

COMPARISON STUDY ON MECHANICAL PROPERTIES OF CONCRETE WITH WATERWASHED AND AIR WASHED MANUFACTURED SAND

Pradeepa.S¹, R.L. Sreenivasa²

¹Assistant Professor, Department of Civil Engineering, SIR MVIT, Karnataka, India

²Professor, Department of Civil Engineering, B.M.S.C.E, Karnataka, India

Abstract

The present experimental investigation makes an attempt to study the properties of concrete containing water washed Manufactured sand(M-sand) and air washed M-sand. In this experimental study both the types of M-sand were tested for their physical properties. M20 and M30 grade of concrete were selected in which natural sand was replaced by water washed M-sand and air washed M-sand at 25% increment levels. The results revealed that concrete with water washed M-sand had higher compressive, tensile and flexural strength when compared to air washed M-sand. Also it is observed that, with increase in percentage of M-sand, performance of concrete with respect to mechanical properties were improved.

Keywords: - Water Washed M-Sand, Air Washed M-Sand, Concrete Properties.

1. INTRODUCTION

Concrete is a great versatile and most consumed man made material. It is a competitive building material and also a valuable source of societal development. Production of concrete depends upon the availability of materials, such as cement, fine aggregates and coarse aggregate. The increasing demand for the production of concrete has led to depletion of aggregate resources especially the fine aggregates. To address this issue various types of waste materials were experimented for the replacement of fine aggregates. Manufactured sand (M-sand) is one of the recently developed alternative materials for the natural sand.

M-sand is obtained from the crushing of rocks. In the process of manufacture of M-sand, broadly two types can be obtained, namely air washed and water washed M-sand. Research is being carried out to study the effect of air washed M-sand and water washed M-sand, on the mechanical properties of concrete. In this paper the study on variations of properties of concrete by these two types of M-sand is presented. Also the observed effect on the mechanical properties of concrete for incremental replacement of river sand with these two types of M-sand is presented. Finally the best alternative to the river sand is proposed.

2. MATERIALS

Materials used in this study are, ordinary Portland cement, river sand, air washed M-sand, water washed M-sand, granite coarse aggregates and potable water.

2.1 Mix Design

M20 grade of concrete with w/c ratio 0.5 and M30 grade of concrete with w/c ratio 0.45 has been selected. Mix design is carried out as per IS 10262:2009. River sand is replaced at increments of 25% by air washed M-sand. Similarly by water washed M-sand.

2.2 Test Specimens and Procedure

Cubes of size 150X150X150 mm, cylinders of size 100mm diameter and 300mm length, prisms of size 100X100X500 mm were used. All the specimens were tested after 28 days. The constituents were weighed and the materials were mixed and compacted thoroughly. The specimens were demoulded after 24hrs, cured in water for 28 days and then tested. The tests were conducted according to IS: 516- 1959.

3. RESULTS AND DISCUSSIONS

3.1 Material Property

Both the materials air washed and water washed M-sand were obtained from standard company and then its physical properties are tested.

The physical properties tests such as, specific gravity, water absorption, sieve analysis tests were carried out. The obtained results are tabulated in the following tables.

Table 1: Physical property of water washed M-Sand

| S. No | Property | Values |
|-------|------------------|---------|
| 1 | Specific gravity | 2.48 |
| 2 | Water absorption | 1.2% |
| 3 | Sieve analysis | Zone II |

Table 2: Physical property of air washed M-Sand

| S. No | Property | Values |
|-------|------------------|---------|
| 1 | Specific gravity | 2.34 |
| 2 | Water absorption | 1.1% |
| 3 | Sieve analysis | Zone II |

Table 3: Physical property of river Sand

| S. No | Property | Values |
|-------|------------------|---------|
| 1 | Specific gravity | 2.59 |
| 2 | Water absorption | 1.51% |
| 3 | Sieve analysis | Zone II |

All the materials locally available in and around Bengaluru, Karnataka state, India were used in this study. From the properties of river sand and M-sand, we can infer that, all the sands confirms to same zone but having different specific gravities and water absorption. We can also observe that both the M-sand is angular in shape but the river sand is cubical in shape.

3.2 Concrete Testing

3.2.1 Compressive Strength Tests

The compression tests were carried out in compression testing machine to determine the compressive strength of the partially replaced river sand with water washed and air washed M-Sand concrete cubes after 7, 14 and 28 days. The results are tabulated in Tables 4 to 7.

Table 4: Compressive strength of M20 grade concrete with different proportions of water washed M-sand

| Percentage replacement of river sand by water washed M-Sand | Compressive strength (MPa) | | |
|---|----------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M-Sand | 15.59 | 22.61 | 28.58 |
| 25% M-Sand | 16.57 | 22.23 | 29.11 |
| 50% M-Sand | 18.75 | 22.75 | 29.54 |
| 75% M-Sand | 19.12 | 24.87 | 31.19 |
| 100% M-Sand | 20.49 | 28.14 | 32.14 |

Table 5: Compressive strength of M20 grade concrete With different proportions of air washed M-sand

| Percentage replacement of river sand by air washed M-Sand | Compressive strength (MPa) | | |
|---|----------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M-Sand | 13.47 | 20.61 | 26.52 |
| 25% M-Sand | 13.48 | 21.26 | 27.13 |
| 50% M-Sand | 15.75 | 21.75 | 27.57 |
| 75% M-Sand | 18.22 | 25.81 | 29.47 |
| 100% M-Sand | 19.32 | 26.16 | 29.84 |

Table 6: Compressive strength of M30 grade concrete with different proportions of water washed M-sand

| Percentage replacement of river sand by M-Sand | Compressive strength (MPa) | | |
|--|----------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M-Sand | 28.61 | 33.84 | 37.47 |
| 25% M-Sand | 28.63 | 33.99 | 36.56 |
| 50% M-Sand | 28.89 | 35.12 | 37.32 |
| 75% M-Sand | 29.75 | 35.95 | 37.79 |
| 100% M-Sand | 30.81 | 36.79 | 39.96 |

Table 7: Compressive strength of M30 grade concrete with different proportions of air washed M-sand

| Percentage replacement of river sand by M-Sand | Compressive strength(MPa) | | |
|--|---------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M-Sand | 26.16 | 33.35 | 34.12 |
| 25% M-Sand | 26.23 | 33.79 | 34.45 |
| 50% M-Sand | 26.89 | 34.23 | 34.89 |
| 75% M-Sand | 27.75 | 35.11 | 35.36 |
| 100% M-Sand | 28.16 | 35.17 | 36.11 |

3.2.2 Split Tensile Strength Tests

The split tensile strength tests were carried out on cylinders in compression testing machine to determine the tensile strength of the M20 and M30 grades of concretes, which are partially replaced river sand with water washed and air washed M-sand, after 7, 14 and 28 days. The results are tabulated in Tables 8 to 11.

Table 8: Split tensile strength of M20 grade concrete for various replacement percentages of water washed M-Sand

| Percentage replacement of river sand by M-Sand | Split tensile strength (MPa) | | |
|--|------------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M-Sand | 1.74 | 2.69 | 2.87 |
| 25% M-Sand | 1.82 | 2.72 | 2.91 |
| 50% M-Sand | 1.83 | 2.79 | 3.26 |
| 75% M-Sand | 1.96 | 2.83 | 3.41 |
| 100% M-Sand | 2.31 | 2.85 | 3.45 |

Table 9: Split tensile strength of M20 grade concrete for various replacement percentages of air washed M-Sand

| Percentage replacement of river sand by M-Sand | Split tensile strength | | |
|--|------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M Sand | 1.65 | 2.62 | 2.78 |
| 25% M Sand | 1.75 | 2.65 | 2.88 |
| 50% M Sand | 1.8 | 2.74 | 3.11 |
| 75% M Sand | 1.89 | 2.81 | 3.21 |
| 100% M Sand | 2.11 | 2.84 | 3.32 |

Table 10: Split tensile strength of M30 grade concrete for various replacement percentages of water washed M-Sand

| Percentage replacement of river sand by M-Sand | Split tensile strength (MPa) | | |
|--|------------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M-Sand | 2.44 | 3.35 | 3.71 |
| 25% M-Sand | 2.41 | 3.39 | 3.72 |
| 50% M-Sand | 2.43 | 3.48 | 3.81 |
| 75% M-Sand | 2.75 | 3.56 | 3.86 |
| 100% M-Sand | 2.98 | 3.69 | 4.11 |

Table 11: Split tensile strength of M30 grade concrete for various replacement percentages of air washed M-Sand

| Percentage replacement of river sand by M-Sand | Split tensile strength | | |
|--|------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M Sand | 2.41 | 3.28 | 3.69 |
| 25% M Sand | 2.41 | 3.31 | 3.70 |
| 50% M Sand | 2.42 | 3.42 | 3.78 |
| 75% M Sand | 2.68 | 3.51 | 3.81 |
| 100% M Sand | 2.91 | 3.63 | 3.97 |

3.2.3 Flexural Strength Test

The flexural strength tests were carried out on prisms in Universal Testing Machine (UTM) to determine the flexural strength of the M20 and M30 grades of concretes, which are partially replaced river sand with water washed and air washed M-sand, after 7, 14 and 28 days. The results are tabulated in Tables 12 to 15.

Table 12: Flexural strength of M20 for various replacement percentages of water washed M-Sand

| Percentage replacement of river sand by M-Sand | Flexural strength (MPa) | | |
|--|-------------------------|--------|--------|
| | 7days | 14days | 28days |
| 0% M-Sand | 4.74 | 5.54 | 5.78 |
| 25% M-Sand | 4.87 | 5.61 | 5.94 |
| 50% M-Sand | 4.91 | 5.89 | 6.12 |
| 75% M-Sand | 5.04 | 6.11 | 6.21 |
| 100% M-Sand | 5.44 | 6.56 | 6.43 |

Table 13: Flexural strength of M20 grade concrete for various replacement percentages of air washed M- Sand

| Percentage replacement of river sand by M-Sand | Flexural strength (MPa) | | |
|--|-------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M-Sand | 4.68 | 5.47 | 5.68 |
| 25% M-Sand | 4.81 | 5.58 | 5.87 |
| 50% M-Sand | 4.88 | 5.81 | 5.99 |
| 75% M-Sand | 5.01 | 5.99 | 6.17 |
| 100% M-Sand | 5.31 | 6.46 | 6.38 |

Table 14: Flexural strength of M30 grade concrete for various replacement percentages of water washed M-Sand

| Percentage replacement of river sand by M-Sand | Flexural strength (MPa) | | |
|--|-------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M-Sand | 5.07 | 5.99 | 6.39 |
| 25% M-Sand | 5.12 | 6.03 | 6.45 |
| 50% M-Sand | 5.61 | 6.87 | 7.01 |
| 75% M-Sand | 5.85 | 6.97 | 7.18 |
| 100% M-Sand | 6.02 | 7.13 | 7.40 |

Table 15: Flexural strength of M30 grade concrete for various replacement percentages of air washed M-Sand

| Percentage replacement of river sand by M-Sand | Flexural strength (MPa) | | |
|--|-------------------------|---------|--------|
| | 7days | 14 days | 28days |
| 0% M-Sand | 5.01 | 5.86 | 6.29 |
| 25% M-Sand | 5.08 | 5.99 | 6.38 |
| 50% M-Sand | 5.56 | 6.82 | 6.97 |
| 75% M-Sand | 5.79 | 6.92 | 7.11 |
| 100% M-Sand | 5.98 | 7.11 | 7.38 |

4. CONCLUSION

Results were analyzed to derive conclusions regarding the strength characteristics of concrete in compression, tension and flexure, with replacement of natural sand with M-Sand in different proportions for M20 and M30 concrete grades. The following conclusions are drawn from the study:

- From the above experimental results it is proved that, M-sand can be used as replacement for the natural sand.
- The superior shape, proper gradation, and surface texture of M-Sand provides greater strength.
- The both types of M-Sand gives better strength in compression, tension and flexure when compare to river sand.
- Water washed M-sand exhibited better strength in compression, tension and flexure when compared to air washed M-sand.
- The M-Sand is a best alternative for natural river sand in terms of strength.
- The dwindling sources of natural sand and its high cost could encourage the adoption of M-Sand by replacement of natural river sand.
- The cost of M-Sand is less comparative to river sand and is easily available.

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