SiO2	21.94
Al2O3	4.82
Fe2O3	3.94
MgO	1.65
K2O	0.6
SO3	0.48
Na2O3	0.1

2.4. Coarse Aggregate

Machine crushed 20 mm nominal size angular granite metal from local source confirming to IS 383:1970 is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter, etc. The coarse aggregate has specific gravity 2.65, and fineness modulus 6.86.

2.5. Fine aggregate

The locally available sand confirming to IS 383:1970 is used as fine aggregate in the present investigation. The sand is free from clay matter, silt and organic impurities. The sand has a specific gravity 2.69 in accordance with IS 2386-1963, and fineness modulus 2.5

2.6. Water

Ordinary tap water was used for mixing and curing operation

III. EXPERIMENTAL PROGRAM

Experimental program comprises of test on cement, fine aggregate,course aggregate , concrete with partial replacement of cement with FA and PG.

3.1. Ordinary Portland Cement:

OPC 53 grade cement is used for this whole experimental study.

Ordinary Portland cement of 53 grade were tested for different tests and physical test results of OPC were as follows:

1) fineness test=2.33%
2)Normal consistency = 32%
3) Initial Setting time = 50 min.
4) compressive strength of cement on 3,7,28 days was respectively 29.40MPa, 37.76MPa, 54.67MPa.

3.2 fine aggregate:

Fine aggregate was tested for different tests and test results as follows:

1) bulking of sand = 4.16%
2) fineness modulus = 2.69
3) Specific Gravity = 2.50

3.3 course aggregate:

course aggregate was tested for different tests and test results as follows:

1) fineness modulus = 6.86
2) Specific Gravity = 2..65

3.4 Mixture Proportioning

The mix proportion was done as per the IS 10262- 1982. The target mean strength was 31.6 Mpa (M25) for the OPC control mixture.

Table 4. Stipulation for proportioning

Grade of concrete	M-25
Type of cement	OPC 53 grade
Max. size of coarse aggregate	20mm
Min. cement content	300 kg/m3 (IS 456-2000 ,table no 5 , pg no 20)
Max. w/c ration	0.5 (IS 456-2000 ,table no 5 , pg no 20)
Workability	100mm
Exposure condition	· Moderate.

	(Reinforced concrete)
Degree of Supervision	Good
Type of Aggregate	Crushed , Angular

Table 5: Mix proportion for M25 grade concrete for tested material as follows:

Material	Quantity	Proportion
Cement	447.72 Kg/ m3	1
Sand	661 Kg/ m3	1.47
Coarse Aggregates	1050.99 Kg/ m3	2.34
Water	197 Kg/ m3	0.44
Slump	75-100 mm	--

3.4 Different Proportion of Cement ,Flyash and Phosphogypsum for testing:

In this experimentation, cement was partially replaced by combinations of Flyash (FA) and Phosphogypsum (PG).

Table 6: Proportion of Cement,Flyash and Phosphogypsum for testing:

Sr.no.	% of cement	% of phosphogypsum	% of Flyash
1	100%	0%	0%
2	75%	5%	20%
3	70%	10%	20%
4	65%	15%	20%

Table 7: Design Mix Proportion for various concrete For M25

Sr. No.	Concrete Type	OPC cement Replacement with PG and FA
1	A0	PG-0% , FA-0%
2	A1	PG-5% , FA-20%
3	A2	PG-10% , FA-20%
4	A3	PG-15% , FA-20%
5	A4	PG-5% , FA-25%

IV. 1V. EXPERIMENTAL RESULTS

4.1 Test on Fresh Concrete

Fresh concrete was tested using slump cone test and compaction factor test to find the workability of conventional concrete and concrete of combination of PG and FA with partial replacement of cement.

Table 8. Slump cone and compaction factor test Result

Sr.no	Type of concrete	Workability (mm)	Compaction factor
1	A0	19	0.81
2	A1	30	0.86
3	A2	55	0.89
4	A3	70	0.93
5	A4	25	0.91

4.2 Test on Harden Concrete

Tests were done as per following codes of Bureau of Indian Standards. The test for compressive strength on cubes were recorded at 7, 14, 28 days of curing as per IS : 516 1959, test for flexural strength on beam was measured at 28 days of curing as per IS : 516 1959 and test for split tensile strength on cylinder was measured at 28 days of curing as per IS : 5816 1999.

4.3 Compressive Strength Results

For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast for M25 grade of concrete for various % combination of PG and FA,

Table 9: Results of Compressive strength with different % combination of PG and FA ,For 7, 14 , 28 days

Concrete Type	Average Compressive Strength [N/mm2]		
	7 days	14 days	28 days
A0	14.36	22.2	30.86
A1	20.78	27.6	31.09
A2	21.6	28.7	33.27
A3	16.42	17.2	22.63
A4	22.23	30.3	30.66

4.4 Tensile strength Results

For tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast.

Table10: Results of Tensile strength with different % combination of PG and FA, For 28 days

Concrete Type	Average Tensile Strength [N/mm2]
	28 days
A0	2.932
A1	3.17
A2	3.217
A3	2.29
A4	2.758

4.5 Flexural Strength Result

The standard sizes of beam specimen were 15x15x70 cm. The beam moulds conform to IS:10086-1982.

Table10: Results of Flexural strength with different % combination of PG and FA, For 28 days

Concrete Type	Average Flexural Strength [N/mm2]
	28 days
A0	3.29
A1	3.68
A2	4.12
A3	3.22
A4	3.02

V. CONCLUSION

An industrial waste like phosphogypsum and Fly ash impairs the strength development of calcined products and hence it can be used in construction industry for preparation of concrete replacing some quantity of cement , which is a valuable ingredient of concrete to achieve economy.

Based on experimental investigations concerning the compressive strength of concrete,the following observations are made: Based on the results presented above, the following conclusions can be drawn:-

a) The Compressive Strength of M25 grade Concrete increases when the replacement of Cement with combination of PG and FA up to 30% replaces by weight of Cement and further replacement of Cement with Phosphogypsum and flyash decreases the Compressive Strength.

(b) Concrete on 30% replacement of Cement with PG & FA, Compressive Strength obtained is 33.27 N/mm2, Tensile strength is 3.217 N/mm2 and Flexural strength is 4.12 N/mm2.

(c) Utilization of PG and FA and its application are used for the development of the construction industry, Material sciences.

(d) It is the possible alternative solution of safe disposal of Phosphogypsum and Flyash.

REFERENCES

[1] IS 10262:1982 *Recommended gidelines for concrete mix design*. IS 456:2000 Code of practise for plain & reinforced concrete.

[2] IS12269 -1987, Indian Standard, Specification for 53 Grade Ordinary Portland cement.

[3] IS: 383 - 1970, *Specification for coarse and fine aggregate from natural sources for concrete, Second Revision*, Bureau of Indian Standards, New Delhi. 1970

[4] IS 12679:1989, *Specification for By-product gypsum for use in plaster*, blocks and boards,