THE EFFECTS OF REPLACING CEMENT IN CEMENT CONCRETE WITH VARYING AMOUNTS OF PHOSPHOGYPSUM WERE EXAMINED IN AN EXPERIMENTAL INVESTIGATION

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Abstract - Naturally available sand is most important component of concrete, currently it's very much costly due to over population or increasing infrastructure projects or in large scale depletion of naturally available resources creating ecological issues. For neglecting this problem we require alternative or efficient resources in construction industry. Quarry Dust is obtained by the process of quarrying; it's used as a filling materials and Metallic dust is a by-product of carbon steel which is obtained from industry. The demand of sand is increasing day by day in developing countries. So serious problem for thousands of workers labors and civil engineers has been arise due shortage of sand for construction. The construction industries one of the largest industries in the world, and sand is a crucial contributor in everything to do with construction materials. More than 50 billion tons of sand is used in construction globally. In this Thesis work sand is half replaced by Mild Steel Scrap or Quarry Dust. This Thesis is about the experimental study on Strength of Concrete of M_{20} Grade with half substitute of Sand by Mild steel Scrap and Quarry Dust. For the Analysis of Mechanical Properties of Concrete like Compressive Strengthening and Split Tensile Strengthening etc. different types of concrete mix prepared. In earlier stage sand has been differentially replaced by 5% of Mild Steel Scrap or Quarry Dust having 10%, 15%, 20%, 25%, 30% partial replacement. In second stage sand has been differentially replaced by Mild Steel Scrap proportion of 10%, 15%, 20%, 25%, 30% and Quarry Dust by 40%, 35%, 30%, 25% and 20% partial replacement. I had also done various trial of mix, control mix etc. Compressive Strength test was done on mould size cube 150 mm x150mm x 150mm for 7th or 28th days and Split Tensile Strength is also done by UTM machine. The entire concrete cube specimen was cured for 7^{th} or 28^{th} days in deep water tank on standard temperature of 27ºC. This experiment results indicated considerable Increasing in the Strength of Concrete with addition of Mild Steel Scrap and Quarry Dust up to 40 percentage replacement of sand and after further increases the % of Mild Steel Scrap and Quarry Dust, a drop in strength of concrete was noted. This thesis study shows Compressive Strengthening and Split Tensile Strengthening of different Mixes of group I and group II.

***Key Words*:** Cube Compressive Strength, Mix Design, Mild Steel Scrap, Workability, Quarry Dust, metallic dust, Split Strength, UTM.

1.INTRODUCTION

Traditionally materials like clay, sand, stone, gravels, cement, brick, block, tiles, distemper, paint, timber and steel are being used as major building components in construction sector. All these materials have been produced from the existing natural resources and will have intrinsic distinctiveness for damaging the environment due to their continuous exploitation. The cost of construction materials is increasing incrementally. In India the cost of cement during 1995 was Rs. 1.25/kg and in 2015 the price increased five times. In case of bricks the price was Rs. 0.66 per brick in 1995 and the present rate is Rs. 7 per brick. Similarly, over a period of 20 years from the year 1995 the price of sand has increased five times. Also due to high transportation costs of these raw materials, demand, environmental restrictions, it is essential to find functional substitutes for conventional building materials in the construction industry. In India, about 6 MT of waste gypsum such as phosphor-gypsum, fluro-gypsum etc., are being generated annually there for it is necessary to set a secondary industries and recycling these waste into useful material. About twelve fertilizer plants in the country produce nearly 4 to 5 million tons of Phosphogypsum as a by-product. While some quantities are utilized for production of ammonium sulphate and few other uses, there are accumulated stocks of more than 10 million metric tons of Phosphogypsum at various plant sites. Major producers are Coromandel Fertilisers (Andhra Pradesh), Fertilisers & Chemicals, Travancore (Kerala), Gujarat State Fertilizer Co. (Gujarat), Hindustan Lever Ltd. (West Bengal), Southern Petrochemical Industries Corporation (Tamil Nadu) & Paradeep Phosphates Ltd. (Orissa). Disposal of Phosphogypsum is not only a serious techno-economic problem but creates environmental pollution and requires large land area for dumping. So by using Gypsum as a building material problem of dumping waste can be solved in eco friendly manner. Gypsum has been in use since ancient times. First known use of Gypsum dates back to 3700 BC in Egypt for the construction of Pyramids. In modern times with the help of advancement in technology for calcining of gypsum and various innovative production processes a range of gypsum based products and construction applications have been developed. These technologies have shown potential for commercialization and wide spread adoption in building materials production and variety of civil works.

2. Phospho-gypsum

It's also called blue metal, cracker, or rock dust, it's a material which is obtained by crushed rock. These are run down from crusher, small particles and dust left behind. Instead of thrown down this waste material, the dust is recycled and becomes a valuable product having so many practical applications in both commercial construction and home projects.
Rocky dust contains fine and gritty pieces of rock and dust, practically it has more dust than gritty pieces. And it's a natural product, so we can see this material in various shapes and sizes.

AIM AND OBJECTIVES

The experimental evaluation of the compressive, tensile, and flexural strength properties of partly cement replaced phosphogypsum concrete employing percentages of 0%, 10%, 20%, 30%, and 40% replacement with various water-binder ratios of 0.40, 0.45, and 0.50 is the subject of the current paper. By casting and testing 225 specimens—including 135 cubes, 45 cylinders, and 45 beams—for 7, 28, and 90 days, the strength properties are examined. It has been demonstrated that Portland cement can be partially replaced with phosphogypsum to create a good, hardened concrete that is economical; however, replacing more than 10% of the cement in concrete with phosphogypsum causes a drastic reduction in both the compressive strength and split-tensile strength. Additionally, the flexural strength decreases as the width and number of cracks significantly increase when replacing more than 10% of the cement with phosphogypsum at various water binder ratios.

RESEARCH METHODOLOGY

Experimental analysis done on concrete mix by using various percentage of replacement of phosphor-gypsum with cement at different water binder ratios.

Three separate group of concrete mixes were prepared-

- In the first group, experimental research was conducted on the compressive, tensile, and flexural strength properties of partly cement-replaced phosphogypsum concrete utilising replacement rates of 0%, 10%, 20%, 30%, and 40% with 0.40 water-binder ratios.
- In the second group, an experimental study was conducted on the compressive, tensile, and flexural strength properties of partly cement-replaced phosphor-gypsum concrete utilising replacement rates of 0%, 10%, 20%, 30%, and 40% with 0.45 water-binder ratios.
- In the third group, an experimental study was conducted on the compressive, tensile, and flexural strength properties of partly cement-replaced phosphor-gypsum concrete utilising replacement rates of 0%, 10%, 20%, 30%, and 40% with 0.50 water-binder ratios.

To obtain the research objectives, following work are to be carried out in the thesis collecting the required information related to the use of Mild Steel Scrap and Quarry Dust in concrete.

- Undertaking a detailed literature reviews on the usage of phosphor-gypsum in concrete.
- Developing a proper experimental program to study the use of phosphor-gypsum in concrete.
- To draw conclusions, analyzing the experimental output test results Future Scope of Work and references.

LITERATURE REVIEW

Chang, Chin and Ho published state of art report on phosphogypsum for secondary road construction. It was concluded phosphogypsum when subjected to compaction could be transformed into a solid of valuable strength. It could be used very effectively as binder to stabilized soil, replace shell or clay in secondary road and aggregate and water. A base course was built by spreading 5 inch of loose phosphogypsum on existing soil, over which the concrete was laid. This pavement was tested for abrasion, durability, shrinkage, compensation, onsite deflection and radiation monitoring. The project demonstrated that PG based RCC was suitable for construction of parking facilities. construction of building using Rapid wall panels is prepared by IIT Madras to suit Indian situation. ***RCF (Rashtriya Chemical and Fertilizers)*** is a PSU of Government of India's undertaken setting their plant at Chembur to meet the huge demand of Mumbai market.

Dr. Manjit Singh carried out research and shown that gypsum produced from Phophogypsum can used for making blocks and boards suitable for internal partition wall and in false ceiling works. Blocks of different densities (900-1100 kg/m3) have been prepared by adjusting the consistency of slurry. Fibrous gypsum plaster board have also been prepared from gypsum slurry and reinforced with sisal/coir/jute fibre. A process for manufacturing of board of size 120×60×12mm has been developed. a high strength hemihydrates plaster(a-plaster) has been developed from the beneficiated Phosphogypsum using autoclave process. Recently cementitious binder has been produced using a-plaster for use in boards, blocks, masonry, plastering works etc. A review also shows that water resistant gypsum binder has been developed by blending ground granulated blast furnace slag or fly ash, opc and chemical additive with calcined phosphogypsum. Phosphogypsum has been used for glass reinforced gypsum binder boards (GRGB) of dimensions 400×750mm by reinforcing E-type of glass fibers in gypsum binder matrix by suction process. These boards are recommended for partial replacement of depleting timber in view of their wood like properties. The phosphogypsum binder has been found suitable for making masonry mortars of properties: mix 1:4(binder: sand) compressive strength 3.5-4.5 MPa bond strength 0.017- 0.018 N/mm2 and water retentivity

65-67%.higher water retentivity implies superior workability of mortar.

Foxworthy, Ott and Seals utilized phosphor-gypsum based slag aggregate in Portland cement concrete mixtures. The durability behaviour of such aggregate was explored. The entire preliminary tests on phosphor-gypsum were performed. The concrete mix including phosphor-gypsum slag aggregate was created and evaluated for compressive strength, flexural strength, and splitting tensile strength. In cement concrete, the slag aggregate functioned well as a coarse aggregate, and the results suggested that it would work well in a highway pavement system as well.

Koduru. Srinivasalu(march 2017): The focus of this work is an experimental investigation of the compressive strength, a long-lasting feature of hardened concrete. Finding the phosphogypsum content that will provide concrete the highest strength is the study's main objective. For concrete grades M20, M25, and M30, the experiment tests concrete with replacement amounts of 0%, 2.5%, 5%, 7.5%, and 10% of phosphogypsum. It has been noticed that phosphogypsum can be utilized to make concrete that is too strong and hardened for commercial use when used in place of cement.

Mahesh A Bagade and S.R.Satone: The strength growth of calcified goods is found to be impaired by an industrial waste, such as phosphor-gypsum, in this paper. As a result, it can be used in the construction sector to increase efficiency. The slurry that has 5% phosphor-gypsum in place of cement has nearly the same 391 | P a g e standards of normal consistency. In this study, it is noted that the author substituted phosphor-gypsum for cement in the proportions of 0%, 5%, 10%, and 15% for mix design M25 grade concrete, respectively, and discovered that the compressive strength at day 28 of curing was 25.51, 28.59, 30.15, and 21.35 N/mm2. As a result, it has been found that when 5% to 10% of the cement is replaced with phosphogypsum, concrete's compressive strength increases, however when more than 10% is replaced, concrete's compressive strength is compromised. At the 28th day of curing, 2100 psi of compressive strength for 35% phosphogypsum, 16.25% lime, and 60% fly ash were discovered, and 2360 psi for 20% phosphogypsum, 20% lime, and 60% fly ash. The compressive strength of 13.33% lime and 66.67% fly ash for 20% phosphogypsum was determined to be 2980 psi. However, it is revealed in this publication that experiments were carried out to see if phosphogypsum might substitute sand in cement mortar. If phosphogypsum were to generate a robust, hard substance when combined with cement kiln dust or silica powder, the resulting blend would have a compressive strength of 420 psi after 28 days of curing. Also, 1590 psi of compressive strength are produced by 65% phosphogypsum, 24% type two cement, and 11% water.

Mahesh a. Bagade, s. R. Satone(july 2012) : 10%, 15%, and 20% of the cement was substituted with phosphogypsum, with a replacement water binder ratio of 0.40. To create good, hardened concrete and achieve economy, phosphogypsum can be used in place of some Portland cement. Although it significantly slows down setting time, phosphogypsum does not contribute to the creation of cement paste that is unstable. It shows that phosphogypsum concrete is employed in mass concrete work when the compressive strength of the mixture increases by 5% and 10%.

Nanni and Chang reported application of phosphogypsum was investigated as an aggregate in construction of various Roller Compacted Concrete (RCC) slabs. Several phosphor-gypsum based mixtures were prepared in three different mixing procedures and were compacted using suitable vibrator. A thickness design procedure of this concrete pavement was also suggested. The project indicated that phosphogypsum based RCC was suitable for pavement construction applications. Moreover, phosphogypsum was suitable, as it provide set retardation and drying shrinkage compensation.

Nanni produced bench model phosphogypsum bricks of size 45 X 95 X 203 mm with semi automatic press having a capacity of 1780 kN. The bricks thus produced were handled immediately after fabrication. The bricks were found good in appearance and strength.

Nurhayat Degirmenci in his research waste phosphogypsum (PG) and natural gypsum were used as stabilization material to improve the properties of adobe soil and to reduce its disadvantages at least partially. The compressive and flexural strength, softening in water, drying shrinkage and unit weight values were determined on adobe samples. The strength values of adobe samples increased with both gypsum additions. The most resistance of the adobe samples against softening in water was obtained with 25% PG addition. Drying shrinkage of test samples reduced with increasing PG content. The dry unit weight of the specimens was not in the recommended range specified in the standards. Test results showed that PG can be used as alternative material in adobe stabilization to bring economy and to reduce environmental pollution. Adobe is one of the oldest and most widely used building materials in the world. Adobe, or as it is called in Turkey ‘‘kerpic’’, has been a traditional construction material especially in rural regions because of its simplicity and low cost. In addition to these, adobe construction has other advantages as well, such as good thermal and acoustical properties. Adobe also is an ecological building material as it uses natural elements. At the end of a building’s life, adobe can easily be reused by grinding and wetting or returned to the ground without any interference with the environment.

Ong, Metcalf, Seals and Taha studied unconfined compressive strength of various cement stabilized Phospho-gypsum (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 phosphor-gypsum could be stabilized with cement to produce an adequate material for road base construction to the requirement of the local codes.

Ouyang, Nanni and Chang studied sulphate attack resistance of Portland cement mixture containing phosphogypsum and conventional aggregate. A wide range of SO3 and C3A contents were investigated with respect to linear expansion and compressive strength development for specimen submerged in fresh and seawater. The cement contents were varied between 10% - 30% by weight, whereas phosphogypsum varied from 0 – 50%, lime rock aggregate was used. The results indicated that, the optimum C3A content, which corresponds to minimum expansion, is about 1.1% for Portland cement having C3A content less than 7%. And phosphogypsum contents directly proportional to

Properties	Value
Grade of Cement	OPC (53 grade)
Sp. gravity of cement	3.05
Initial setting time	(35 minutes) Not least than 30 min
Final setting time	(190 minutes) Not least than 60 min
Normal Consistency	29.5%
fineness	6 %
Soundness	1

expansion in cement mixes. Seawater immersion decreases the strength development rate of cylinders and increases linear expansion of bars.

Rapid Building System Pvt. Ltd. An Australian building industry for a decade where it is called Rapid wall. Shown that in there broacher until 2001 more than 3000 dwellings have been built out of Rapid wall panels across Australia. Rapid wall technology was introduced to Malaysia in 1997. It has also been exported to China since 2001 to satisfy the demand for an alternative residential walling product to replace clay bricks. The use of clay bricks is being outlawed by the Chinese authorities as an environmental protection measure, which has resulted in an unprecedented interest in Rapid wall panels. Rapid wall panels have undergone testing by Indian authorities and are presently imported to India to satisfy the need for a cost-effective, easy to construct and environment friendly solution to their housing crisis. Rapid wall panels are Australian developed and manufactured walling product used in building industry to provide habitable enclosures for residential, commercial and industrial buildings. Now in India method of

Roy, Kalvakaalava and Seals were studied micro structural mand phase characteristics of phosphogypsum cement mixtures. The effect of tricalcium aluminate (C3A) content of the stabilizing cement (with two different C3A percentage), curing time (7, 28, 45 and 90 days), proportion of phosphogypsum (5% to 60%), grain size, impurities in phosphogypsum on microstructure (SEM) and phase properties of mix was studied. Derivative thermogravitimetric analysis (DTA) was used in this study for hydrated products of these mixes. The study was concluded the addition of phosphogypsum to Portland cement produced large amount of ettringite. Phosphogypsum increased the degree of hydration of cement in the mixtures in the long term. The amount of carbonation in phosphogypsum based mixture was found relatively low.

S. Deepak, c. Ramesh(march 2016) : The effect of replacing cement by phosphor-gypsum at two different water-cement ratios (0.4 and 0.5) of 10%, 20%, and replacement on the strength characteristic, namely split tensile strength and flexural test of beam increases 28 days, is examined in this article.

S. Kumar investigated the physical and mechanical propertiesm of FALG bricks and hollow blocks by using different proportions of fly ash, lime and gypsum. The durability of these blocks was also investigated. It was concluded that these blocks were sufficient strength for their use in load bearing walls.

MATERIALS USED

Cement

Table: Properties of cement

Fine Aggregate

Table: Properties of F.A.

Properties	Value
Specific Gravity	2.69
Fineness Modulus	2.9
Water absorption	0.6%

Coarse Aggregate

Table :Properties of C.A.

Properties	Values
Specific Gravity	2.72
Size of Aggregate	20 mm
Fineness Modulus	2.9
Water absorption	0.219
Aggregate Impact value	15.2%
Aggregate Crushing value	22.5%

Phosphogypsum

Table: Chemical Properties of Phosphogypsum

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

MIX PROPORTIONING OF CONCRETE INGREDIENTS

To set the percentage of aggregate in concrete, All-In aggregate grading for 20mm nominal size aggregate was employed in accordance with BIS 383:1970 standards. Trial and error was used to determine the proper proportions of 20mm nominal size aggregate, 10mm nominal size aggregate, and natural sand in the concrete. A constant proportion of 20 mm nominal size aggregate, 10 mm nominal size aggregate, and natural sand was used to compute the quantities of coarse aggregate and fine aggregate at the time of mix design. based on this all-in aggregate grading.

Concrete mix design followed IS 10262:2009 guidelines. The control concrete's grade was set at M30, and the desired slump was 100mm. We considered the exposure conditions to be moderate. According to the IS 10262:2009 process, the target strength was first estimated using an appropriate standard deviation value. According to the target strength of the concrete to be achieved, the estimated water content was calculated for the required workability, and the free w/c ratio was selected based on experience. The cement content was computed using the expected water content and free w/c ratio. The quantity of coarse and fine aggregate was determined based on the volume of aggregate in concrete, and the proportion was fixed in accordance with all-in aggregate grading. The SSD (Saturated Surface Dry) condition was used to compute the quantities of coarse and fine aggregate. Accordingly, based on the moisture content of the coarse aggregate and fine aggregate at the moment of casting, any necessary water corrections must be made.

Concrete mixes containing sandstone quarry dust were determined based on the proportions of the various constituents in control concrete. Concrete mixtures of 10%, 20%, 30%, 40%, and 50% quarry dust in place of natural sand were referred to as QD10, QD20, QD30, QD40, and QD50, respectively.

MIXING OF INGREDIENTS AND CASTING OF SAMPLES

Quantities of Ingredients Quantities of ingredients for concrete mix are calculated by absolute volume method conforming to IS 10262-1982. In this method, the absolute volume of the fully compacted concrete mixed freshly is equal to the sum of the absolute volumes of all the ingredients. The final quantities of these ingredients for 0%, 10%, 20%, 30% and 40% replacement of phosphogypsum with lower water-binder ratios of 0.40, 0.45 and 0.50 are arrived at. The strength characteristics are studied by casting and testing nine cubes of 150 mm side, three cylinders of 150 mm diameter and 300 mm height, and three beams of 100mm×100mm×500mm in case of each water-binder ratio with a particular percentage replacement of phosphogypsum. The final quantities with 5% extra (i.e. total volume 0.064575 m3), for example, for 10% replacement of phosphogypsum with lower water binder ratio of 0.40 are: cement – 31.3 kg, phosphogypsum – 3.5 kg, water – 14.2 liters, coarse aggregate – 64.0 kg, and fine aggregate – 42.7 kg respectively.

Preparation of materials Before the results were started, all items were brought to room temperature. When the cement paste arrived at the lab, it was mixed dry by hand to ensure the best possible blending and consistency, to remove any dangerous particles, and to ensure that proper maintenance was carried out. Cement was kept in a dry location.

2.RESULT AND DISCUSSION

SLUMP TEST

Slump of 0.40 water cement ratio

Table: slump value of 0.40 water cement ratio

S.No.	Mixes	Cement %	Phosphogypsum %	Slump(mm)
1	Mix1	100	0	21
2	Mix2	95	5	31
3	Mix3	90	10	52
4	Mix4	85	15	63
5	Mix5	80	20	28

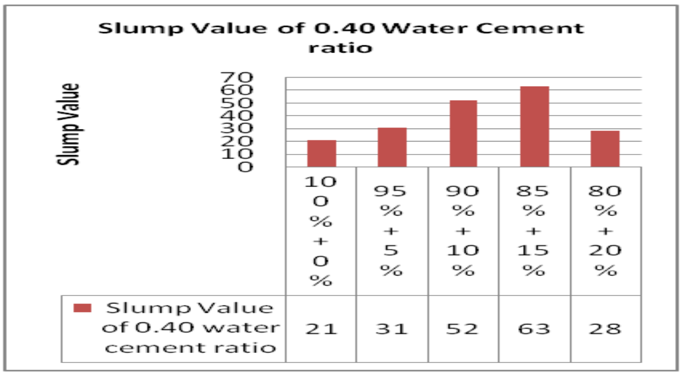
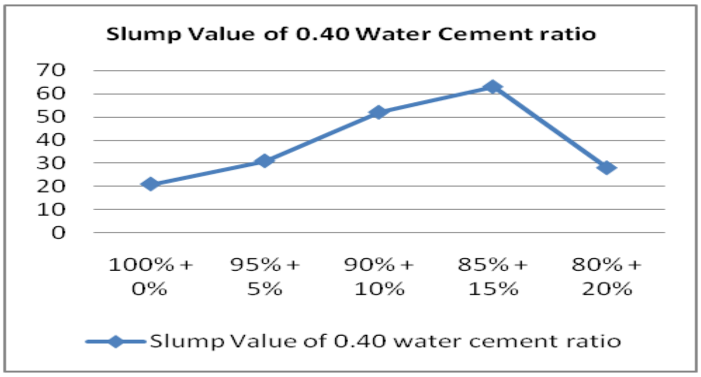


Fig.:Variation in slump of 0.40 Water Cement ratio



Graph :Variation in slump of 0.40 Water Cement ratio

Slump of 0.45 Water Cement ratio

Table: slump value of 0.45 Water Cement ratio

S.No.	Mixes	Cement %	Phosphogypsum %	Slump(mm)
1	Mix1	100	0	45
2	Mix2	95	5	54
3	Mix3	90	10	64
4	Mix4	85	15	85
5	Mix5	80	20	46

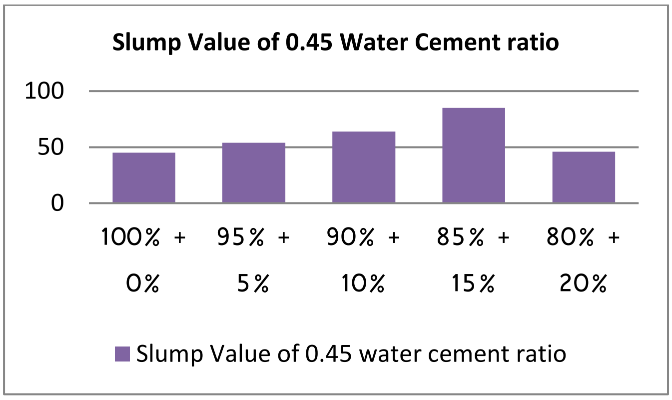
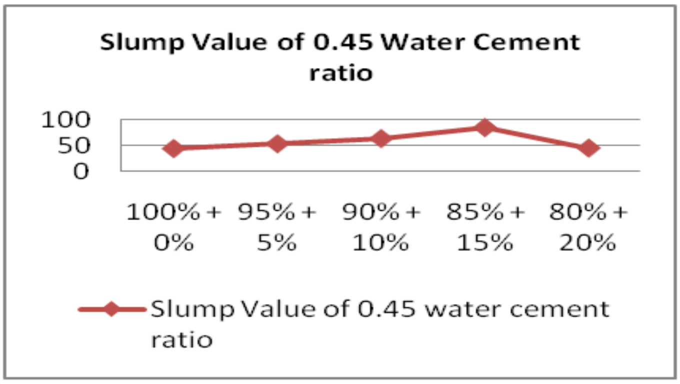


Fig.:Variation in slump of 0.45 Water Cement ratio



Graph: Variation in slump of 0.45 Water Cement ratioSlump of 0.50 Water Cement ratio

Table: slump value of 0.50 Water Cement ratio

S.No.	Mixes	Cement %	Phosphogypsum %	Slump(mm)
1	Mix1	100	0	95
2	Mix2	95	5	106
3	Mix3	90	10	125
4	Mix4	85	15	134
5	Mix5	80	20	101

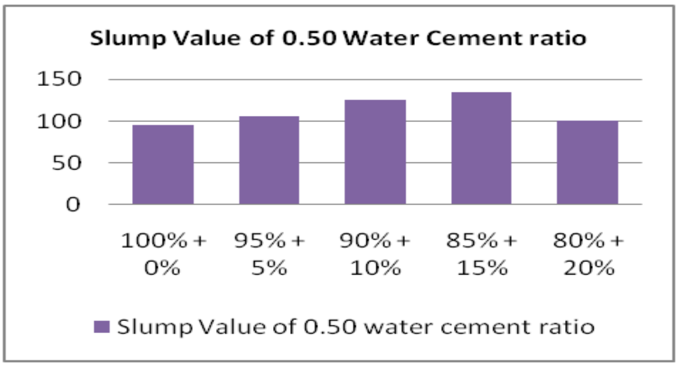
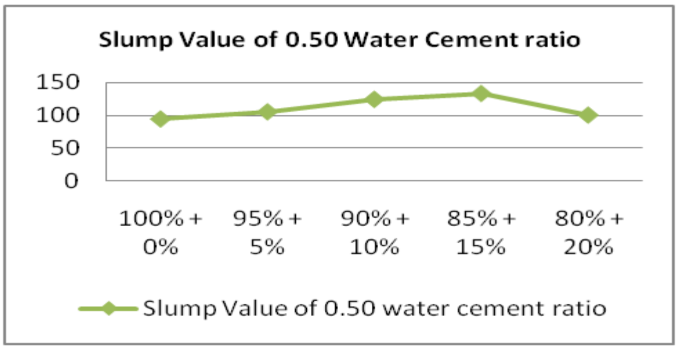


Fig.:Variation in slump of 0.50 Water Cement ratio



Graph: Variation in slump of 0.50 Water Cement ratio

COMPRESSIVE STRENGTH

Table 4.4 Compressive Strength of 0.40 water cement ratio

S.No.	Mixes	Cement %	Phospho-gypsum %	Compressive Strength		
				7th Days	28th Days	90th Days
1	Mix 1	100	0	31.50	47.80	48.90
2	Mix 2	95	5	32.20	48.30	52.0
3	Mix 3	90	10	29.70	42.70	45.80
4	Mix 4	85	15	23.00	30.20	34.40
5	Mix 5	80	20	15.00	15.50	17.30

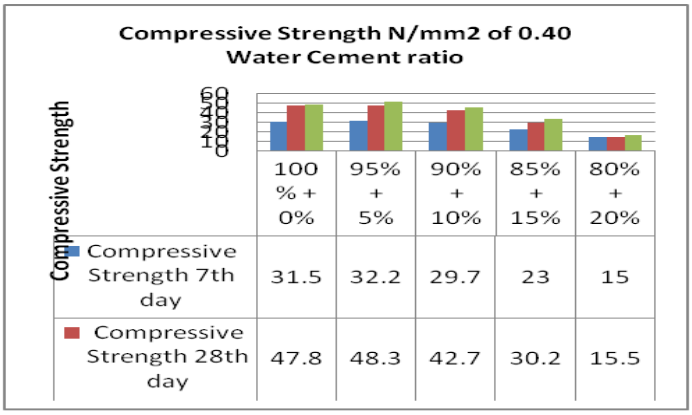


Fig.: Compressive strength of 0.40 Water Cement ratio

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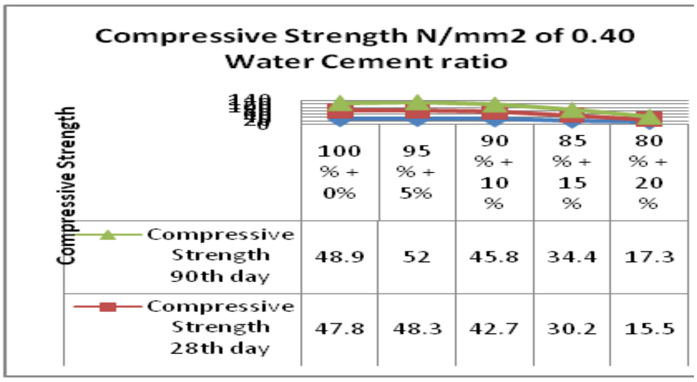
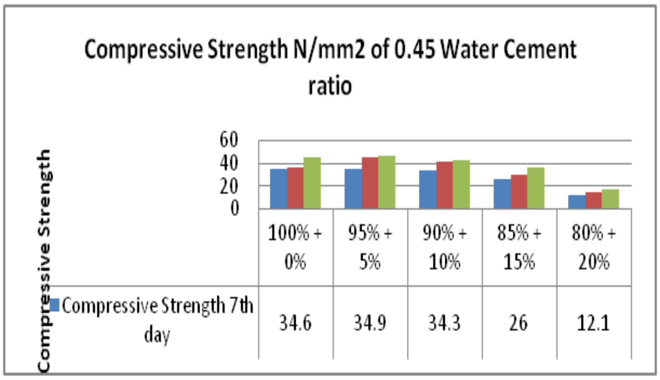


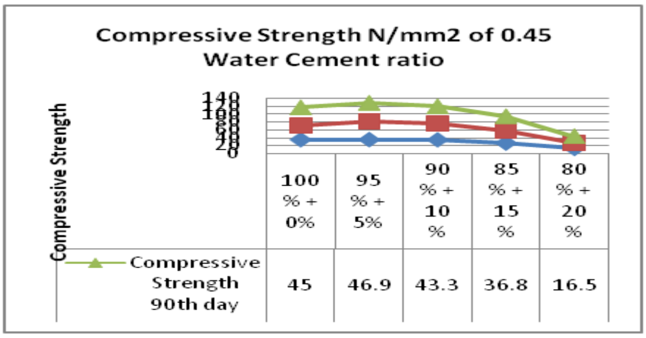
Graph:Compressive Strength of 0.40 Water Cement ratio

Compressive Strength of 0.45 Water Cement ratio

Table:Compressive Strength of 0.45 water cement ratio

S. No.	Mixes	Cement %	Phospho-gypsum %	Compressive Strength		
				7th Days	28th Days	90th Days
1	Mix 1	100	0	34.60	36.80	45.00
2	Mix 2	95	5	34.90	46.10	46.90
3	Mix 3	90	10	34.30	41.70	43.30
4	Mix 4	85	15	26.00	30.60	36.80
5	Mix 5	80	20	12.10	14.30	16.50





Graph: Compressive Strength of 0.45 Water Cement ratio

Compressive Strength of 0.50 Water Cement ratio

Table 4.6 Compressive Strength of 0.50 water cement ratio

S.No.	Mixes	Cement %	Phospho-gypsum %	Compressive Strength		
				7th Days	28th Days	90th Days
1	Mix 1	100	0	27.00	33.80	40.30
2	Mix 2	95	5	32.50	35.00	41.20
3	Mix 3	90	10	29.80	32.70	36.20
4	Mix 4	85	15	22.50	28.40	30.50
5	Mix 5	80	20	7.60	8.30	11.20

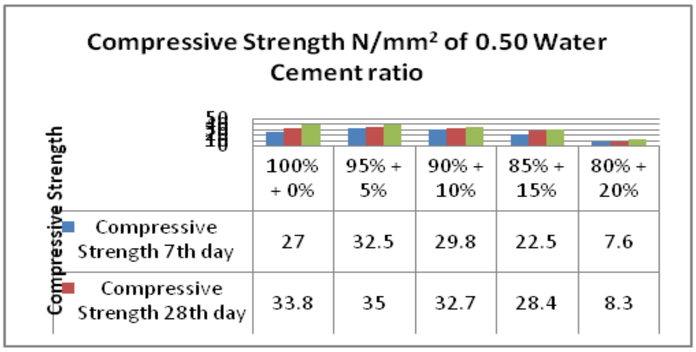
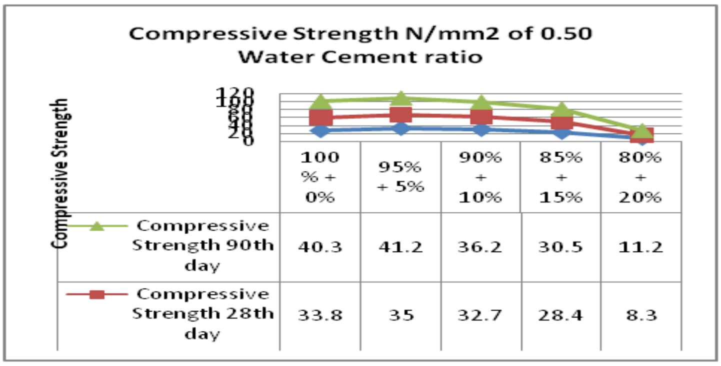


Fig.:Compressive strength of 0.50 Water Cement ratio



Graph:Compressive Strength of 0.50 Water Cement ratio

SPLIT TENSILE STRENGTH TEST

Split cylinder test of 0.40 Water Cement ratio

Table:Value of Split Tensile Strength of 0.40 Water Cement ratio in 28th Days

S.No.	Mixes	Cement %	Phospho-gypsum %	Split Tensile Strength 28th Days
1	Mix1	100	0	3.60
2	Mix2	95	5	3.95
3	Mix3	90	10	3.40
4	Mix4	85	15	2.76
5	Mix5	80	20	2.44

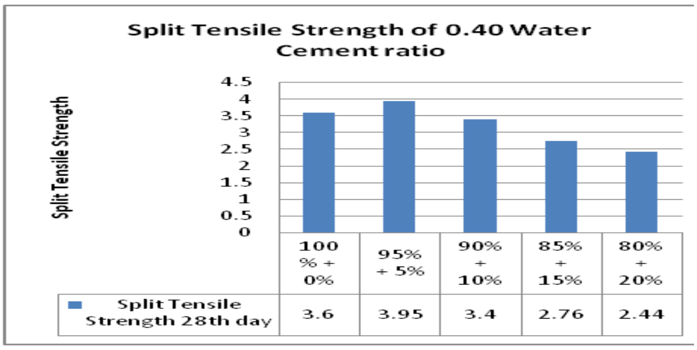
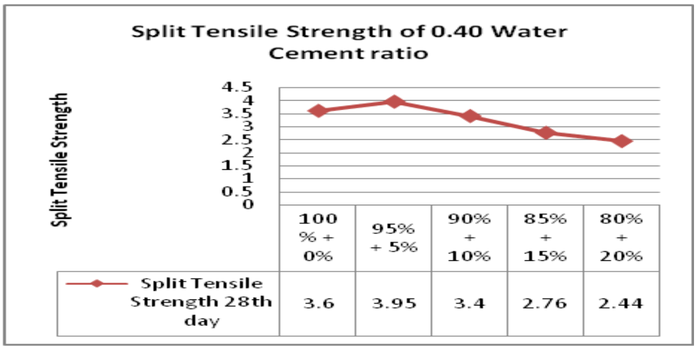


Fig:Variation in Split Tensile Strength of 0.40 Water Cement ratio in 28th Days



Graph:Variation in Split Tensile Strength of 0.40 Water Cement ratio in 28th Days

Split cylinder test of 0.45 Water Cement ratio

Table:Value of Split Tensile Strength of 0.45 Water Cement ratio in 28th Days

S.No.	Mixes	Cement %	Phospho-gypsum %	Split Tensile Strength 28th Days
1	Mix1	100	0	3.80
2	Mix2	95	5	4.00
3	Mix3	90	10	3.45
4	Mix4	85	15	2.86
5	Mix5	80	20	2.30

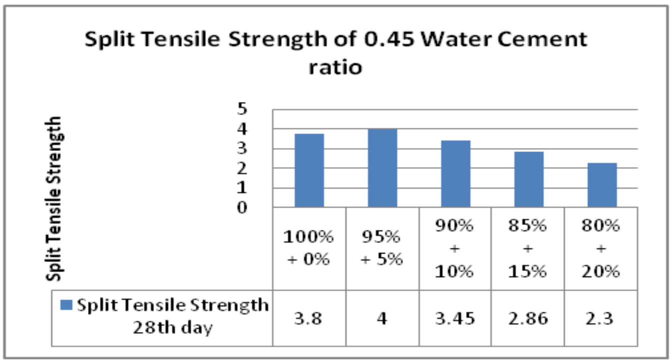
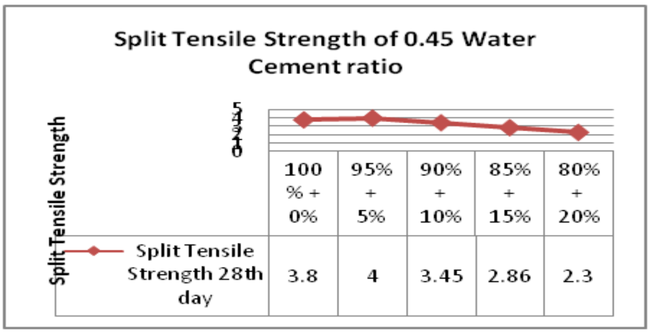


Fig.:Variation in Split Tensile Strength of 0.45 Water Cement ratio in 28th Days



Graph:Variation in Split Tensile Strength of 0.45 Water Cement ratio in 28th Days

Split cylinder test of 0.50 Water Cement ratio.

Table:Value of Split Tensile Strength of 0.50 Water Cement ratio in 28th Days

S.No.	Mixes	Cement %	Phospho-gypsum %	Split Tensile Strength 28th Days
1	Mix1	100	0	3.75
2	Mix2	95	5	4.05
3	Mix3	90	10	3.34
4	Mix4	85	15	2.82
5	Mix5	80	20	2.25

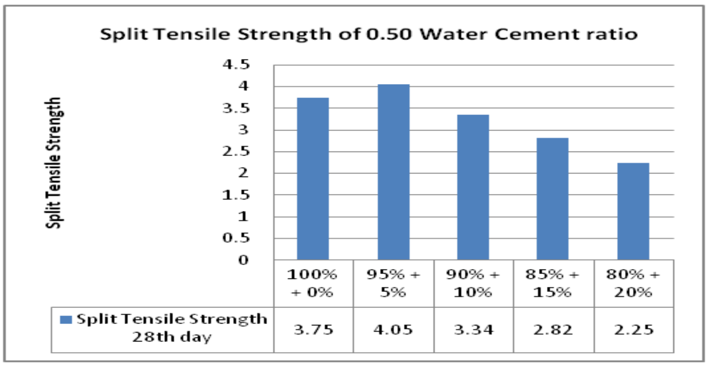
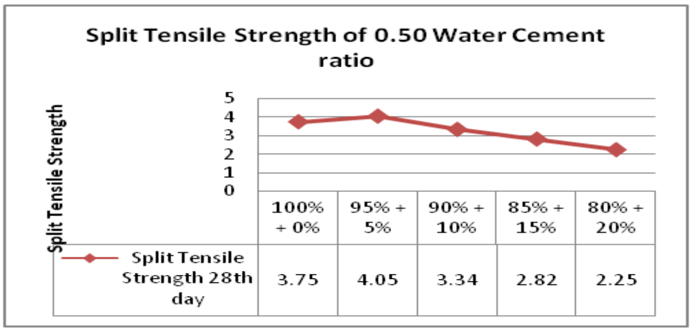


Fig.:Variation in Split Tensile Strength of 0.50 Water Cement ratio in 28th Days



Graph:Variation in Split Tensile Strength of 0.50 Water Cement ratio in 28th Days

FLEXURAL STRENGTH TEST

Flexural strength test of 0.40 Water Cement ratio

Table :Value of Flexural strength of 0.40 Water Cement ratio in 28th Days

S.No.	Mixes	Cement %	Phospho-gypsum %	Flexural strength 28th Days
1	Mix1	100	0	2.30
2	Mix2	95	5	2.30
3	Mix3	90	10	2.35
4	Mix4	85	15	1.50
5	Mix5	80	20	0.80

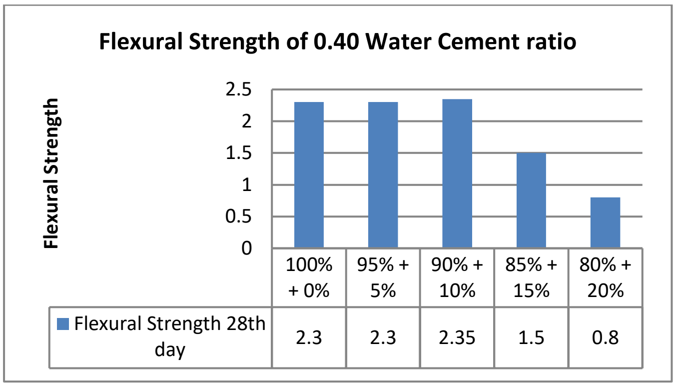
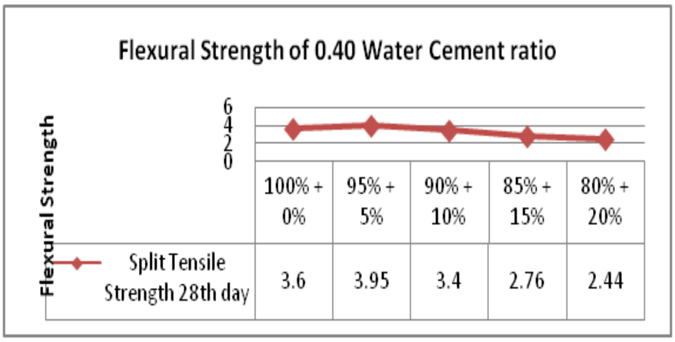


Fig.:Variation in Flexural Strength of 0.40 Water Cement ratio in 28th Days



Graph:Variation in Flexural Strength of 0.40 Water Cement ratio in 28th Days

Flexural strength test of 0.45 Water Cement ratio

Table:Value of Flexural strength of 0.45 Water Cement ratio in 28th Days

S.No.	Mixes	Cement %	Phospho-gypsum %	Flexural strength 28th Days
1	Mix 1	100	0	2.40
2	Mix 2	95	5	2.40
3	Mix 3	90	10	2.10
4	Mix 4	85	15	1.10
5	Mix 5	80	20	0.80

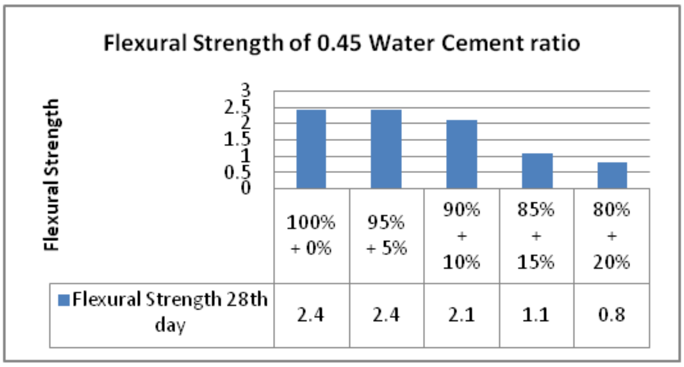
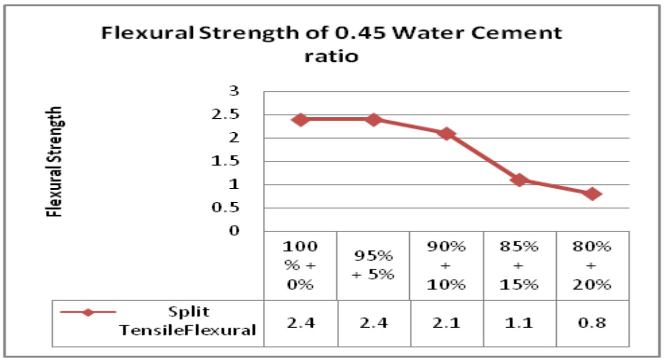


Fig.:Variation in Flexural Strength of 0.45 Water Cement ratio in 28th Days



Graph:Variation in Flexural Strength of 0.45 Water Cement ratio in 28th Days

Flexural strength test of 0.50 Water Cement ratio

Table:Value of Flexural strength of 0.50 Water Cement ratio in 28th Days

S.No.	Mixes	Cement %	Phospho-gypsum %	Flexural strength 28th Days
1	Mix1	100	0	2.70
2	Mix2	95	5	2.40
3	Mix3	90	10	2.20
4	Mix4	85	15	1.10
5	Mix5	80	20	0.80

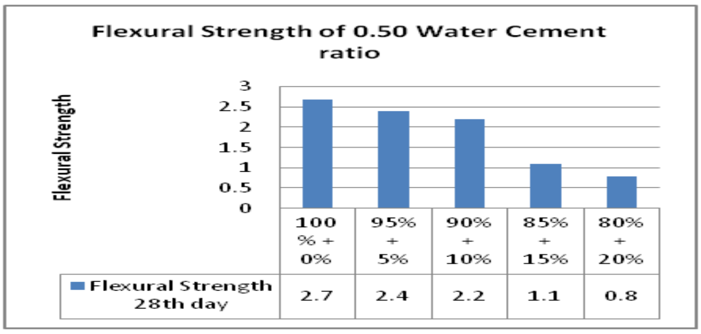
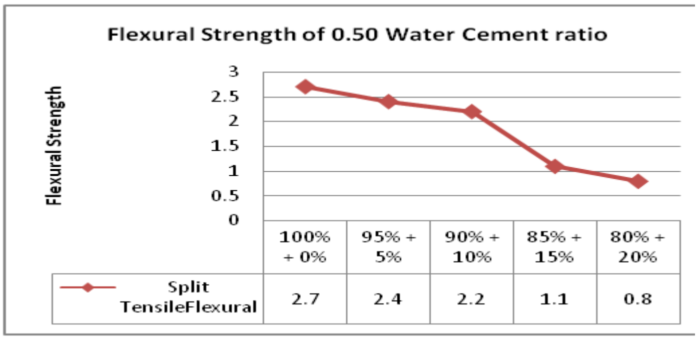


Fig.:Variation in Flexural Strength of 0.50 Water Cement ratio in 28th Days



Graph:Variation in Flexural Strength of 0.50 Water Cement ratio in 28th Days

3.CONCLUSIONS

Based on the limited experimental investigation conducted and the analysis of test results, the following conclusions are drawn.

In order to save money, phosphogypsum, an industrial waste that hinders the strength growth of calcined products, can be utilized in the construction sector to prepare concrete by partially substituting cement, a valuable component of concrete.

With 10% replacement of cement with phosphogypsum not only the compressive strength increased marginally/significantly with age but also the split-tensile strength at 28 days increased commendably in case of different water-binder ratios. However, further replacement of cement with phosphogypsum lead to drastic reduction not only in the compressive strength but in the split-tensile strength also.

The flexural strength not only decreased significantly with higher replacement of cement with phosphogypsum but with increase in water-binder ratio also. The width and number of cracks increased with the increase in replacement of phosphogypsum above 10%.

For preparations of 'standard concrete' with grade designations M 25, M 30, M 35 and M 40 (as per IS 456-2000) we can use any appropriate replacement of cement with phosphogypsum in the range of 10-30% with appropriate water-binder ratio of 0.40-0.50,

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