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# Research on Strength and Durability of Concrete Manufactured with Artificial Sand

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**Annotation:** The use of synthetic sand in concrete has attracted the interest of numerous academics all over the world. The growing demand for fine aggregate for the needs of building is greater than the supply of limited natural sand that is currently available. The physical properties of naturally occurring river sand and man-made sand should be compared (M-sand). The current study focused on the M30, M40, and M50 mixtures. The modulus of elasticity (MOE) was calculated by altering the proportion of M-sand from 0 to 100%. To determine the optimal percentage of manufactured sand, the aforementioned mixes were also evaluated for sorptivity and impact resistance. Moreover, microscopic studies were performed using scanning electron microscopy (SEM) and electron dispersive spectroscopy (EDS). Yet, as concrete grade and M-sand content increased, sorptivity was found to decrease. Also, a comparison between experimental MOE values and IS code results was done. According to microscopic investigations, M-sand has an angular and rough surface in comparison to natural sand, which is thought to be the cause of the material's improved MOE and impact resistance as well as its decreased sorptivity.

**Keywords:** impact resistance, modulus of elasticity, manufactured sand, sorptivity.

## I. INTRODUCTION

Concrete has regularly been used as a building material for the nation's sustainable development. The demand for fine aggregate has sky rocketed as a result of the rising use of concrete. The natural river sand, though, has been utilized as a fine aggregate for concrete. Because it is a ordinary resource, fine aggregate used in concrete manufacture eventually runs out. Due to its decreasing availability and rising transportation costs from the riverbed to the construction site or concrete batching plant, using natural river sand has become exceedingly luxurious. Moreover, removing the natural sand from a riverbed alters the river's direction, the local water table, and consequently environmental problems. The global research community has been interested in this cascade impact of using natural river sand. Making concrete with manufactured sand (M-sand) rather of regular river sand is one way to solve this issue. The natural granite stone is crushed in vertical shaft impact crushers to produce M-sand, which is then screened to remove any fine particles smaller than 4.75mm. The impact of M-sand on the strength and durability of concrete has been the subject of certain investigations. This is a discussion of a few significant important research findings. According to Patel and Pitroda [1], the MOE decreased when fly ash was present relative to the control mix. When the 40% of cement was substituted by fly ash, it was revealed that MOE decreased by 53.79% and 46.43% for concrete grades M25 and M40, respectively. According to Pitroda and Umrigar [2], similar results were obtained when fly ash and hypo sludge were used as cementitious materials. It was demonstrated that replacing 40% of the cement with hypo sludge and fly ash was successful. For M25 and M40 grade mixtures, volume caused a drop in MOE of 32.50% and 31.12%, respectively.

## II. MATERIALS

The following lists the materials used for the current experimental study and the pertinent attributes.

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**Cement**

For the experimental work, ordinary portland cement (OPC) of grade 53 conforming to IS 12269 - 1987 was employed. Table No. 1 displays the OPC's characteristics.

| Property | Value |
|---|---|
| Specific gravity | 3.15 |
| Initial setting time | 33 min. |
| Final setting time | 385 min. |
| Fineness $m^2$ / Kg. | 270.80 |
| Soundness | 1.00 mm |
| Standard consistency | 31% |
| Compressive strength 7 days | 43.50 MPa |
| Compressive strength 28 days | MPa |

**Table-1** Physical properties of cement

**Coarse aggregates**

By breaking locally accessible granite stone, aggregates were produced. The aggregate's largest possible size was 20 mm. The study used a combination of aggregates with sizes of 20 mm and 12.50 mm. IS 389-1989 was verified for the aggregates.

| Property | Coarse aggregate | Fine aggregate | |
|---|---|---|---|
| | | River sand | M-sand |
| Specific gravity | 2.70 | 2.60 | 2.45 |
| Bulk density (kg/$m^3$) | 1510 | 1460 | 1556 |
| Water absorption (%) | 0.45 | 1.15 | 1.00 |
| Moisture content (%) | 0.85 | 1.10 | 1.15 |
| Aggregate impact value (%) | 12.50 | - | - |
| Fineness modules | 6.67 | 3.44 | 3.54 |
| Fineness particles Less than 150mm (%) | - | 4.14 | 5.30 |

**Table-2** Physical properties of coarse aggregate and fine aggregates

**Fine aggregates**

Locally available natural sand was used as fine aggregate. The fine aggregate used was confirmed to IS 389-1989. The physical properties calculated are presented in Table-2. Locally available granite boulders were used to obtain the artificial sand. The granite boulders were fed into the crusher and output was thoroughly screened to the required size and shape to eliminate the unwanted micro- fines. Then the screened fine aggregate was washed with water to obtain clean M-sand. The physical properties of manufactured sand were evaluated and are presented in Table-2. It was found form the sieve analysis that both natural river sand and M-sand were in zone-II.

**Mix proportion**

According to the requirements outlined in IS: 10262-2009(15) and IS: 456-2000, concrete mixes M30, M40, and M50 grades were created (16). Table 3 displays the mix proportions developed and the w/c ratio utilised for the control mix and the mix with 100% M-sand replacement.

| MixID | M30 | | M40 | | M50 | |
|---|---|---|---|---|---|---|
| | Mix proportion | w/c ratio | Mix proportion | w/c ratio | Mix proportion | w/c ratio |
| M1 | 1:2:3.53 | 0.45 | 1:1.69:3.13 | 0.40 | 1:1.54:2.97 | 0.35 |
| M11 | 1:1.88:3.53 | 0.45 | 1:1.6:3.13 | 0.40 | 1:1.45:2.97 | 0.35 |

**Table-3** Mix proportions and w/c ratio for various grades

## III. METHODOLOGY

### Modulus of elasticity

The moulds used were cylindrical, 150 mm in diameter and 300 mm long. The concrete specimen samples were left in the moulds for 24 hours after being cast. After 24 hours, the specimens were taken out of the moulds and allowed to cure for 28 days in the water tank. The sample was maintained in an open environment for two to three hours prior to testing before being taken for the test. The dial gauge was positioned so that the gauge points were symmetrical around the specimen's centre. After an average stress of (C+5) Kg/cm2 was obtained, the load was applied continuously at a rate of 140 Kg/cm2/minute, where "C" stands for the average compressive strength of the cubes, calculated to the nearest 5 Kg/cm2.

The load was maintained at this stress for at least one minute before being gradually lowered at an average stress of 1.5 kg/cm2, at which point the reading was collected. Once more, the load was applied at the same pace until the compressometer readout reached an average stress of (C + 1.5) Kg/cm2. The reading was recorded after the load was gradually decreased to 1.5 Kg/cm2. The extensometer results were taken after the third application of the load.

### Impact resistance

The impact test was conducted in accordance with the methods for impact testing that ACI Committee 544 has advised. The test involved repeatedly striking a 64mm (2.5 inch) hardened steel ball that was put on top of the centre of the cylindrical specimen (disc) with a hammer that weighed 44.7N (10 lb) from a height of 457mm (18 inch). The test was carried out until it failed. The number of blows for the initial fracture and the ultimate crack on each specimen were counted. The former figure gauges the number of blows needed to start a crack that is visible, whereas the latter gauges the number of blows needed to start cracks that eventually fail.

### Sorptivity

In accordance with ASTM C 1585-04, cylindrical specimens of 100 mm x 50 mm were cast to measure the sorptivity. The samples were cured for 28 days in water. For three days, concrete samples were oven-dried at 50 2 oC. The samples were kept in a sealable container for 15 days after 3 days. measures were taken measures are taken to ensure that the specimen has little to no contact with the container walls, allowing unrestricted circulation of air around it. The specimens' weights were recorded and their sides were sealed after 15 days. The specimen's average diameter was measured, and the top surface was sealed as well. After placing the samples in water, the stopwatch was started. At intervals of 1 minute, 5 minutes, 10 minutes, 20 minutes, 30 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, 7 days, and 8 days, the mass of the specimen was recorded.

## IV. RESULT AND DISCUSSIONS

### Modulus of elasticity

According to Table 4, it is clear that adding more M-sand improved the MOE up until mix M8, which contained 30% river sand and 70% M-sand. The MOE of concrete was adversely affected by additional M-sand addition. Also, it can be shown that with an increase in concrete grade, greater MOE was seen for the same mix. While there was a greater performance disparity between M30 and M40 in MOE, there was a smaller performance gap for the mixes M40 and M50. For concrete of the M30, M40, and M50 grades, respectively, a maximum increase of roughly 11%, 10%, and 12% in MOE was noted.

| Mix | Modulus of elasticity (GPa) |
|---|---|

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| | M30 | M40 | M50 |
|---|---|---|---|
| M1 | 33.10 | 39.40 | 39.90 |
| M2 | 33.50 | 39.80 | 41.20 |
| M3 | 33.80 | 39.80 | 41.40 |
| M4 | 34.20 | 39.90 | 41.80 |
| M5 | 34.80 | 41.20 | 42.00 |
| M6 | 35.50 | 41.40 | 42.80 |
| M7 | 36.00 | 41.80 | 43.60 |
| M8 | 36.40 | 43.20 | 44.80 |
| M9 | 36.80 | 42.20 | 43.00 |
| M10 | 35.50 | 41.80 | 42.80 |
| M11 | 35.00 | 41.20 | 42.60 |

**Table-4** Modulus of elasticity test results

**Impact resistance**

Table 5 lists the number of strikes the specimens received prior to the initial crack and the final crack. At first look, it is clear that an increase in concrete grade provided greater impact loading resistance for a given proportion of river sand and M-sand. It was found that the specimen that required more blows to cause the initial crack also required more blows to cause the final crack.

| Mix | No. of blows | |
|---|---|---|
| | First crack | Rupture |
| M30-M1 | 45 | 99 |
| M30-M8 | 51 | 116 |
| M30-M11 | 49 | 112 |
| M40-M1 | 98 | 135 |
| M40-M8 | 109 | 147 |
| M40-M11 | 107 | 143 |
| M50-M1 | 104 | 145 |
| M50-M8 | 124 | 154 |
| M50-M11 | 121 | 147 |

**Table-5** Impact resistance of various mix proportions.

**Sorptivity**

The water absorption capabilities of various concrete specimens in a unilateral orientation. In order to calculate the initial rate of absorption (IRA) and secondary rate of absorption, the total weight of water absorbed across a range of time periods was measured and shown on graphs (SRA). With the identical ratios of river sand and M-sand, it was found that higher-grade concrete had lower IRA and SRA. Also, it was observed that IRA and SRA values decreased as the proportion of M-sand increased.

## V. CONCLUSIONS

We have learned more about the presentation of M-sand in concrete through experimental tests that were done both with and without M-sand. The experimental investigation can be used to draw the following findings.

The mix design of concrete utilizing M-sand as a partial and full replacement of cement was developed using a weighted average technique based on the specific gravity of the river sand and the M-sand.

The presence of M-sand resulted in a small improvement in MOE. As comparison to other ratios, a relative

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percentage of 30% Natural River sand and 70% M-sand produced better MOE.

The impact resistance of concrete was positively impacted by the presence of M-sand. M8 mix outperformed the control and M11 mixes in terms of performance.

Compared to the control mix, the addition of M-sand slowed the rate at which water was absorbed.

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