Polyolefin Fiber Reinforced Cementitious Mortar with Partial Replacement of Fine Aggregate by M- Sand

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Abstract:
Aggregate is the main of constituents of concrete. Natural sand is mainly excavated from river beds, and its removal in excess quantities is harmful to living beings, directly or indirectly. So, it is high time that we find an alternative material to replace natural fine aggregate, partially or fully. An alternative material that can be used in concrete is Manufactured Sand (M-Sand) which is produced by crushing gravel into finer parts, screening and washing. In this study, natural fine aggregate is replaced by manufactured sand in cement mortar in various proportions, viz., 0%, 10%, 20%, 30%, 40%, 50%, and 100%. Polyolefin fiber is added in various proportions, 0.5%, 1%, 1.5% and 2%. OPC 53 Grade, Sand- Cement ratio of 2:1 and Water-Cement ratio of 0.43 are used to prepare the cementitious matrix. Out of the various replacement percentages, the cement mortar with optimum strength is identified through hardened concrete tests such as compressive and split tensile strength tests. The test results have shown that there is a gradual increase in strength when M-Sand is replaced up to 100%. The compressive and split tensile strength is found to be optimum when polyolefin fiber is used at 1.5%.

Keywords: Natural Sand, Polyolefin Fiber Manufactured sand, crushing gravel, Split Tensile Strength.

1. INTRODUCTION
Fiber Reinforced Mortar (FRM) is used as a construction material since the 19th century which is developed as a wonderful construction material. Fiber Reinforced Mortar is composed of cement, mortar and suitable fibers. The use of fiber to reinforce a brittle material was done first by Egyptians who employed straw to reinforce sun baked bricks and horsehair to reinforce plaster material. In the early 1900’s, asbestos fiber was used in concrete. In 1960’s, the researchers found that the individuals who worked with or purchased products made from asbestos were developing respiratory problems, internal tissue scarring and even forms of cancer. The researchers found that even a small amount of asbestos can lead to all of these health issues (like cancer). Hence the production of asbestos fiber was halted and items containing the material were destroyed. Huge construction activity in India has resulted in mining of fine aggregate in large quantities from river beds. Sand mining from river beds leads to erosion of river banks, degradation of river beds, encroachment with river buffer zone and deterioration of water quality of rivers. Excess removal of fine aggregate from beds may change the morphology of the river beds affecting the quality of aquatic habitat. By removing the sand from river beds in enormous quantities for construction purposes, there are chances that the natural equilibrium of a stream channel is distorted. In order to protect the natural resources like fine aggregate which is under great demand, Manufactured Sand (M-sand) can be partially or fully replaced with fine aggregate in concrete and cement mortar.

2. METHODOLOGY
The present study brings out the experimental investigation, testing of materials and casting of specimens. Required materials were procured for casting and various strength tests were performed.
The materials, cement, fine aggregate, M-sand, potable water and polyolefin fiber in required quantities were arranged. Cubes and cylinders have been cast (replicate specimens) and tested at 7 days and 28 days. The test specimens were cast with hydraulic cement mortar cement and polyolefin fiber in varying proportions, 0.5%, 1%, 1.5% and 2% are tested. The results of the test specimens were compared with control specimens.

3. MANUFACTURED SAND
Manufactured Sand (M-Sand) is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of M-Sand is less than 4.75 mm. M-Sand is well graded in the required proportion. It does not contain organic and soluble compound that affects the setting time and properties of cement, thus the required strength of concrete can be maintained. It does not have the presence of impurities such as clay, dust and silt coatings. It does not increase the water requirement as in the case of fine aggregate which impairs the bond between cement paste and aggregate. Thus, increased quality and durability of concrete is achieved with M-Sand. M-Sand is obtained from specific hard rock (granite) using the state of- the- art technology, thus the required property of sand is obtained. M-Sand is cubical in shape and is Manufactured using technology like High carbon steel hit rock and then rock to rock process which is synonymous to that of natural process in the case of fine aggregate. Modern and imported machines are used to produce M-Sand to ensure required grading zone for the sand.
1. POLYOLEFIN FIBER
Polyolefin fiber used in this study is 0.52 mm diameter and length 54 mm. The polyolefin fiber is white in color. Polyolefin fiber has been used in this study in various volume fraction, 0.5%, 1.0%, 1.5%, and 2.0% of the volume of specimen.

2. TEST FOR SPECIMEN
Testing of hardened mortar specimens with and without fiber is tested to determine the required compressive and split tensile strength of cement mortar. Compressive Strength Test of the cube has been as per IS 1199-1959. The cube mould of size 100mm x 100mm x 100mm were cast at 7 and 28 days. The cubes were tested in compressive testing machine. Failure load was noted and compressive strength was calculated by using the formula (C = P/A).

Density of the specimen: The density of the hardened cement mortar is determined by weighing the specimens and dividing the value by volume of specimens. When fine aggregate is used at 100% (i.e., M-Sand at 0%) in cement mortar, the density value is 2237 kg/m. But the density value show a consistent increase from 2237 to 2260 kg/m when M-sand replacement percentage is increased from 0 to 100%. When M-sand is replaced at 100%, the density value is 2260 kg/m. When M-sand is replaced for fine aggregate at 100% and with addition of polyolefin fiber in cement mortar; the density value is 2282 kg/m³. When fiber is added at various proportions (Vf =0.5%, 1%, 1.5% and 2%), the density value decreases from 2282 to 2260 kg/m³. The density value is 2260 kg/m³ when polyolefin fiber is added at Vf = 2.0%. Compressive Strength: When fine aggregate is replaced with M-Sand at 100%, the compressive strength at 28 days is 34 N/mm², and when fine aggregate is used at 100% (i.e., M-Sand 0%), the compressive strength at 28 days is 31 N/mm², when M-sand is added at 100%, the compressive strength value has gradually increased from 24 to 29 N/mm² at 7 days and 36 to 40 N/mm² at 28 days, when polyolefin fiber is added is from 0.5 to 1.5%. The maximum value of compressive strength at 28 days is 40 N/mm² with an optimum value of 1.5%. The maximum value of compressive strength at 7 days is 31 N/mm² with an optimum value of 1.5%. The optimum compressive strength of 38 N/mm² is achieved at an optimum polyolefin fiber Vf of 1.5%. The increase in percentage between 0.5% and 1% is 11%. The percentage increase in compressive strength is 0 to 0.5%, 0.5 to 1.0%, 1.0 to 1.5%, 1.5% to 2.0 are 2.8%, 11%, 5.2% respectively. The percentage difference in compressive strength for 0 to 1%, 0 to 1.5%, 0 to 2% is 8.5%, 14.2% and 12.9% respectively.

4. RESULT AND DISCUSSION
In the present study, mortar cubes of size 100 mm x 100 mm x 100 mm and cylinders of size 100 mm x 200 mm were cast to determine the compressive and split tensile strength of cement mortar. Density of the specimens has been determined. The results of various replacement percentages of fines aggregate with partial replacement of M-Sand in various percentages, 10%, 20%, 30%, 40%, 50% and 100% have been brought out.
Split Tensile Strength Test: When M-sand is used in cement mortar at 100%, the split tensile strength value at 28 days is found to be 5.73 N/mm$^2$, whereas for fine aggregate of 100% in cement mortar, the tensile strength is only 2.12 N/mm$^2$. When M-sand is increased from 30% and 40%, the split tensile strength is found to be 18.18%. The maximum increase in split tensile strength of 13.5% is achieved when M-sand is replaced at 30%. The split tensile strength has gradually increased from 2.33 to 3.71 N/mm$^2$ at 7 days and 3.50 N/mm$^2$ to 5.57 N/mm$^2$ at 28 days, when polyolefin fiber is added from 0.5 to 1.5%. The peak value is obtained at 4.06 N/mm$^2$ at 7 days, when fiber is added at Vf = 1.5%. The peak value is obtained at 6.21 N/mm$^2$, when fiber is added at Vf = 1.5%.

5. CONCLUSION
A study is conducted on fibre reinforced cementitious mortar with replacement of Fine Aggregate by M-Sand and also adding polyolefin fibers in various volume fraction Vf = 0.5%, 1%, 1.5% and 2%. In this project, M- Sand is replaced with sand at various replacement percentages of 0%, 10%, 20%, 30%, 40%, 50% and 100%. The compressive and split tensile strength was conducted at 7 and 28 days. It was found that the optimum fibre percentage is 1.5% and corresponding compressive and split tensile strength are 40 and 6.21 N/mm$^2$ respectively showing an increase of 14.2% and 21.14%. This work concludes that as polyolefin fibers increase the compressive and split tensile strength in cement mortar, this product can be recommended as a high strength cementitious composite in the construction industries.

6. REFERENCES


