



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 8, August 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

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Experimental Investigation of Properties of M20 Grade Concrete Using Crushed Sand and Polypropylene Concrete

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ABSTRACT: India is the second-largest cement manufacturer in the world. With more than 7% of the installed capacity worldwide. Domestic output totaled 294.40 million tonnes in FY 2021. In FY 2027, it is anticipated that cement consumption would amount to 419.92 million tonnes. India's cement industry emissions have risen sharply in recent years, peaking at 144 million metric tonnes of carbon dioxide in 2019 (CO₂). There are a number of unfavorable social and ecological effects from the over use of cement and natural sand in the civil engineering sector. Also, the demand supply ratio of natural sand cannot be fulfilled, which has further led to some ecological imbalances in the environment. In this experimental research addition of 1.75% polypropylene fiber with respect to weight of cement and 100% use of manufactured sand has been done. Concrete of grade M20 was casted from OPC 43 grade cement. The test was conducted on 28 days, 56 days, & 90 days and comparative study has been performed using test results of Compressive Test, Split Tensile Test, Flexure Test, Shear Test, Acid Bath Test, Permeability Test, Rapid Chloride penetration Test (RCPT), between samples casted using 100% natural sand, 100% manufactured sand and 100% Manufactured sand + 1.75% Polypropylene Fiber with respect to weight of cement.

In this experimental research work the result showed that the use of polypropylene fiber with manufactured sand gives better result in flexure strength, split tensile strength, resistance against chloride ion penetration, and acid attack. But for M20 grade of concrete there is no significant gain in compression strength and as compared to that of concrete casted using 100% crushed sand. The use of polypropylene fiber for different grades of concrete can be done and tested for compression strength. Also, test for durability can be done for more duration that is 120, 180 and 365 days.

KEYWORDS: Natural sand, crushed sand (Manufactured Sand), Silica fume, Rapid chloride penetration test, Acid Bath, Compression Test, Split Tensile Test.

I. INTRODUCTION

Concrete is one of the most widely used construction material all over the world from last seventy years in view of its strength, high mould ability, structural stability and relative low cost. Concrete design is both an art and science, with the new technology, new knowledge and novel materials. Rapid advances in Construction materials technology have enabled civil and structural engineers to achieve impressive gains in the safety, economy, and functionality of structure built to serve the common needs of society. Through such gains, the health and standard of living of individuals are improved. The use of high strength, high stiffness structural Fibers in concrete resulted in composite materials with substantial improvement in the mechanical properties and durability of concrete structures. There are clear indications that the use of Fibers in concrete will increasingly continue to be the preferred choice for many repair and rehabilitation projects involving construction of bridges, Industrial floors, airport pavements, overlays, and high-rise buildings, TV towers, parking garages, offshore structures, historic monuments and other structures. It is widely used as construction material in world, and it is very difficult to find another material of construction as versatile as concrete. Though concrete is versatile material but it has biggest disadvantages such as delayed hardening, low tensile strength, large drying shrinkage, and low chemical resistance. To overcome this disadvantages attempt is made to modify cement concrete with polypropylene additive such as thermoplastics like epoxy, resins thermosets, elastomers and rubbers.

Fiber Reinforced Concrete (FRC) may be characterized as composite materials constructed with Portland cement, aggregate, and integrating discrete discontinuous fibers. The usage of polypropylene fibers has expanded considerably



with building of structures because incorporation of fibers in concrete enhances the toughness, flexural strength, tensile strength and impact strength as well as failure mode of concrete. Polypropylene twine is inexpensive, easily accessible, and like all manufactured fibers of a constant grade

II. MATERIAL AND METHODS

The natural sand used in the mix was obtained from the Krishna River basin. The crushed sand used was obtained from Vertical Shaft Impact (VSI) crusher. The parent rock in the manufacturing of crushed sand was basalt. The same rock was used in the manufacturing of normal coarse aggregate used in the mix. Ordinary Portland Cement (OPC) conforming to IS 8112: 1989 [9] was used in all mixes with standard consistency of 34 %, Initial Setting Time (IST) of 40 minutes, Final Setting Time (FST) of 390 minutes Fineness of 4%.

1. Particle size distribution: This is the most important property of Fine aggregate as it affects the particle packing. After conducting a sieve analysis of natural sand and crushed sand, the particle size distribution curve obtained is as shown in fig. 1
2. Specific gravity: The specific gravity of aggregate was found using the pycnometer method as specified in IS 2386: 1963 (Part III) [10]. After carrying out the standard procedure, the specific gravity of natural sand, crushed sand, normal aggregates were found as given in table 1.
3. Water absorption: Water absorption of aggregate is an important property in the concrete mix design. The water absorption of natural sand, crushed sand, normal aggregate was found as per IS 2386: 1963 (Part III) [10], and the results obtained after the test are shown in table 1.
4. Silt content: The % silt content of natural sand was determined as per IS 2386: 1963 (Part II) [11] and was found to be 4.05%.
5. Crushing, Impact, and Abrasion value: The Crushing value, Impact value, and abrasion value are the most important mechanical properties in accessing coarse aggregate quality. The test on normal aggregate was conducted as per IS 2386: 1963 (Part IV) [12], and the results of the test are shown in table 2.

Polypropylene Fiber: Polypropylene fibers were purchased from “Konark Construction materials pvt. ltd.” Located at Karad, Satara. Following are the properties of silica Fume.

Property	Values
Fiber Type	Single fiber
Length (mm)	6,12,20
Unit weight (KN/m3)	9.1
Tensile strength (MPa)	500-700
Modulus of elasticity (MPa)	2800

Properties of fresh concrete: For preparing the concrete, the coarse aggregate passing through a 20mm IS sieve and retained on a 10 mm IS sieve were used. The natural sand and crushed sand used were passed through 4.75 mm and retained on 150 microns IS sieve. While mixing ingredients for the preparation of concrete normal weigh batching was done for mixes M1, M2 and M3. The mixing is done in 2 stages, firstly the mixing is done in dry state and secondly mixing is wet mixing after addition of water. After the production of concrete, the workability of fresh concrete was checked using the slump cone apparatus. The workability of concrete mix M1 was found to be 100mm while that of mix M2 and mix M3 was found to be 90mm and 100mm respectively.



Figure. 1. Particle Size Distribution Curve

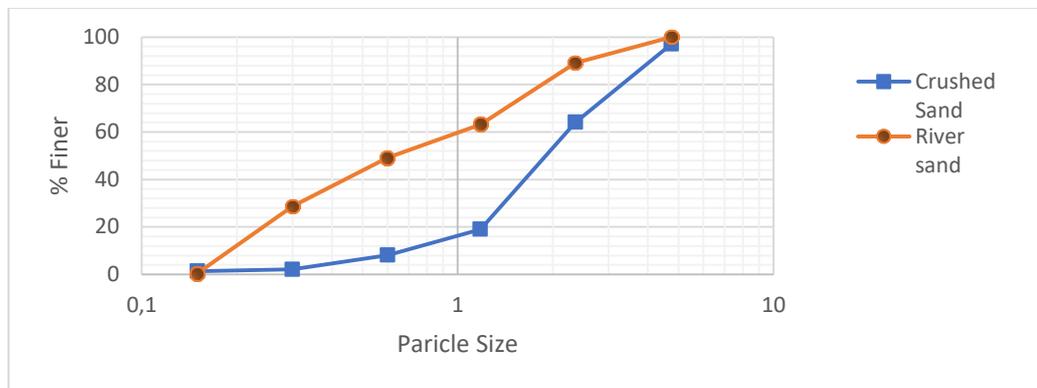


Table 04. Mechanical Properties of Coarse Aggregates

Properties	Normal Aggregate
Crushing Value	12.65
Impact Value	5.97
Abrasion Value	21.32

Table 03. Physical Properties of Fine and Coarse Aggregates

Properties	Natural sand	Crushed sand	Normal Aggregate
Specific Gravity	2.95	3.21	2.95
Water Absorption	3.1	1.43	0.7
Silt content (%)	4.05	-	-

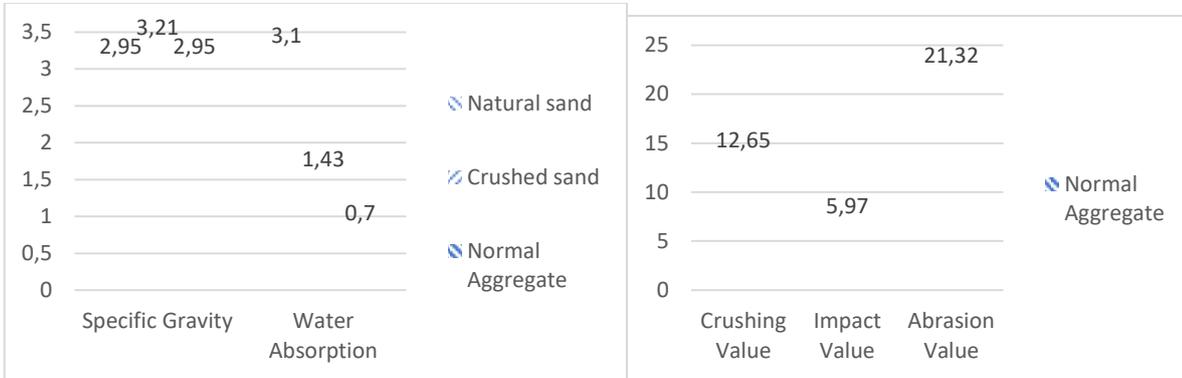
III. RESULTS AND DISCUSSION

The specific gravity of natural sand was found to be 2.95 while that of crushed sand was found to be 3.21. As crushed sand is produced after crushing rock, the number of organic impurities present in the crushed sand is less. Due to this, the specific gravity of crushed sand is more as compared to natural sand. On the other hand, the specific gravity of natural coarse aggregate is 2.95.

In the case of natural sand, the water absorption was found to be 3.1% while that of crushed was found to be 1.3%. As stated earlier the percentage of silt and other organic impurities is almost zero in crushed sand, the percentage of water absorbed by it is less compared to natural sand.

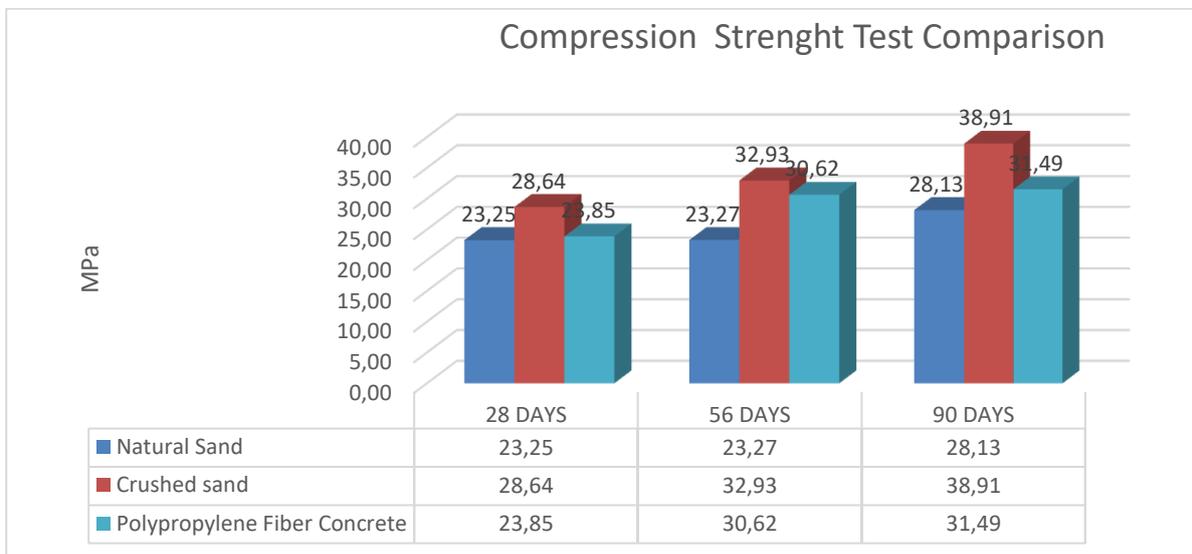


Graph 01. Comparison of Physical Properties of Aggregate Graph 02. Comparison of Mechanical Properties of Coarse Aggregate



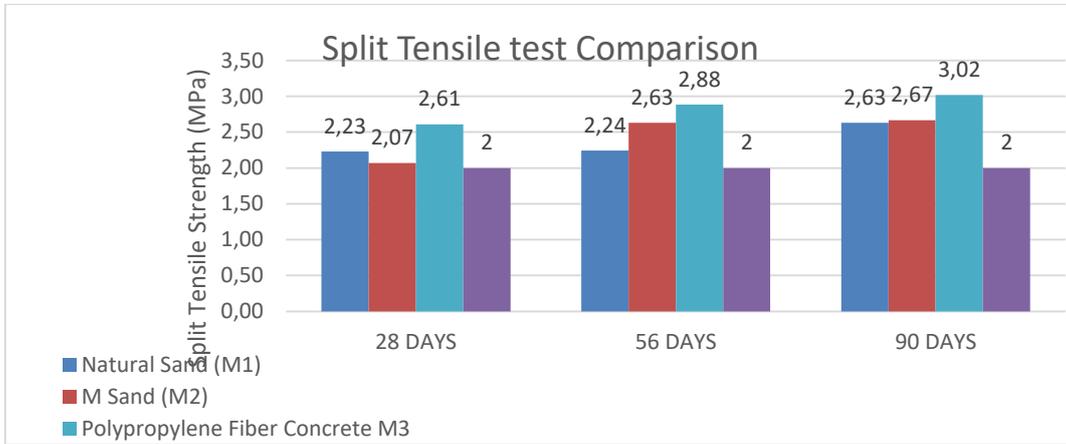
The workability of fresh concrete produced using natural sand and natural aggregate was 100mm, while that of crushed sand and natural aggregate was 90mm. The decrease in workability in concrete containing crushed sand was due to the presence of more angular particles. The natural sand contains spherical particles which enhances the ability of concrete to flow. Mix M3 containing crushed sand and 10% Silica fume, which has a workability of 100mm

Graph 03 Comparison of Compression Test of Mix M1, M2, And M3 for 28, 56 & 90 days.

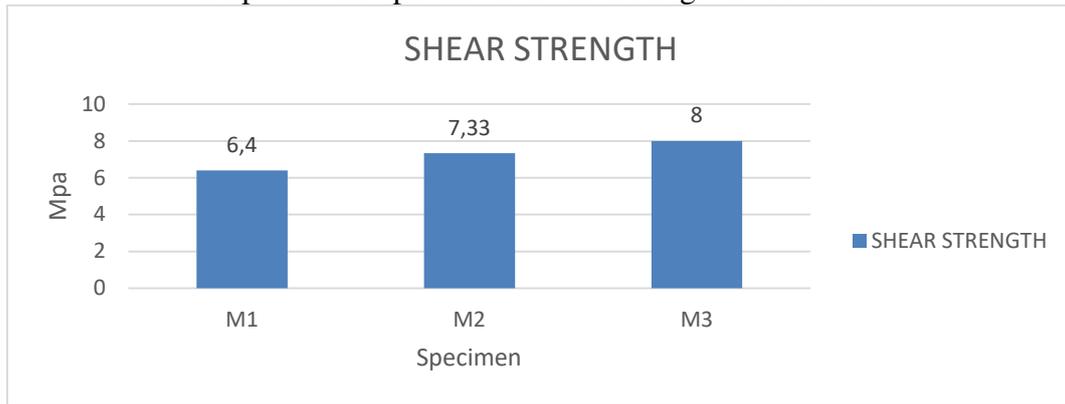




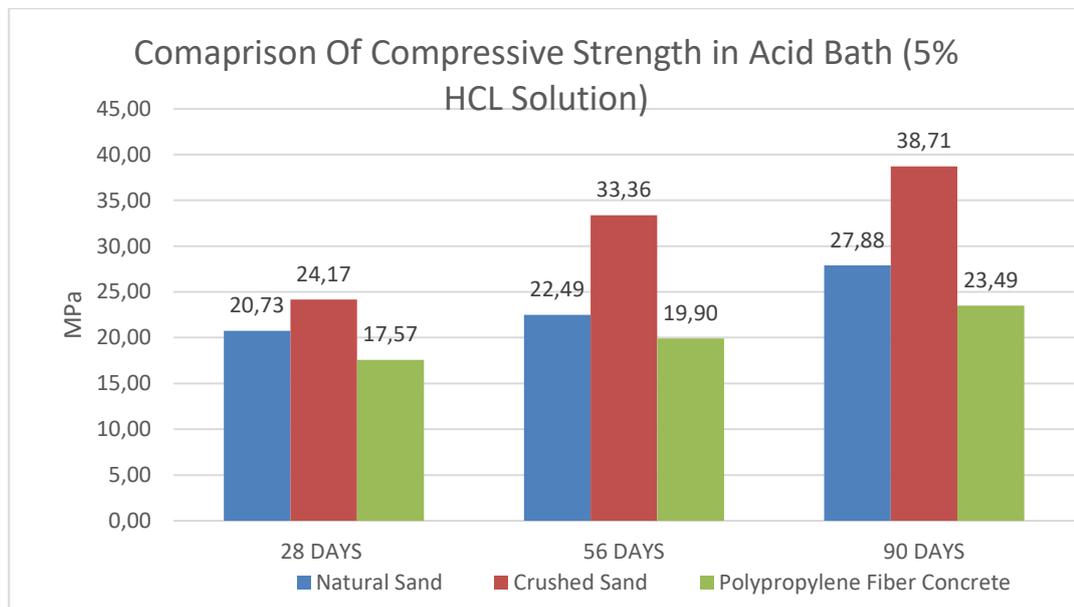
Graph 04. Comparison of Split Tensile Test of Mix M1, M2, And M3 for 28, 56 & 90 days.



Graph 05. Comparison of Shear Strength of concrete

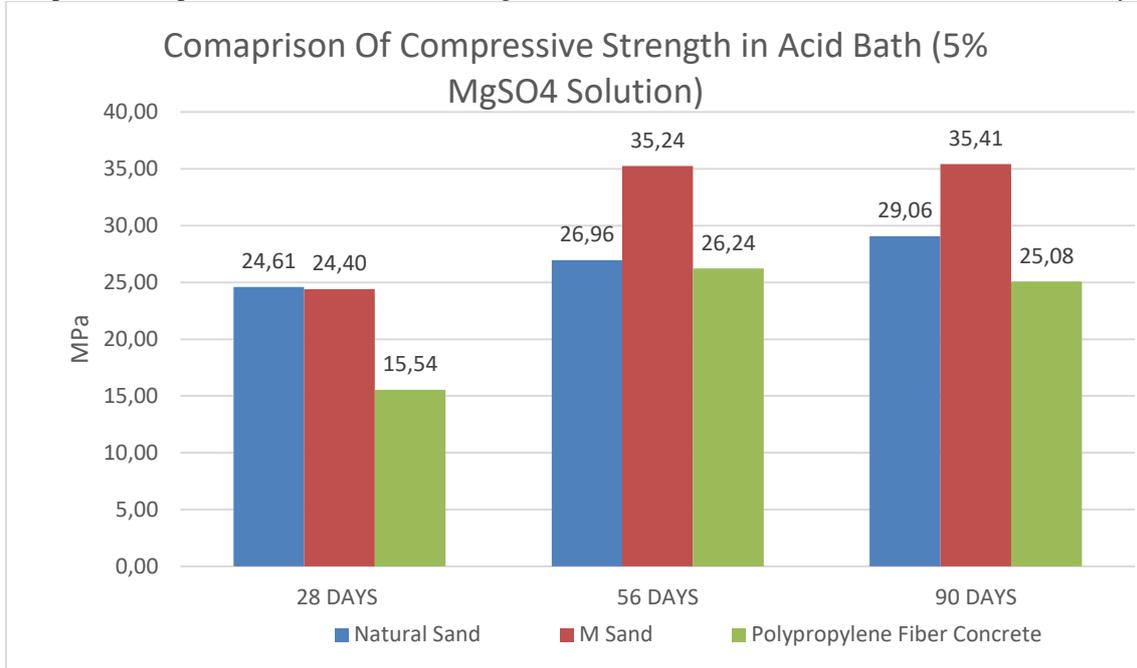


Graph 06. Comparison Of Acid Bath Test (HCL Soln.) Of Mix M1, M2, And M3 for 28, 56 & 90 days.

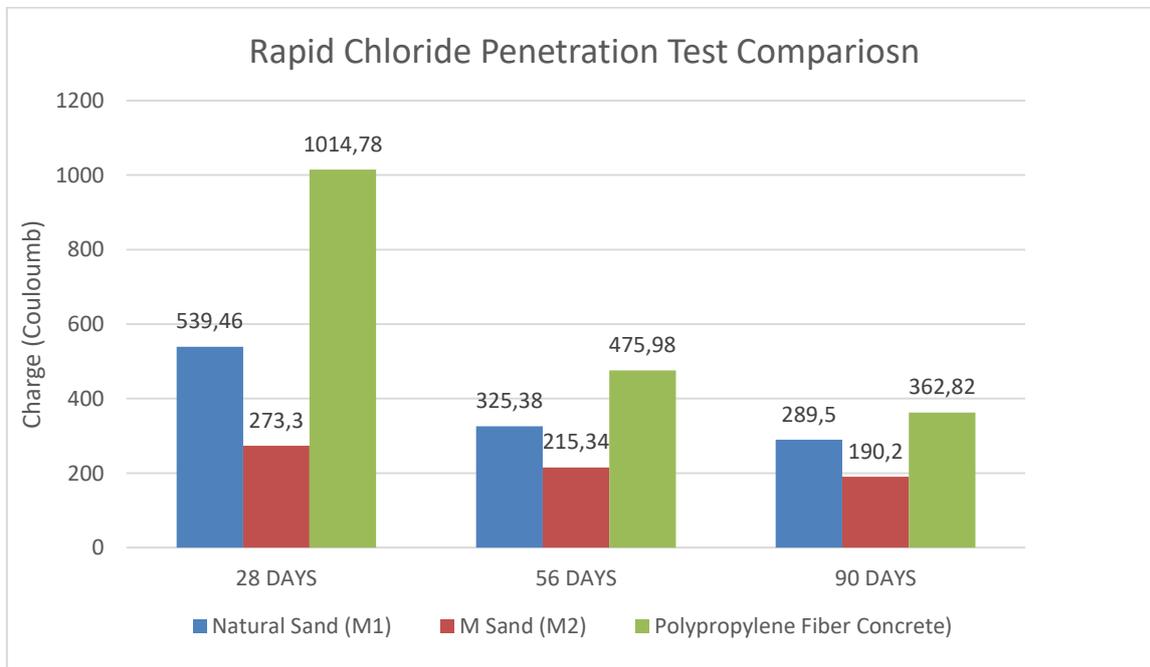




Graph 07. Comparison Of Acid Bath Test (MgSO₄ Soln.) Of Mix M1, M2, And M3 for 28, 56 & 90 days



Graph 08. Comparison of Rapid Chloride Penetration Test Of Mix M1, M2, And M3 for 28, 56 & 90 days



IV. CONCLUSION

Based upon the results obtained after experimental investigation of mix M1 (natural sand + normal aggregates), M2 (crushed sand + normal aggregates) and M3 (crushed sand + 1.75% polypropylene fiber with respect to cement) it was concluded that:

1. The compressive strength for mix M2 was more than mix M1 by 23.18%, 41.51% & 38.32% and M3 by 20.08%, 7.34% & 23.56% for 28, 56, and 90 days respectively. This shows that the use of crushed sand in concrete has proved to be effective in its compressive strength development.
2. The Compressive strength for mix M3 was 2.58%, 31.58% & 11.94% more than that of M1 for 28, 56 and 90days respectively. This shows that addition of polypropylene fiber in cement gives better strength than natural sand.
3. The split tensile strength of mix M3 is greater than 2 N/mm² for 28 and 56days and 90 days. Also mix M3 had more split tensile strength than mix M1 and M2 by 17.04%, 26.08% respectively for 28days and 28.57%, 9.50% respectively for 56days and 14.82%,13.10% respectively for 90days. Hence it can be concluded that the use of polypropylene fiber in concrete gives good results split tensile strength considerably.
4. The Flexure strength of mix M3 is more than that of M2 and M1. This result indicates that use of polypropylene fiber in concrete will help in achieving more flexural strength that is 28.30% as compared to mix M1 and 53.48% as compared to mix M2.
5. When cubes were immersed in 5% HCl solution, it is seen that for mix M3 compressive strength increases at very slow rate as compared to mix M1 and M2. For mix M3 the compressive strength decreased by 17.98%, 13.02% and 18.69% at 28 & 56days and 90days respectively as compared to mix M1 and 37.56%, 67.64% and 64.80% at 28,56 and 90days respectively. Mix M3 showed poor results than that of mix M1 and M2, concluding that addition of polypropylene fiber in cement gives poor resistance to acid attack. Also, when cubes were immersed in 5% MgSO₄ solution, the 28days compressive strength of mix M1 and M2 is almost same and more than 58.37% & 57.01% respectively as that of mix M3. But at 56 & 90 days mix M2 have 30.71%, 34.29% & 21.85%, 41.19% respectively as that of mix M1 and M3. Hence, it is conclude that mix M2 is more resistant to base attack.
6. In Rapid Chloride Penetration Test (RCPT) all the mixtures M1, M2 & M3 have chloride ion penetration in between 100-1000 coulomb and hence it is very low according to ASTM 1202 guidelines. Also, in mix M3 there was decrease in charge value by 113.20% between 28 to 56days and 31.20% between 56 to 90days. For 28 days Mix M3 is 88.11% & 270.73% less than that of M1 and M2 respectively. For 56 days Mix M3 is 46.28% & 121.04% less than that of M1 and M2 respectively. For 90 days Mix M3 is 25.33% & 90.76% less than that of M1 and M2 respectively. From results mix M2 can be used where chloride ion penetration occurs, such as sea water or marine environment. Finally, From the experimental work it can be concluded that addition of 1.75% polypropylene fiber with respect to weight of cement and crushed sand gives better results in Flexure strength and split tensile strength. Hence fiber can be used where tensile strength is importance. The failure of beam specimen was gradual, there was no initial flexure cracks developed. Shrinkage cracks can be avoided by using polypropylene fiber. From durability aspect polypropylene fiber does not shows resistance to acid and base attacks

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