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An Experimental Study of M30 Grade of Concrete by Partially Replacing Fine Aggregate with Surkhi and Phosphogypsum in Rigid Pavement

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Abstract: ***In this project, an experimental study is done by replacing the fine aggregates with the partial amount of surkhi and small percentage of Phosphogypsum. Some of the tests have been performed such as; compressive strength test and flexural strength test, by adding different percentages of Surkhi as 5%, 10%, 15%, 20% and 25% and Phosphogypsum as 5%, 7%, 10%, 12% and 15% and replaced with fine aggregate. The reason for partially replacing surkhi is that it makes concrete more water proof and more resistant to alkali and salt action as compared to those in which no surkhi is present. Phosphogypsum is formed as one of the by-products of production of fertilizer from phosphate rock. The combination of surkhi (which is the crushed form of bricks) and phosphogypsum as replacement of fine aggregate, makes it more resistant to various forms of attacks without decreasing its strength. Concrete mix design of grade M30 is designed. Water-cement ratio of 0.45 is used. The experimental work analyses that when fine aggregate is replaced with combination of surkhi at 20% and phosphogypsum with 12%, the compressive strength and flexural strength both increased upto the normal grade strength. This experimental analysis is economical; as it reduces the cost of fine aggregate.***

Keywords: Rigid pavement, Surkhi, Phosphogypsum, Water-cement ratio.

I. INTRODUCTION

A multilayer system that distributes the vehicular load over a larger area is termed as Pavement. Function of a pavement is to provide economy, limit the noise and air pollution, reduce the traffic loading and distribute the traffic loading. Also, it provides safe, smooth and comfortable ride to the road users. Rigid pavement has longer life, and may require asphalt topping due to noise or comfort issues. In this experimental work, M30 grade of concrete is designed. The use of waste materials is increasing nowadays, we should try to reuse that material; so that its proper utilization can be done. Surkhi and phosphogypsum both are available in abundant and both can be used in different construction work. Surkhi, which is powdered form of bricks, generally available in the construction areas where bricks are arranged in order for its use. Also, surkhi can be obtained from the brick industry. Phosphogypsum is used for various purposes such as, for agricultural work, gypsum blocks, as roofing material, as soil surface covering, as cover for landfills, etc. Cement is one of the binding materials used for the construction work. Fine aggregates are generally obtained from the river bed. Coarse aggregate available in different sizes are obtained from crusher. These 3 materials (i.e., cement, fine aggregate and coarse aggregate) are very important for any type of construction or pavement work. Hence, in this experimental work, the fine aggregate is replaced with surkhi and phosphogypsum with different percentages, and its compressive strength is determined after 7, 14, and 28 days and its flexural strength is checked after 28 days. Different tests were performed to determine the mix ratio for M30 grade of concrete. Mix design of concrete is adopted as per IS 10262:2009 and IS 456:2000.

II. LITERATURE REVIEW

Various studies have been carried out internationally which explained about different topics related to the topic I have selected. Some of the literature reviews which have been studied are: Nurhayat Degirmenci (2008) “Utilization of phosphogypsum as raw and calcinated material in manufacturing of building product”. Phosphogypsum was used as a raw material for making cementitious binder. Result obtained was the curing condition have an important influence on the compressive and flexural strength of binder specimen. It was also concluded, that the cementitious binder obtained, can be used from the production of the interior wall materials such as bricks and blocks. Ajam, L. et.al (2009) “Characterization of Tunisian phosphogypsum and its valorization in clay bricks”. The study concerns the analysis of incorporation of phosphogypsum (PG) into fired clay bricks. After characterization, tunisian phosphogypsum; which plays the part of the grease-remover, was added into the clay bricks with different percentages of

0%, 5%, 15%, 25%, 30% and 40%. Result showed that with 30% of phosphogypsum incorporation, bricks successfully satisfied the standard requirements. 25% was considered as most effective considering physical, chemical, mechanical and environmental tests.

T. Siva Sankar Reddy. D Rupesh Kumar, and H. Sadursana Rao (2010) "A study on strength characteristics of Phosphogypsum concrete". The paper deals with experimental investigation on compressive, tensile and flexural strength characteristics of partially cement replaced phosphogypsum concrete using 0%, 10%, 20%, 30%, and 40% replacement with different water binder ratios of 0.40, 0.45, 0.50, 0.55, 0.60, 0.65. Upto 10% replacement of phosphogypsum provided increase in flexural and compressive strength.

S. R. Satone and Rasika P. Akhare (2014) "An experimental investigation on use of phosphogypsum and marble powder for making green concrete". Phosphogypsum of 5%, 10% and 15% and marble powder of 25% replacement with cement by weight was used. By replacing; 5% of phosphogypsum and 25% of marble powder resulted in the increase of the split tensile strength by 10.83%, 12.18% decrease in the compressive strength and 27.58% decrease in the flexural strength compared with conventional concrete at 28 days. Also, workability increased with increase in marble powder and phosphogypsum.

Mohammad Shahid Arshad and Dr. P.Y. Pawade (2014) "Reuse of natural waste material for making light weight bricks". Main objective of the work was to reduce the quantity of clay with natural waste material. Bricks were prepared of orange peels and coconut waste with varying composition of clay reduced the quantity of clay by (10% - 40% weight) and (10% - 60% weight). Bricks prepared by natural wastes were light weight, shock absorbing and meet the compressive strength requirements.

III. METHODOLOGY

A. *Materials used*

1) *Cement:* Cement of 53 Grade is used for the project work. Emami double bull Portland Pozzolana Cement (PPC); which is fly ash based and used as per IS 1489 (Part-1). It is obtained from Emami Cement Limited, Risda, Baloda Bazar,

Table 1. Physical Properties Of Cement

Name of Cement	Emami Double Bull Cement (Fly ash based)
Grade of Cement	53
Initial Setting Time	32 minutes
Final Setting Time	600 minutes
Standard Consistency	29.75 %
Specific Gravity	3.15

2) *Fine Aggregate:* Fine aggregate is determined as passing through 4.75mm IS sieve and retained on 0.075mm sieve. Fine aggregates are generally obtained from river beds. It is taken from Baloda bazar, Chhattisgarh.

3) *Coarse Aggregate:* Aggregates are used as a base material beneath the foundations, roads, etc. For the experimental work; aggregates of 40mm size are used. It is taken from Uma stone crusher, Baloda Bazar, Chhattisgarh.

4) *Surkhi:* Surkhi is the powdered form of burnt bricks which is available in the construction area as waste material. It makes concrete water proof and resistant to alkali and salt action as compared to those in which surkhi is not present. It is taken from Prakash traders, Supela, Bhilai, Chhattisgarh.

Table 2. PHYSICAL PROPERTIES OF SURKHI

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

5) *Phosphogypsum:* Phosphogypsum is a by-product obtained from the production of fertilizer from phosphate rock. Various applications of phosphogypsum is observed for 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
Colour	White
Specific gravity	2.3–2.6

6) *Water:* Water used for the mixing and curing purposes are free from any sort of impurities. It is taken from college campus.

B. Mix Design as Per is Code 10262:2009 & IS 456:2000

1) Grade of concrete = M30
2) Characteristic compressive strength at 28 days = 30 MPa
3) Type of Exposure = Moderate
4) Size of coarse aggregate used = 40mm
5) Cement Used = Emami double bull Portland Pozzolana Cement (Fly Ash Based)
6) Specific Gravity of cement = 3.15
7) Specific Gravity of water = 1.0
8) Specific Gravity of fine aggregate = 2.61
9) Specific Gravity of coarse aggregate = 2.64
10) Water Absorption of fine aggregate = 0.80
11) Water Absorption of coarse aggregate = 0.82
12) Admixture used = Surkhi and Phosphogypsum

Based on the properties of materials; design mix of M30 is calculated based on the procedure provided in IS 10262:2009 and IS 456:2000. Water-cement ratio of 0.45 is adopted. Ratio obtained is: 1: 1.3:3.72.

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

IV. TESTING AND RESULT

Firstly, water absorption test and specific gravity test of both fine aggregate as well as coarse aggregate is performed. Slump test and compaction factor test of concrete in fresh state were determined. Compressive strength test was performed and its average values obtained were noted after 7, 14 and 28 days. Flexural Strength test was performed to determine its strength in bending after 28 days.

Table 5. COMPRESSIVE STRENGTH VALUES

DAYS / SAMPLE	COMPRESSIVE STRENGTH IN N/mm^2		
	7 DAYS	14 DAYS	28 DAYS
A_0	19.03	28.34	39.33
A_1	14.59	22.20	30.80
A_2	16.15	17.32	23.90
A_3	20.20	26.92	30.20
A_4	21.30	31.12	42.35
A_5	19.76	26.56	36.16

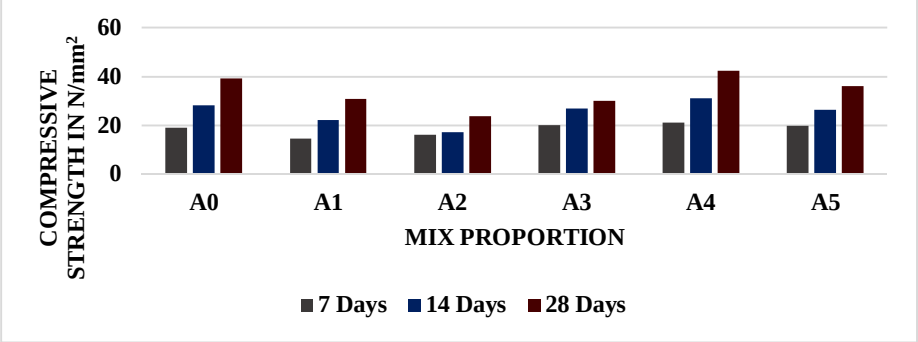

Chart 1. Compressive strength values represented in chart

Table 6. Flexural strength values

DAYS / SAMPLE	FLEXURAL STRENGTH IN N/mm^2 28 DAYS
B_0	5.18
B_1	3.31
B_2	3.92
B_3	4.32
B_4	5.20
B_5	4.10

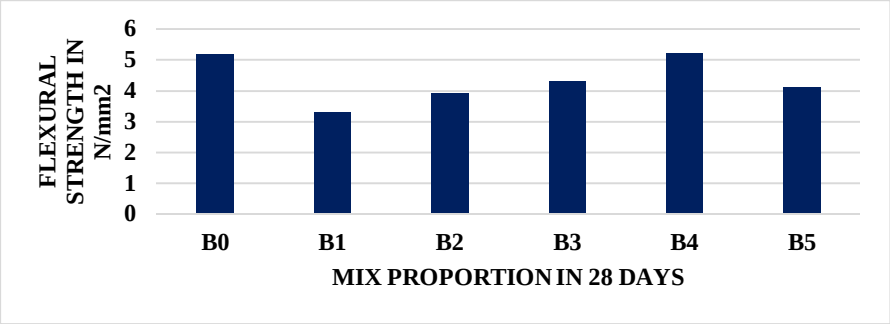

Chart 2. Flexural strength values represented in chart

V. CONCLUSION & FUTURE SCOPE

A. *Conclusion*

1) Phosphogypsum and Surkhi being an industrial waste, which are available in large quantity; imparts strength and hence, it can be used as the replacement material for fine aggregate to achieve economy.

2) The result obtained from the project is that after addition of surkhi of 20% and phosphogypsum of 12% by weight of fine aggregate; the compressive strength values reached the normal M30 grade strength, and after addition of percentages of surkhi and phosphogypsum its strength reduced.

3) Both the waste materials are available easily and it reduces the cost of fine aggregate.

4) The flexural strength increased when the percentage of Surkhi and Phosphogypsum was 20% and 12%. Later on, by increasing the percentage, the strength values decreased.

5) At 32% replacement of fine aggregate the maximum flexural strength was achieved.

6) Actual percentage of fine aggregate in total used was 68%, in which maximum compressive strength and flexural strength was obtained.

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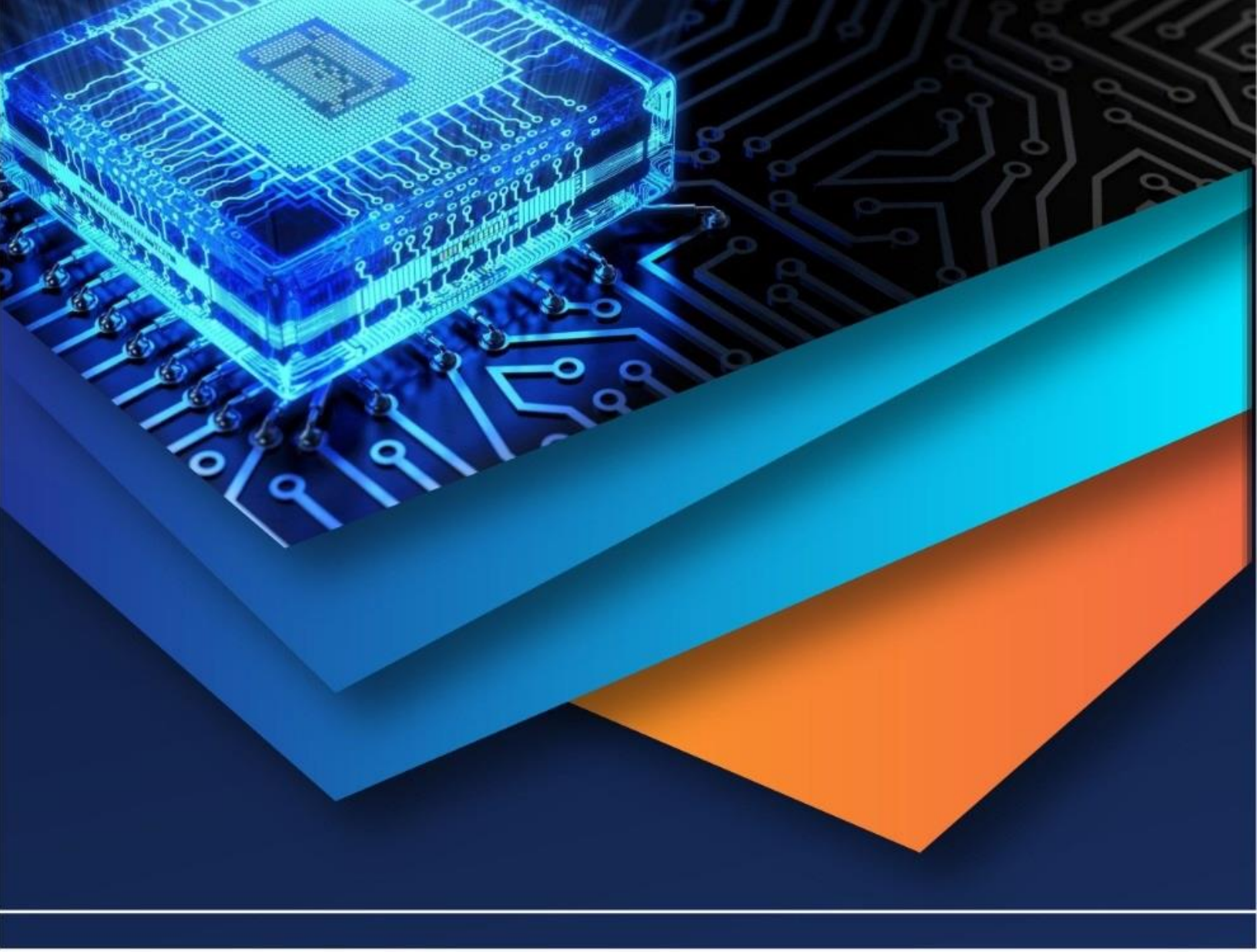

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