Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

# Durability Properties of Concrete with M-Sand As Fine Aggregate Incorporating with Acrylic Fiber

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***Abstract*—The river sand is the natural form of fine aggregate material which is used in the concrete and mortar. It is usually obtained from the river bed and mining has disastrous environment consequences. Instead of the river sand we are using M-sand as fine aggregate in the concrete. The development of acrylic fiber concrete marks an important milestone in improving the product quality and efficiency of the concrete. Usage of acrylic fiber in the concrete will increase the strength and durability of the concrete. It enhances the performance of the concrete and increase energy absorption compared with plain concrete. In the present work we are going to analysis the durability properties of fiber reinforced M-sand concrete like water permeability test and accelerated electrolytic corrosion.**

***Keywords*— *Concrete, manufactured sand, acrylic fiber, and durability.***

## I. INTRODUCTION

Concrete is the most widely used construction material in the world, which is commonly consists of cement, aggregates and water. It is the material, which is used more than any other man made material on the earth for construction works. Fiber reinforced concrete contains short discrete fibers that are uniformly distributed and randomly oriented. Fiber includes steel fibers, glass fibers, synthetic fibers and natural fibers each of which lend varying properties to the concrete. In addition, the character of fiber reinforced concrete changes with fiber material, geometries, distribution, orientation, and densities. We can use fiber reinforced concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduces bleeding of water. Some types of fibers produce greater impact, abrasion, and shatter resistance in concrete. Generally fibers do not increase the flexural strength of concrete, and so cannot replaced moment resisting or structural steel reinforcement. Recent studies performed on a high strength fiber reinforced concrete in a bridge deck found that adding fibers provided residual strength and controlled cracking. There were fewer and narrower cracks in the FRC even though the FRC had more shrinkage than the control. Residual strength is directly proportional to the fiber content.

Acrylic AC50 fiber are modified polymer fibers that greatly enhance the performance and durability of concrete. They drastically reduce plastic shrinkage cracking, provide secondary reinforcement and increase impact resistance.

## II. LITERATURE REVIEW

Kuldeep Kumar, Er. Ritu [1] The main objective is to develop concrete which does not concern on the strength of concrete, it also having many other aspects to be satisfied like less porous, capillary absorption, durability, high flexural strength, less shrinkage, controlled cracking. So for this we need to go for the addition of acrylic fiber along with having low water cement ratio. Acrylic fiber exhibits very good resistance to acids and alkalis and are low in cost. Also now a day's one of the greatest application in various structural field is fiber reinforced concrete, which is getting popularity because of its positive effects on various properties of concrete. R. Ilangovan, N. Mahendran, K. Nagamani [2] made a study on concrete by 100% replacement of natural sand by quarry dust. They concluded that the compression strength, flexural strength and durability properties of concrete made of quarry dust are nearly 10% more than the conventional concrete. S. Muralikrishnan, T. Felix Kala, P. Asha, S. Elavenil [3] the purpose of this study is to conduct a systematic comparison of the effects of natural and manufactured sand exert on strength and durability properties. This paper presents the mechanical behavior of the selected fine aggregate, followed by the durability

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

behavior of conventional and M-sand concrete. T. Shanmugapriya, R.N. Uma [4] concluded from experimental researchers that compressive and flexural strength of concrete can be improved by partial replacement of cement by silica fume and manufactured sand for natural fine aggregates. They suggested that optimum replacement of natural sand by manufactured sand is 50%. Luiz A. Pereira-de-Oliveira, João P. Castro-Gomes, Miguel C.S. Nepomuceno [5] the main objectives of this research is therefore to study the behavior of cement mortar specimen reinforced with acrylic fibers. The effect of aspect ratio (l/d) and volume fraction ($v_f$) of acrylic fibers on compressive and flexural strength were asset. For this purpose acrylic fibers volume were added to mortar mix at 0.2%, 0.5% and 1%.

## III. MATERIAL PARAMETER

For this investigation concrete cubes of size 150mm x 150mm x150mm, concrete cylinder of size 150mm diameter and 300mm long and prism specimens of size 100mm x 500mm, were casted.

### *A. Cement*

Cement is a material that has cohesive an adhesive properties in the presence of water. Such cements are called hydraulic cements. This consists of primarily silicates and aluminates of lime obtained from limestone and clay. There are different types of cements, out of which OPC is used. Ordinary Portland cement (OPC) is the basic Portland cement and its best suited for use in general concrete construction. It is of three types 33 grade, 43 grade, 53 grade. One of the the important benefits is the faster rate of development of strength. Ordinary Portland cement (OPC) available in the market conforming to IS 12269-1987 was used for casting the specimens. The cement used is 53 grade.

TABLE I CHEMICAL COMPOSITION (%) OF CEMENT

| Composition | OPC 53 grade |
|---|---|
| $Sio_2$ | 21.52 |
| $Al_2o_3$ | 6.16 |
| $Fe_2o_3$ | 4.60 |
| Cao | 63.36 |
| Mgo | 0.83 |
| $So_3$ | 1.87 |
| IR | 1.30 |
| Loss of ignition | 1.64 |

### *B. Fine aggregate*

It shouldbe passed through IS sieve 4.75 mm. It should have fineness modulus 2.50-3.50 and slit contents should not be more than 4%. Manufacturer's sand has been used for the present investigation; it is also called M-sand. Manufactured sand has been regularly used to make quality concrete for decades in india and abroad. M-sand is crushed aggregates produced from hard granite stone which is cubically shaped with grounded edges, washed and graded with consistency to be used as a substitute of river sand. It confirms to IS 383-1970 which comes under zone II.

TABLE II PHYSICAL PROPERTIES OF FINE AGGREGATE

| | |
|---|---|
| Specific gravity | 2.54 |
| Water absorption | 11% |

### *C. Coarse aggregate*

It should be hard, strong, dense, durable and clean. It mean be free from vein, adherent coatings and injurious amount of disintegrated pieces, alkalis, vegetable matters and otherdeleterious substances. It should be roughly cubical in shape. Flaky pieces should be avoided. It should confirm to IS 2838(I). Coarse aggregate used are of two sizes 20 mm maximum size and 12.5 mm minimum size.

TABLE III PHYSICAL PROPERTIES OF COARSE AGGREGATE

| | |
|---|---|
| Specific gravity | 2.778 |
| Water absorption | 0.25% |

### *D. Water*

Water should be free from acids, oils, alkalies, vegetables or other organic impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form the cement paste in which the inert aggregate are held in suspension until the cement paste has hardened. Secondly, it serves as a lubricant in the mixture of fine aggregates and cement.

### *E. Superplastizer*

In order to improve the workability of high performance concrete, superplasticizer in the form of poly-carboxylic either based superplasticizer (Glenium 8233) was used as chemical admixture. The product has specific gravity of 1.09 and solid content not less than 30% by weight of cementitious material.

### *F. Acrylic fiber*

Acrylic fibers are synthetic fibers made from a polymer (polyacrylonitrile) with an average molecular weigth of 1900 monomer units. For a fiber to be called "acrylic" in the united state, the polymer must contain at least 85% acrylonitrile monomer. Dupont created the first acrylic fibers in 1941 and trademarked them under the name orlon. Strong and warm, acrylic fiber is often used for sweaters and tracksuits and as linings for boots and gloves, as well as in furnishing fabrics and carpets. Application of acrylic fiber reinforced concrete used in construction. The thinner and stronger elements spread across entire section, when used in low dosage arrests cracking and increase flexural strength. Acrylic prevents the shrinkage cracks developed during curing making and component inherently stronger. Further when the loads imposed on concrete approach that for failure, cracks will propagate, sometimes rapidly. Addition of acrylic in concrete prevents/arrests cracking caused by volume change (expansion & contraction). The modulus of elasticity of acrylic is high with respect to the modulus of elasticity of the concrete. The acrylic fiber help increase flexural strength. Acrylic fiber are environmental friendly and non-hazardous.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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They easily disperse in the mix. Only 0.5-5% by cement acrylic is sufficient for getting the above advantages. Thus it not only pays for itself, but results in net gain with reduced labour cost and improved properties. Figure 1 represent the acrylic fiber used.

TABLE IV SPECIFICATION OF ACRYLIC FIBER

| | |
|---|---|
| Diameter (µm) | 14.4 |
| Length (mm) | 1.55 |
| Density (kg/m$^3$) | 1170 |
| Tensile strength(N/mm$^2$) | 690 |
| Elongation (%) | 15-20 |
| Acid resistance | Excellent |
| Alkali resistance | Good |

"Fig. 1 Acrylic fiber"

*G. Mix design*

The concrete mix is designed as per IS 10262-1982, IS 456-2000 and SP16 for the conventional concrete and finally river sand is replaced by M-sand. The water cement ratio and the mix proportions of M50 concrete with ratio of 1:1.472:3.043.

## IV. EXPERIEMENTAL INVESTIGATION

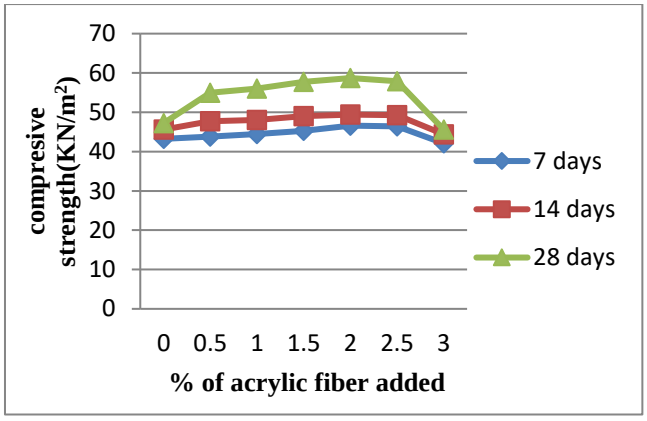
The results obtained from experimental tests conducted on hardened concrete for conventional and acrylic fiber reinforced concrete with fiber dosages of 0.5%, 1%,1.5%,2%,2.5%. Test details and results are discussed below.

*A. Water absorption test*

Cube specimens of size 150mm x 150mm x 150mm were cast for different dosage of acrylic fiber of 0.5%,1%,1.5%,2%, 2.5% and 3%. Results are tabulated in table 5 and plotted in the graph below,

TABLE V WATER ABSORPTION RESULTS

| Percentage of acrylic fiber added | Water absorption test(%) | |
|---|---|---|
| | *7 days* | *28 days* |
| 0 | 0.53 | 0.47 |
| 0.5 | 0.55 | 0.45 |
| 1 | 0.56 | 0.44 |
| 1.5 | 0.57 | 0.42 |
| 2 | 0.58 | 0.41 |
| 2.5 | 0.62 | 0.48 |

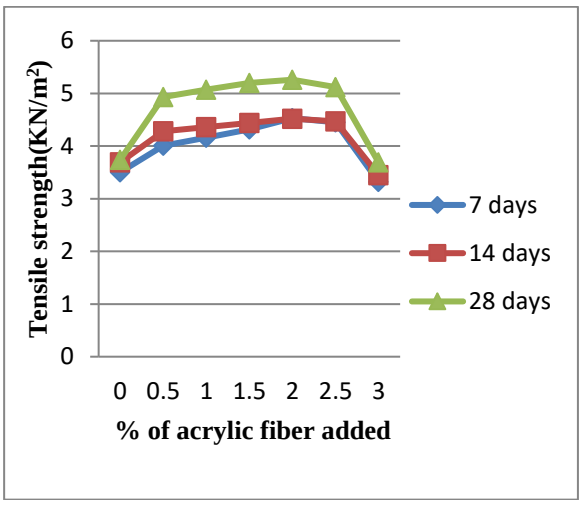



*B. Accelerated electrolytic corrosion test*

Cylindrical specimens of size 150 mm diameter x 300 mm in height were cast for varying dosage of acrylic fiber at 0.5%, 1%, 1.5% ,2% and 2.5% are tested for corrosion. To obtained results are tabulated in table 6 and plotted in the graph below,

TABLE VI ACCELERATED ELECTROLYTIC CORROSION TEST

| Percentage of acrylic fiber added | Accelerated electrolytic corrosion test(%) | |
|---|---|---|
| | *7 days* | *28 days* |
| 0 | 0.56 | 0.45 |
| 0.5 | 0.54 | 0.44 |
| 1 | 0.53 | 0.41 |
| 1.5 | 0.51 | 0.40 |
| 2 | 0.49 | 0.38 |
| 2.5 | 0.46 | 0.36 |




## V. CONCULSION

The following important conclusions were drawn based on the results obtained from the above mentioned tests,

- By increasing the addition of acrylic fiber dosages from 0% to 0.5%, 1%,1.5%,2%,2.5% and 3%, the workability decreases. Hence, superplasticizer

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

(Glenium 8233) was used in the dosage of 10ml to improve the workability.

- When compared to conventional concrete, compressive strength of M50grade for varying dosages of acrylic fiber at 0.5%,1%,1.5%,2% and 2.5% , increased durability respectively.
- If high durability is exhibited by the concrete specimen it establishes a good property for the structure.
- The acrylic fiber reduces the crack by filling the gap with fibers and minimizing interconnecting voids
- From the results it is observed that there is an increase in durability (water absorption test, accelerated electrolytic corrosion test) up to 2% of fibers by weight of concrete and decreases for 2.5% addition of fiber.

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