IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 7.105 ⁜ Vol. 9, Issue 6, June 2022

DOI: 10.17148/IARJSET.2022.9626

Strength and Durability of Steel Fiber Reinforced Concrete Containing Phosphogypsum as Partial Reolacement for Cement

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Abstract: As we well known that, the world is developing rapidly and the construction of buildings takes vital role in this development. If we go through in detail the usage of concrete get raised up so it leads to the shortage of the natural resources. In order to save our natural resources we thought that replace some of the proportions in the concrete with the following measures.The study focuses on the compressive strength, split tensile strength, flexural strength performance of concrete containing steel fiber and different percentage of phosphogypsum as a partial replacement of cement. The cement in concrete is replaced accordingly with the percentage of 5%, 10%, 15%, 20% and 25% by weight of silica fume and 1% of steel fiber is added by weight of cement. Concrete cubes, cylinders and beams are tested at the age of 3, 7 and 28 days of curing. Finally the strength performance of slag blended fiber reinforced concrete is compared with the performance of conventional concrete.

Keywords: steel fiber, phosphogypsum, compressive strength, split tensile strength, flexural strength.

1. INTRODUCTION

Concrete is most normally utilized and exceptionally solid constructional material. Concrete is a blend of concrete, coarse total and fine total and water. Concrete is the coupling material which holds the coarse and fine total together. The concrete and water frames a glue or gel which covers the sand and rock. Coarse total is utilized as quality material. Fine total is utilized as filler. Concrete is excellent in pressure and powerless in strain. To evade these issues now-a-days we are utilizing various sorts of admixtures in the solid. In this examination the expansion of steel strands in the solid and fractional supplanting of cement with silica fume and total volume of concrete with steel fibers.The interest for concrete is next just to water. With the progression of innovation and expanded field of utilization of cement and mortars, different properties of the standard cement required adjustment to make it progressively appropriate for different circumstances, conservative and eco well disposed. This has prompted the utilization of cementitious materials, for example, phosphogypsum, fly debris, silica fume, silica smolder, metakaolin, and so forth which have contributed towards better, vitality protection and economy. The utilization of phosphogypsum in part supplanting the fine total concrete in solid outcomes in decrease of concrete utilized, decrease in the emanation of carbon dioxide (Co2), protection of existing assets alongside the improvement in the quality and strength properties of cement.

1.1 PHOSPHOGYPSUM

Phosphogypsum 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.

1.2 STEEL FIBERS

Engineered for long-term performance and superior concrete crack control in demanding industrial applications, the line of steel concrete fibers is specifically designed ot enhance concrete and shotcrete in its hardened state. Industrial concrete floor slab systems are often required to perform under intense loading conditions, including point loads from rack legs and dynamic loading from vehicular traffic. The uniform distribution of steel fibers throughout the concrete mix transforms concrete into a more ductile composite material that increases the energy absorption capability, long-term durability and overall performance of the slab.

Additionally, it provides exceptional control of long-term drying shrinkage cracking and load stability at the floor

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joints, where it is most needed. Steel fiber reinforced shotcrete improves ductility, fracture toughness and energy absorption capacity. Fiber reinforced shotcrete has many benefits including greater homogenic of the support structure, and simpler application logistics.

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 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 phosphogypsumconcrete.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.

MURTHY DAKSHINA N R ET AL (2005) , in their paper entitled ‘Splitting tensile strength of high volume fly ash concretes with and without steel fibres in different grades’ have discussed about the effect of combination of fly ash and random steel fibres in improving tensile strength of concrete in lower, medium and higher grades. They have studied M25, M50 and M60 grades of concrete. They have used steel fibres with aspect ratio of 75 and volume fraction of 1%. They have made following comments on their studies. In lower grades ductility of concrete can be increased by replacing the cement by fly ash upto 20%. At 40% replacement ductility can be achieved by adding steel fibres of 1%. In medium grade the split tensile strength of concrete has been increased upto 30% replacement. 1% addition of fibres can improve tensile strength even at 40% replacement of cement by fly ash. There is an improvement in ductile behavior of concrete when steel fibres are added to it. In higher grade concrete ductility has been increased upto 10% replacement of cement by fly ash. At higher percentage replacement the brittleness of concrete has been increased. With steel fibres ductility can be improved upto 20% replacement. There is a drop in the split tensile strength at 30% and 40% replacements. For all grades on concrete there is overall improvement in the ductility when 1% fibres are added.

3. MATERIALS PROPERTIES AND EXPERIMENTAL INVESTIGATION

3.1MATERIALS

Raw materials required for the concreting operations of the present work are Phosphogypsum, steel fibers, 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	30%
3	Initial setting time	36 min

4	Final setting time	470 min
5	Soundness	6.3 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 specifies four ranges or zones for fine aggregate grading. Table gives the range of percentage passing for each zone.
Zone I sand is the coarsest and Zone IV is the finest whereas sand in Zone II and Zone III are moderate. It is recommended that fine aggregates conforming to grading zone II or Zone III can be used in reinforced concrete.

S.No	Property	Result
1	Fineness Modulus	2.75
2	Specific Gravity	2.65

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	8.15
2	Specific Gravity	2.72

3.3 Physical properties of coarse aggregates

3.5 PHOSPHOGYPSUM

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

IARJSET
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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

3.6 STEEL FIBER

Steel fiber is a metal reinforcement. Steel fiber for reinforcing concrete is defined as short, discrete lengths of steel fibers with an aspect ratio (ratio of length to diameter) from about 20 to 100, with different cross-sections, and that are sufficiently small to be randomly dispersed in an unhardened concrete mixture using the usual mixing procedures. A certain amount of steel fiber in concrete can cause qualitative changes in concrete's physical property, greatly increasing resistance to cracking, impact, fatigue, and bending, tenacity, durability, and other properties .

type	Single hooked
Specific gravity	7.85
Diameter	0.5
Length	30
Aspect ratio (l/d)	60
Tensile strength (MPa)	1100
Elastic modulus (GPa)	205

3.5 Physical properties ofsteel fibers

4. MIX DESIGN

Cement	Fine aggregate	Coarse aggregate	Water
562.85	653.32	1018.53	197.16
1	1.16	1.80	0.35

Table no 4.1 mix proportion for m40 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

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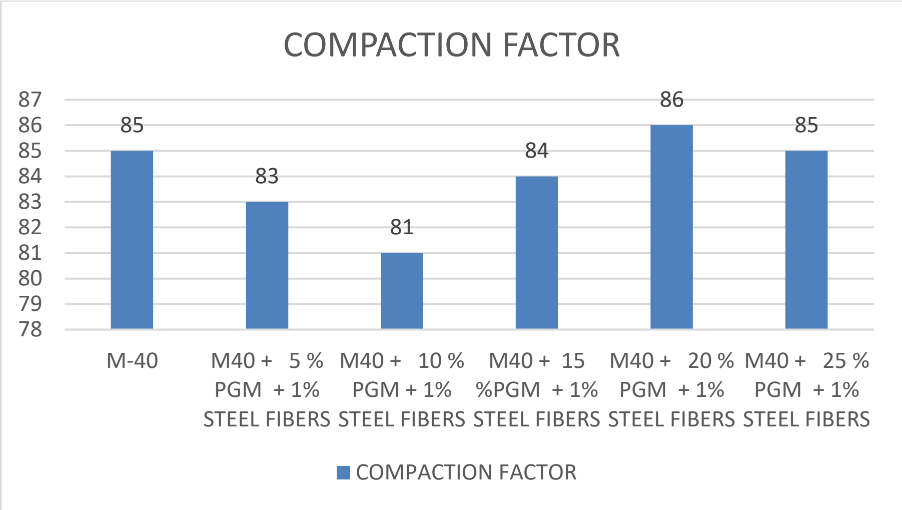
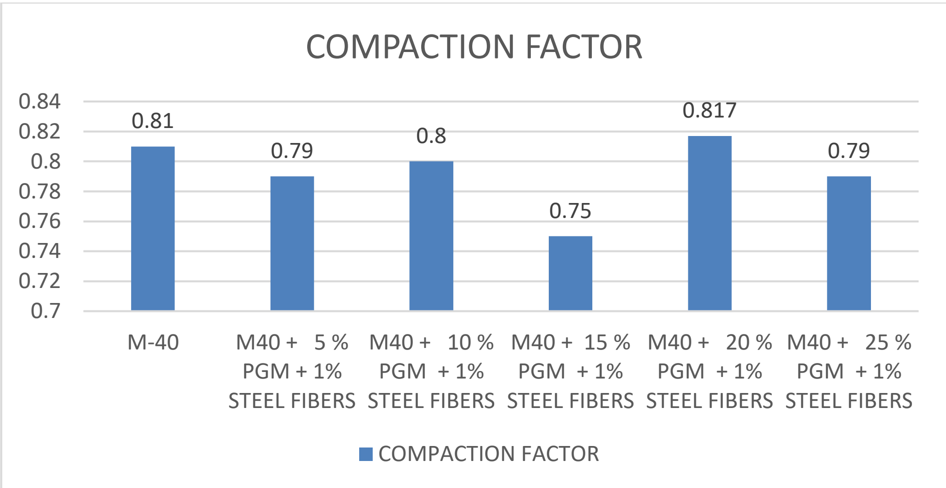


Graph no 5.1 workability results

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. 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

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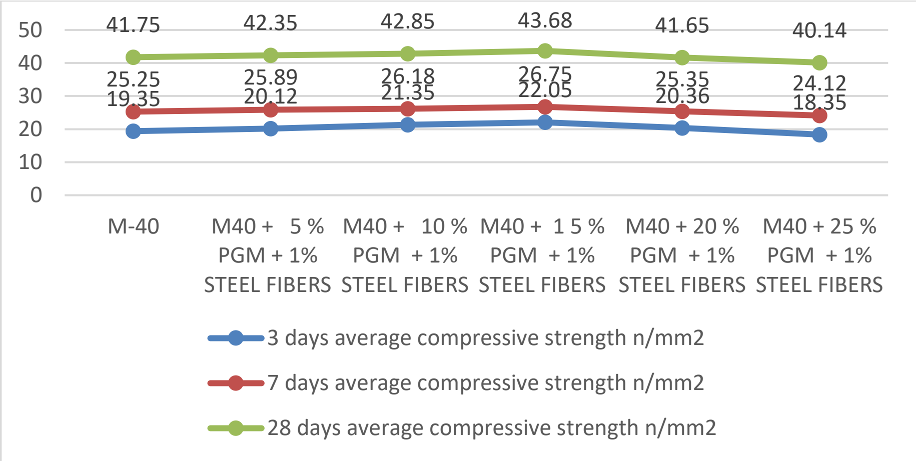
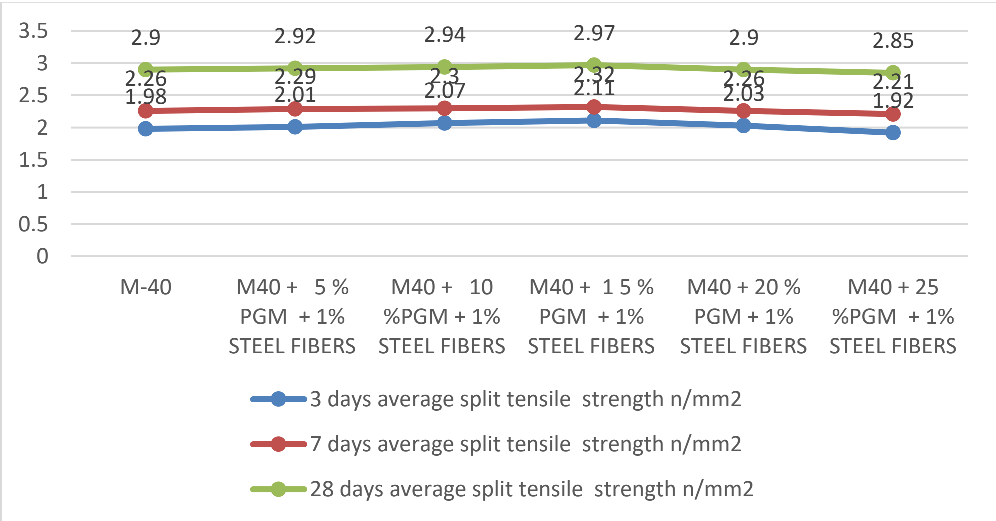
personnel or by a certified test house. The cubes are tested on the face perpendicular to the casting face. The compression machine exerts a constant progressing force on the cubes till they fail, the rate of loading is 0.6 ± 0.2 M/Pas (N/mm²/s). The reading at failure is the maximum compressive strength 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

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

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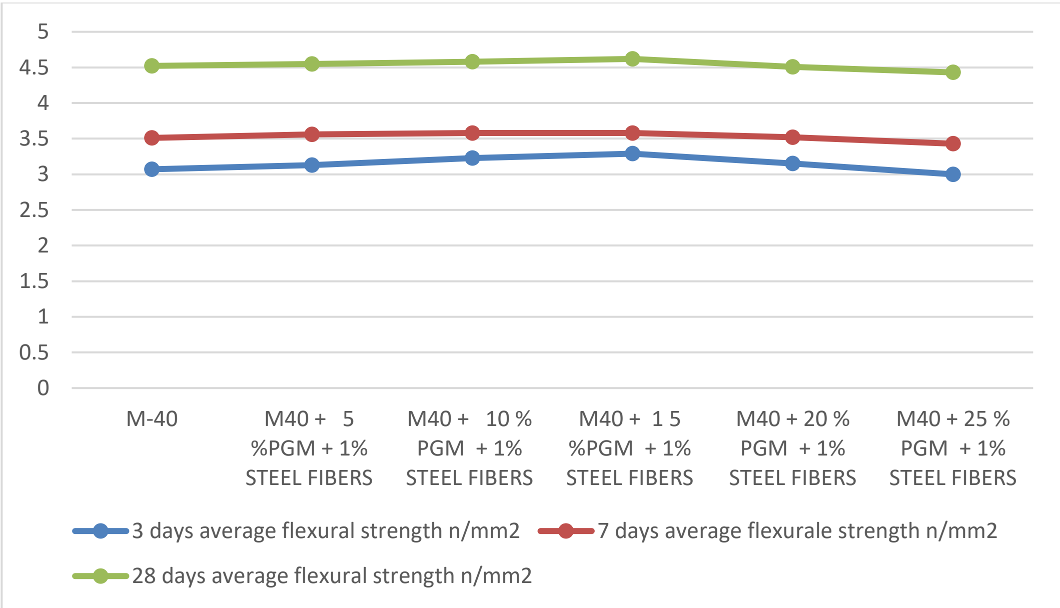
from defects, the flexural strength will be controlled by the strength of those intact 'fibers'. However, if the same material was subjected to only tensile forces then all the fibers in the material are at the same stress and failure will initiate when the weakest fiber reaches its limiting tensile 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.



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

6. CONCLUSION

- We gain the highest compressive strength at the percentage of different admixtures added in M-40 grade concrete (M40 + 15 % Phosphogypsum.+ 1% steel fibers)– 43.68 N/mm2
- We gain the highest split tensile strength at the percentage of different admixtures added in M-40 grade concrete (M40 + 15 % Phosphogypsum.+ 1% steel fibers)– 2.97 N/mm2
- We gain the highest flexural strength at the percentage of different admixtures added in M-40 grade concrete (M40 + 15 % Phosphogypsum.+ 1% steel fibers) – 4.62 N/mm2

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IARJSET

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ISO 3297:2007 Certified ⋇ Impact Factor 7.105 ⋇ Vol. 9, Issue 6, June 2022

DOI: 10.17148/IARJSET.2022.9626

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