Performance Evaluation and Comparisonof M30 Grade of Concrete by Partial Replacement of Fine Aggregate with Surkhi and Phosphogypsum Separately in Rigid Pavement

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Abstract-Theproject analyses the comparison between two different waste materials i.e., Surkhi and Phosphogypsum; which are available easilyand used as a replacement material with fine aggregate for the design of rigid pavement. Phosphogypsum is one of the by-products of the production of fertilizer obtained from the phosphate rock. Surkhi is powdered form of bricks.M30 grade of concrete is designed. Water cement ratio of 0.45is used. Fine aggregate is replaced with surkhi in different proportions of 5%, 10%, 15%, 20% and 25% and phosphogypsum in different percentages of 5%, 7%, 10%, 12% and 15%. This experimental study analyses that when surkhi was replaced with 20% and phosphogypsum with 10%; the compressive strength values and flexural strength values both increased when they were compared with the normal concrete of M30 grade. This experimental analysis is very much economical and also it reduces cost of the fine aggregate.

Keywords: Rigid pavement, Phosphogypsum, Surkhi, Compressive Strength test, Flexural Strength test, Water-Cement Ratio.

1. INTRODUCTION

The experimental work, analysesthe design of rigid pavement for M30 grade concrete. The waste materials in the construction areas are available abundantly nowadays, we must try to use the waste materialsfor its proper utilization. Phosphogypsumand Surkhiare available in great quantity and both can be recycled in the construction work. Phosphogypsum is a side-product from the production of phosphoric acid by treating phosphate ore with the sulphuric acid. Surkhi, also called as brick dust or trass; is obtained by grinding to powder burnt bricks or burnt clay. It is used as a substituent for the sand for concrete and mortar. It makes concrete more water proof. In this experimental work, for rigid pavement, the replacement of fine aggregate is done with phosphogypsum and surkhi with various percentages, and its

compressive strength test is performed after 7, 14, and 28 days and the flexural strength is performed after 28 days. Mix design of concrete is adopted as per IS 456:2000and IS10262:2009.

2. LITERATURE REVIEW

Roseli F. Gennari, Isabella Garcia et.al. (2011) "Phosphogypsum analysis: Total content and extractable element concentration", In this work, Inductively CoupledPlasma-Mass Spectrometry (ICP-MS) was used to study phosphogypsum sample. Some acid solution for sample digestion was evaluated in order to be feasible for the chemical analysis. The result showed that analite concentration are highly dependent on acid solution used.

Mahesh A. Bagade and S.R. Satone (2012) "An experimental investigation of partial replacement of cement by various percentage of phosphogypsum in cement concrete". Replacement of phosphogypsum by 0%, 10%, 15% and 20% with 0.40 water-binder ratio adopted. Above 10% replacement of phosphogypsum in concrete lead to drastic reduction in compressive strength.

Zamir Irfan, Syed Zeeshan Shafi and Altaf Ahmad Bhat (2017) "Utilization of surkhi as a partial replacement of sand in concrete".The paper included the physical properties and chemical composition of surkhi andabout its workability. The properties of compressive strength of concrete produced by replacement of 10%, 15% and 20% surkhi by the weight of fine aggregate,was suitable material for use as a pozzolana, and the concrete becomes less workable as the percentage of surkhi increases. The compressive strength gradually increases with curing time and also increases with increased amount of surkhi.

Junaid Showkat Hamdani and Ravi Kumar (2017) "Replacement of fine aggregate by mixture of ceramic and surkhi powder in concrete". He concluded that this replacement not only made concrete economical but also increased its strength properties to a considerable extent with a maximum compressive and split tensile strength of 33.50 N/mm^2 and 3.81 N/mm^2 for an M25grade of concrete, 80% of sand was replaced by mixture of ceramic and surkhi powder. He also observed that the increase in percentage of ceramic and surkhi, compressive strength and split tensile strength of concrete mix was decreased.

S. Venkatasubbaiah and Sri.V.K. Visweswararao (2017)"A study on replacement of phosphogypsume in conventional cement concrete". Paper deals with the experimental investigation on mechanical properties of partial cement replacement with phosphogypsum using 0%, 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5% & 20% replacement with M25 grade concrete with water-binder ratio of 0.48. Strength characteristics were studied after 28 & 56 days, which showed that a part of OPC can be replaced with phosphogypsum to develop a good and hardened concrete to achieve economy.Above 10% replacement of phosphogypsum in concrete; leads to drastic

reduction not only in compressive strength, but also in the flexural and split tensile strength.

Jan Wakeel Ahmad Wani (2017) "The influence of surkhi on various properties of concrete bricks".Conclusion was that, the brick in which surkhi was used as fine aggregate had less water absorption value as compared to conventional bricks. By incorporating surkhi; as replacement of fine aggregate, bricks with better properties were produced. Also, higher compressive strength, better hardness and better water absorption values, less efflorescence and better soundness obtained.

3. METHODOLOGY

3.1. MATERIALS USED:

a) CEMENT: Cement is one of the binders, which when mixed with fine aggregate provides mortar for the masonry purpose and when mixed with fine aggregate and gravel, provides concrete. Emami double bull Portland Pozzolana Cement (PPC) which is fly ash based is used as per IS 1489 (Part-1). It is obtained from Emami Cement Limited, Risda, Baloda Bazar.

Table 1. PHYSICAL PROPERTIES OF CEMENT

Grade of Cement	53
Name of Cement	Emami Double Bull Cement (Fly ash based)
Initial Setting Time	32 minutes
Final Setting Time	600 minutes
Fineness Modulus	359m^2/kg
Specific Gravity	3.15

b) FINE AGGREGATE: Fine aggregate as per IS:2386 (Part-1), passing through 4.75mm IS sieve and retained on 0.075mm sieveis termed as fine aggregate. Fine aggregates generally occur from the river beds. It is taken from Baloda bazar, Chhattisgarh.

c)COARSE AGGREGATE: As per IS:2386 (Part-1), when it is passed through IS sieve of 4.75mm, aggregates retained on it is termed as coarse aggregate. Coarse aggregatesareone of the base materials of the concrete. It is taken from Uma stone crusher industry, Baloda Bazar, Chhattisgarh.

d) SURKHI: Surkhi is the powdered form of burnt bricks which is available in the construction area. It is taken from Prakash traders, Supela, Bhilai, Chhattisgarh.

Table 2. PHYSICAL PROPERTIES OF SURKHI

PHYSICAL PROPERTIES	TEST RESULT
Colour	Reddish orange
Fineness modulus (% retained on 90micron IS sieve)	0.70
Specific Gravity	2.65

(e) PHOSPHOGYPSUM: Phosphogypsum is a by-product obtained from the production of fertilizer from phosphate rock. Phosphogypsum is used in fly-ash based bricks, road pavement, artificial roofs, gypsum blocks. It is obtained from Sirsakala, Bhilai-3, Chhattisgarh.

Table 3. PROPERTIES OF PHOSPHOGYPSUM

PHYSICAL PROPERTIES	TEST RESULT
Specific Gravity	2.3-2.6
Colour	White

➢ **Applications of Phosphogypsum:**

- As a cover for landfills, to increase the life of a landfill.
- For road pavement.
- With flyash bricks.
- In agriculture, as a fertilizer.
- For making ceramic roof tiles.

f)WATER: Water used for the mixing and curing purpose is free from any kind of impurities.

3.2 MIX DESIGN AS PER IS CODE456:2000& IS 10262:2009

CONCRETE MIX DESIGN: Properties of materials are based upon the design mix of M30 grade of concrete and it is calculated by the procedure given in IS:10262-2009 and also IS 456:2000. Water-Cement ratio of 0.45 is adopted. Ratio of cement, fine aggregate and coarse aggregate occurred is: 1: 1.3:3.72.

- ❖ Grade of concrete = M30
- ❖ Characteristic compressive strength at 28 days = 30 MPa
- ❖ Size of coarse aggregate = 40mm
- ❖ Cement Used = Portland Pozzolana Cement (Fly Ash Based)
- ❖ Specific Gravity of Cement = 3.15
- ❖ Specific Gravity of water = 1.0
- ❖ Specific Gravity of fine aggregate = 2.61
- ❖ Specific Gravity of coarse aggregate = 2.64
- ❖ Water Absorption of fine aggregate = 0.80
- ❖ Water Absorption of coarse aggregate = 0.82

Table 4. MIX PROPORTION FOR M30 GRADE

S.NO.	ITEMS	FOR $1m^3$ CONCRETE	MIX RATIO
1	Cement	367 kg	1
2	Fine aggregate	474.34 kg	1.3
3	Coarse aggregate	1365.56 kg	3.72
4	Water	165 kg	0.45

4. TESTING AND RESULT

Compressive strength test is determined and its average values occurred after 7 days, 14 days and 28 days. The flexural strength test is determined to find its strengthafter 28 days.

Following are the results obtained from the experimental work performed:

Table 5. COMPRESSIVE STRENGTH VALUES WITH SURKHI REPLACEMENT IN N/mm^2

DAYS / SAMPLE	COMPRESSIVESTRENGTH (N/mm^2)		
	7 DAYS	14 DAYS	28 DAYS
A_0 (NORMAL)	23.98	30.55	38.12

A_1	15.65	23.77	34.12
A_2	18.11	24.22	35.11
A_3	19.94	26.00	35.98
A_4	22.16	30.01	39.44
A_5	20.71	28.44	37.45

Table6. COMPRESSIVE STRENGTH VALUES WITH PHOSPHOGYPSUM REPLACEMENT IN N/mm^2

DAYS / SAMPLE	COMPRESSIVE STRENGTH(N/mm^2)		
	7 DAYS	14 DAYS	28 DAYS
B_0(NORMAL)	23.98	30.55	38.12
B_1	13.50	20.33	30.30
B_2	14.39	22.02	31.41
B_3	15.94	23.99	33.00
B_4	19.63	28.81	38.54
B_5	18.15	25.36	34.44

Table7. FLEXURAL STRENGTH VALUES WITH SURKHI REPLACEMENT IN N/mm^2

SAMPLE	FLEXURAL STRENGTH AFTER 28 DAYS
C_0(NORMAL)	4.98
C_1	2.20
C_2	2.99
C_3	3.87
C_4	5.07
C_5	3.43

Table8. FLEXURAL STRENGTH VALUES WITH PHOSPHOGYPSUM REPLACEMENT IN N/mm^2

SAMPLE	FLEXURAL STRENGTH AFTER 28 DAYS
D_0(NORMAL)	4.98
D_1	2.01
D_2	2.39
D_3	3.59
D_4	4.99
D_5	2.38

5. CONCLUSION

1. Phosphogypsum and Surkhi are waste products obtained from industry, which are available in abundant, it is used as replacement material for the fine aggregate for economical achievement.
2. The compressive strength of M30 grade of concrete increases when replacement of fine aggregate with Surkhi was up to 20% by weight of fine aggregate and further replacement resulted in decrement of compressive strength.
3. On 12% replacement of the fine aggregate with Phosphogypsum, the flexural strength obtained was approximately same as compared to the normal M30 grade of concrete.
4. The compressive strength of M30 grade concrete increases when replacement of fine aggregate with Phosphogypsum was up to 12%by weight of fine aggregate and further replacement resulted in decrement of compressive strength.
5. Concrete on 20% replacement of the fine aggregate with Surkhi, the flexural

strength obtained was slightly increasedwhen compared to the normal M30 grade of concrete.

6. Both waste materials are easily available, also it reduces cost of fine aggregate.
7. Phosphogypsum and Surkhi bothare industrial waste, which are available in great quantity which imparts strength and thus, can be replaced with fine aggregate to achieve good economy.
8. On comparing surkhi with phosphogypsum the better result occurred for surkhi replacement at 20%; where the compressive strength as well as flexural strength; both values were achieved as similar to the normal M30 grade concrete strength.

REFERENCE

[1] Roseli F. Gennari, Isabella Garcia et.al., "Phosphogypsum analysis: Total content and extractable element concentration". International Nuclear Atlantic Conference (INAC), ISBN:978-85-99141-04-5, (2011).

[2] Mahesh A. Bagade and S.R. Satone,"An experimental investigation of partial replacement of cement by various percentage of phosphogypsum in cement concrete". International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, Vol. 2, Issue4, pp. 785-787, (2012).

[3]Zamir Irfan, Syed ZeeshanShafi and Altaf Ahmad Bhat,"Utilization of surkhi as a partial replacement of sand in concrete". International Journal for Research in Applied Science and Engineering Technology (IJRASET), ISSN: 2321-9653, Vol. 5, Issue 11, pp. 2090-2095, (2017).

[4] Junaid Showkat Hamdani and Ravi Kumar,"Replacement of fine aggregate by mixture of ceramic and surkhi in concrete". International Journal of Engineering Research and Technology (IJERT), ISSN: 2278-0181, Vol. 6, Issue 04, pp. 1184-1192, (2017).

[5] S. Venkatasubbaiah and Sri.V.K. Visweswararao,"A study on replacement of phosphogypsume in conventional cement concrete". International Journal of Innovative Research in Science, Engineering & Technology (IJIRSET), ISSN(Online): 2319-8753, ISSN(Print): 2347-6710, Vol. 6, Issue 1, pp. 194-201, (2017).

[6] Jan wakeel Ahmad Wani and Ravi Kumar, "Influence of surkhi on various properties of concrete bricks". International Journal of Engineering Research and Technology (IJERT), ISSN: 2278-0181, Vol. 6, Issue 04, pp. 1201-1208, (2017).

[7] Advanced concrete design by M.S. Shetty.

[8] Basic civil engineering by V.K. Kumawat, Jayant D. Supe, Ravindra Sharma.

[9] Engineering Materials by S.C. Rangwala.

[10] IS:10262,Recommended the guidelines for concrete mix design, BIS (Bureau of Indian Standards), (2009).

[11] IS:456-2000,Code of practice for plain and reinforced concrete. Bureau of Indian Standards.