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Experimental Study of Mechanical Properties of Concrete with Stone Dust and Phosphogypsum

MD.MUSHARRUF QADEER[1], PARSINENI BALAKRISHNA[2]

[1]PG Scholar, Department of civil Engineering, Newton's Institute of Science and Technology, Macherla, Guntur, AP, India.

[2]Assistant Professor, Department of Civil Engineering, Newton's Institute of Science and Technology, Macherla, Guntur, AP, India.

Abstract: Stone dust a waste from the stone crushing unit accounts 25% of the final product from stone crushing unit. This Stone dust which is released directly into environment can cause environmental pollution. To reduce the impact of the Stone dust on environment and human, this waste can be used to produce new products or can be used as admixture in concrete so that the natural resources are used efficiently and hence environmental waste can be reduced. Here Stone dust is used for partial replacement of fine aggregate in concrete and gypsum is used for partial replacement of cement for studying the strength property of concrete. The aim of the experiment is to find the maximum content of stone dust partial replacement of fine aggregate and phosphogypsum partial replacement of cement in concrete. The percentages of stone dust partial replacement of fine aggregate in concrete are 10, 20%,30%,40% and 50% and phosphogypsum replacement of cement 5,% 10%, 15 %, 20%, and 25 % In M35, grade concrete cubes of 150x150x150mm size and cylinders of 150x300mm and beams 50x10x10cm were cast for conducting compressive strength, split tensile and flexural test.

Keywords: stone dust, phosphogypsum, compressive strength, split tensile strength, flexural strength.

1. INTRODUCTION

Concrete is an assemblage of cement, aggregate and water. The most commonly used fine aggregate is sand derived from river banks. The global consumption of natural sand is too high due to its extensive use in concrete. The demand for natural sand is quite high in developing countries owing to rapid infrastructural growth which results supply scarcity. Therefore, construction industries of developing countries are in stress to identify alternative materials to replace the demand for natural sand. On the other hand, the advantages of utilization of by products or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load & waste management cost, reduction of production Costas well as augmenting the quality of concrete. In this context, fine aggregate has been replaced by stone dust a by-product of stone crushing unit and few admixtures to find a comparative analysis for different parameters which are tested in the laboratories to find the suitability of the replacement adhered to the Indian Standard specifications for its strength. stone dust has been used for different activities in the construction industry such as road construction and manufacture of building materials such as light weight aggregates, bricks, and tiles. Crushed rock aggregates are more suitable for production of high strength concrete compared to natural gravel and sand. High percentage of dust in the aggregate increases the fineness and the total surface area of aggregate particles. The surface area is measured in terms of specific surface, i.e. the ratio of the total surface area of all the particles to their volume. The main objective is to provide more information about the effects of various proportion of dust content as partial replacement of crushed stone fine aggregate on workability, air content, compressive strength, tensile strength, absorption percentage of concrete.

2. LITERATURE REVIEW

T. SIVA SANKAR REDDY This paper deals with the experimental investigation on compressive tensile and flexural strength characteristics of partially cement replaced phosphogypsum concrete using 0%, 10%, 20% replacement with different water binder ratio 0.40, 0.45, 0.50. The strength characteristics are studied by casting and testing a cube for 7, 28 days. It is shown that the part of Portland cement can be replaced with phosphogypsum to develop well and harden concrete to achieve economy. Experimental investigation shows that on replacement of cement by phosphogypsum by 10% gives compressive strength 49.3 N/mm2 at 28th day of curing .Author found that the compressive strength at 7th day increased significantly around 20% at water binder ratio 0.5 and marginally around 10% increase of the water

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binder ratio. The split tensile strength at 28th day increased marginally around 3 to 10 % at different water binder ratio.

NADARGHAFOORI AND WEN F. CHANG In this paper experimental investigations states that, standard proctor value of dry density of phosphogypsum is 14.52 KN/m3 for compressive strength 1789.50Kpa and split tensile strength was found 165.40Kpa and for modified proctor test dry density of phosphogypsum was 15.17KN/m3. whereas compaction strength was found 2452.8 Kpa and split tensile strength was 227.40 Kpa and hence test results indicates that phosphogypsum is highly compressible material and its strength improves by increasing compaction energy and hence it is comparable to the compressive strength of good quality concrete. Experimental study also states that, the 28th day compressive strength of all compacted samples have shown considerable compressive strength considering the percentage level of cement in mixture, strength above 20.67 and 31.00 Mpa can be readily obtained by using 7.5% and 10% cement content respectively. The use of limited amount of phosphogypsum (20-25%) by weight of total solid appears to be beneficial for strength characteristics of phosphogypsum concrete. Test results obtained from strength versus time diagram indicates that the concrete mixture containing phosphogypsum continue to gain strength with curing age, if proper curing condition is provided.

(1996) T.S. NAGARAJ et al. reported that rock dust due to its higher surface area consumes more cement in comparison to sand which increases workability. He studied to effect of rock dust and pebble as aggregate in cement and concrete and found that crushed stone dust could be used to replace the natural sand in concrete. The mix design introduced by Nagaraj T.S reported that there are three possibilities of ensuring the workability namely combination of rock dust and sand, use of super plasticizers and change water content.

(1998) SHUKLA et al. investigated the behavior of concrete made by partial or full replacement of river sand by crushed stone dust as fine aggregate and reported that 40 percent sand can be replaced by crushed stone dust without effecting the strength of concrete.

(1999) HUDSON reported that, ‘‘concrete manufactured with a high percentage of minus 75 micron material will yield a more cohesive mix then concrete made with typical natural sand’’

3. MATERIALS PROPERTIES AND EXPERIMENTAL INVESTIGATION

3.1MATERIALS

Raw materials required for the concreting operations of the present work are stone dust, phosphogypsum, cement, fine aggregate, coarse aggregate and water.

3.2CEMENT

Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most non- specialty grout. Cement is the main ingredient in manufacturing of concrete. The characteristics of concrete will be greatly affected by changing the Cement content. The Cement used in this project is Ordinary Portland Cement of 53 grade confirming to IS 12269 – 2013.

S No	Properties	Values observed
1	Specific Gravity	3.15
2	Normal consistency	33%
3	Initial setting time	37 min
4	Final setting time	510 min
5	Soundness	7.3 mm

3.1 Physical properties of Ordinary Portland cement -53 Grade

3.3FINE AGGREGATE

Gradation refers to the particle size distribution of aggregates. Grading is a very important property of aggregate used for making concrete, in view of its packing of particles, resulting in the reduction of voids. This in turn influences the water demand and cement content of concrete.

Grading is described in terms of the cumulative percentages of weights passing a particular IS sieve. IS 383-1970

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specifies four ranges or zones for fine aggregate grading. Table gives the range of percentage passing for each zone.

S.No	Property	Result
1	Fineness Modulus	2.75
2	Specific Gravity	2.7

3.2 Physical properties of fine aggregates

3.4 COARSE AGGREGATE

The aggregate which is retained over IS Sieve 4.75 mm is termed as coarse aggregate.The normal maximum size is gradually 10-20 mm; however particle sizes up to 40 mm or more have been used in Self Compacting Concrete. Gap graded aggregates are frequently better than those continuously graded, which might expensive grader internal friction and give reduced flow

Locally available coarse aggregate having the maximum size of 20 mm and minimum size of 12.5 mm was used in this work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 383-1970.

S.No	Property	Result
1	Fineness Modulus	8.1
2	Specific Gravity	2.75

3.3 Physical properties of coarse aggregates

3.4PHOSPHOGYPSUM

Refers to the gypsum formed as a by-product of processing phosphate ore into fertilizer with sulphuric acid. Phosphogypsum can be gainfully utilized in cement and building materials industries. It needs beneficiation before use because of the presence of deleterious constituents like P2O5 and fluoride.

Major elements	**Percentage**
SO_3	50.2
CaO	44.7
F	1.56
Na_2O	1.16
Cl	0.72
P_2O_5	0.67
SiO_2	0.43
Al_3O_3	0.24
MgO	0.14
Fe_2O_3	0.07
SrO	0.07
Y_2O_3	0.02
LOI^b	21.2

3.4 chemical properties of phosphogypsum

Parameters	**Size**
Specific surface area(m2/g)	263
Specific pore volume(cm3/g)	0.31
Density (kg/m3)	682
pH (5% aqueous solution)	4.5
Humidity%	12%
Average particle size (mm)	4

3.5 Physical properties of phosphogypsum

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3.5 STONE DUST

All materials have properties that make them suitable for different purposes. Stone dust has many properties that make it a useful by product to use for many hardscaping jobs. Understanding the properties of stone dust can help you to decide which jobs it is most suitable.

property	Stone dust
Sp. gravity	2.56
Bulk density(kg/m3)	1750
Absorption	1.25
Moisture content %	Nil
Fine partical less then 0.075 mm %	12.25
Sieve analysis	Zone-2

3.6 Physical properties ofstone dust

4. MIX DESIGN

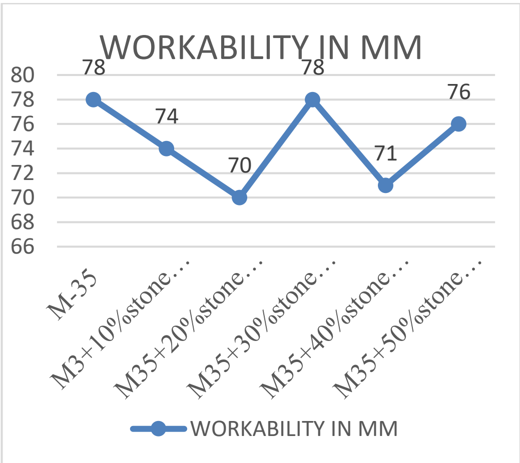
Cement	Fine aggregate	Coarse aggregate	Water
492.0	709.24	1056.87	197.16
1	1.44	2.14	0.40

Table no 4.1 mix proportion for m35 grade

5. RESULTS

5.1 SLUMP CONE TEST

The strength of concrete of a given mix proportion is seriously affected by the degree of its compaction. It is therefore important that the consistency of the mix is such that the concrete can be transported, placed and finished sufficiently easily and without segregation. A concrete satisfying these conditions is said to be workable. Workability is a physical property of the concrete depending on the external and internal friction of the concrete matrix; internal friction being provided by the aggregate size and shape and external friction being provided by the surface



Graph no 5.1 workability results

5.2 COMPACTION FACTOR TEST

Scope and Significance Compaction factor test is adopted to determine the workability of concrete, where nominal size of aggregate does not exceed 40mm, and is primarily used in laboratory. It is based upon the definition, that workability is that property of the concrete which determines the amount of work required to produce full compaction. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction.

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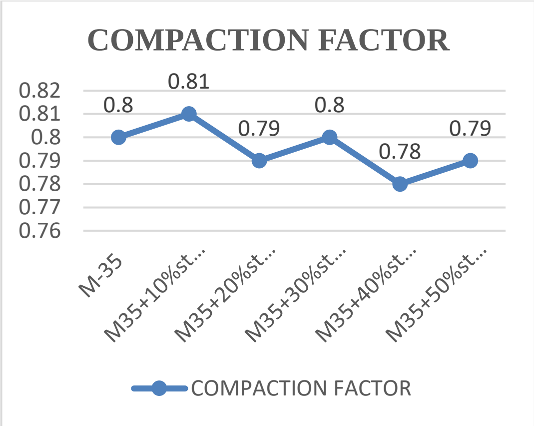
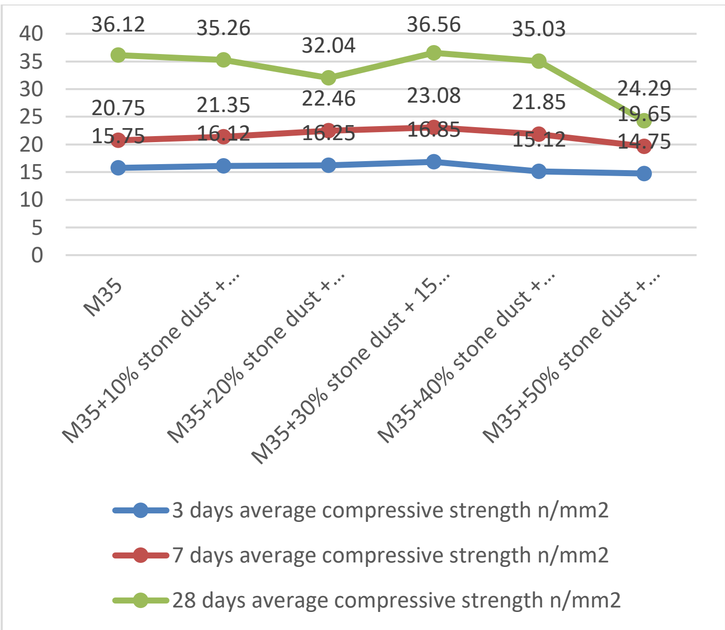
To find the workability of freshly prepared concrete, the test is carried out as per specification of IS: 1199-1959.



Graph no 5.2 compaction factor results

5.3 COMPRESSION TEST ON CONCRETE CUBES

The determination of the compressive strength of concrete is very important because the compressive strength is the criterion of its quality. Other strength is generally prescribed in terms of compressive strength. The strength is expressed in N/mm2. This method is applicable to the making of preliminary compression tests to ascertain the suitability of the available materials or to determine suitable mix proportions. The concrete to be tested should not have the nominal maximum size of aggregate more than 20mm test specimens are either 15cm cubes or 15cm diameter used. At least three specimens should be made available for testing. Where every cylinder is used for compressive strength results the cube strength can be calculated as under. Minimum cylinder compressive strength = 0.8 x compressive strength cube (10 cm x 10 cm) The concrete specimens are generally tested at ages 3 days 7 days and 28 days. The cubes are generally tested at 3 days 7 days and 28 days. The cubes are removed from the curing tank, dried and grit removed. The cubes are tested using a calibrated compression machine. This can be carried out internally by competent personnel or by a certified test house. The cubes are tested on the face perpendicular to the casting face. The compression machine exerts a constant progressing force on the cubes till they fail, the rate of loading is 0.6 ± 0.2 M/Pas (N/mm²/s). The reading at failure is the maximum compressive strength of the concrete. BS EN 12390-2: 2009 / BS EN 12390-3:2009. The concrete minimum compressive strength will be specified by the client/designer in a specific format



Graph no 5.3 compressive strength results for 3, 7 and 28 days

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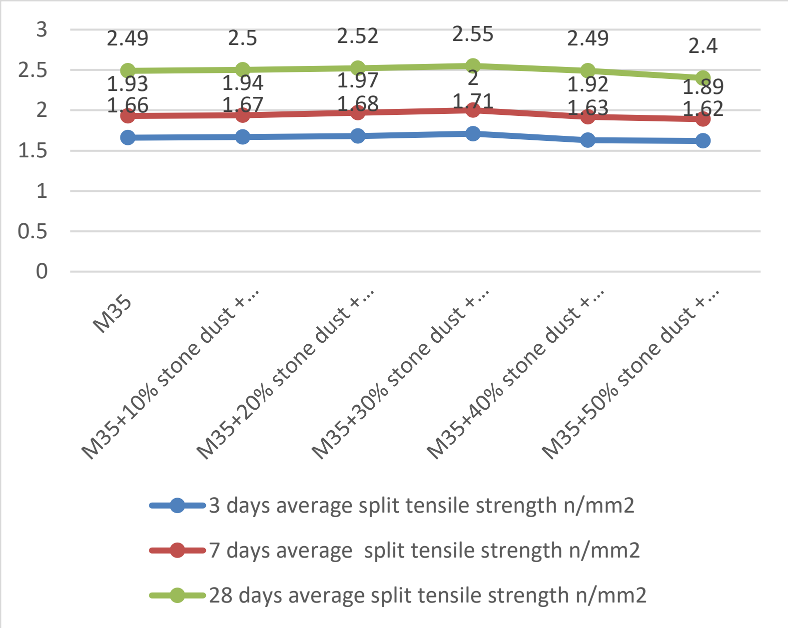
3.4 SPLIT-CYLINDER TEST

It is the standard test, to determine the tensile strength of concrete in an indirect way. This test could be performed in accordance with IS : 5816-1970.A standard test cylinder of concrete specimen (300 mm X 150mm diameter) is placed horizontally between the loading surfaces of Compression Testing Machine. The compression load is applied diametrically and uniformly along the length of cylinder until the failure of the cylinder along the vertical diameter. To allow the uniform distribution of this applied load and to reduce the magnitude of the high compressive stresses near the points of application of this load, strips of plywood are placed between the specimen and loading platens of the testing machine. Concrete cylinders split into two halves along this vertical plane due to indirect tensile stress generated by poison's effect.



Graph no 5.4 split tensile strength results for 3, 7 and 28 days

5.5 FLEXURAL STRENGTH OF CONCRETE

The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibers are at the largest stress so, if those fibers are free from defects, the flexural strength will be controlled by the strength of those intact 'fibers'. However, if the same material was subjected to only tensile forces then all the fibers in the material are at the same stress and failure will initiate when the weakest fiber reaches its limiting tensile stress. Therefore, it is common for flexural strengths to be higher than tensile strengths for the same material. Conversely, a homogeneous material with defects only on its surfaces (e.g., due to scratches) might have a higher tensile strength than flexural strength.

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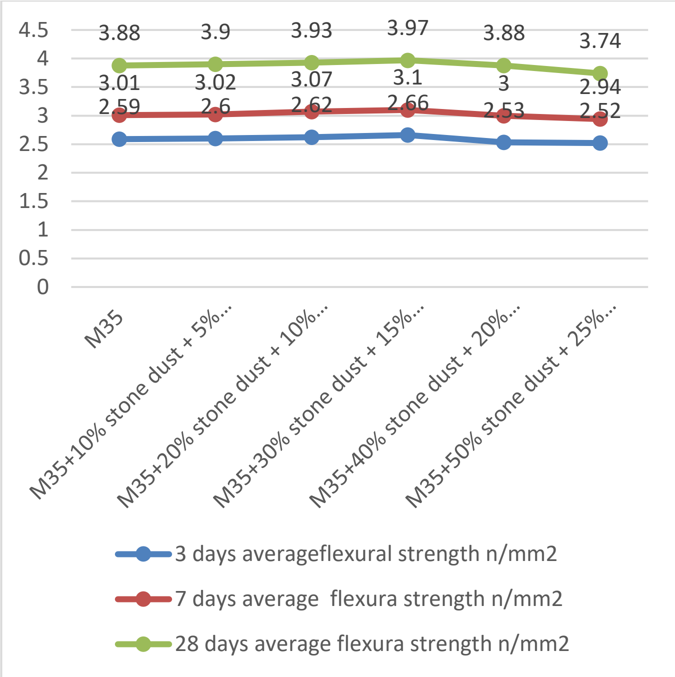

Graph no 5.5flexural strength results for 3, 7 and 28 days

6. CONCLUSION

1. We gain the highest compressive strength at the percentage of different admixtures added in M-35 grade concrete (M35+30%stone dust+15% phosphogypsum) – 36.56 N/mm2
2. We gain the highest split tensile strength at the percentage of different admixtures added in M-35 grade concrete (M35+30%stone dust+15% phosphogypsum)– 2.55 N/mm2
3. We gain the highest flexural strength at the percentage of different admixtures added in M-35 grade concrete (M35+30%stone dust+15% phosphogypsum) – 3.97 N/mm2

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AUTHOR'S PROFILE

MD.MUSHARRUF QADEER pursuing M.Tech in department of CIVIL (STRUCTURAL ENGINEERING)Newton's Institute of Science and technology.

P. BALAKRISHNA Working as Assistant Professor in Newton's Institute of Science and technology.