

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

Partial Replacement of M-Sand on Concrete by Self Curing and Standard Curing Method

N.R.Monika¹, S.Sarankokila²

Assistant Professor, Department of Civil Engineering, Nandha Engineering College, Erode, Tamilnadu, India¹

Assistant Professor, Department of Civil Engineering, Nandha Engineering College, Erode, Tamilnadu, India²

ABSTRACT: The volume of concrete consumed by the construction industry is very large. About 35% volume of concrete is comprised of sand. The fine aggregates or sand used is usually obtained from natural sources specially river beds or river banks. Now-a-days due to scarcity of river sand the only option to this problem is the use of artificial sand or M - sand. The material is obtained by crushing the rocks. The M sand is easily available and has shown better results as compared to the natural sand. In this project the natural sand was replaced with M Sand by 50% proportions. Plain concrete needs for a minimum period of 28 days curing to attain good strength. The present study involves the use of polyethylene glycol 400(PEG 400) in concrete which helps in self-curing and helps in better hydration and hence strength. It also shows the effect of admixture (PEG 400) on compressive strength, split tensile strength and flexural strength by varying the percentage of PEG by weight of cement by 0.3%, 0.5%, 0.7% were studied for 50% replacement of M-Sand on M25. An experimental results shows that the quality of M-Sand is better than the river sand in all aspects sand self-curing gives better results as compared to the standard moist curing.

KEYWORDS: Natural river sand, M-Sand, Self curing, Standard curing, Polyethylene Glycol.

I. INTRODUCTION

Quality of construction is the most important aspect under consideration in the construction sector. Sand is the one of the main constituents of concrete making which is about 35% of volume of concrete used in construction industry. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete. Natural sand is mainly excavated from river beds and always contain high percentage of in organic materials, chlorides, sulphates, silt and clay that adversely affect the strength, durability of concrete and reinforcing steel there by reducing the life of structure, when concrete is used for buildings in aggressive environments, marine structures, nuclear structures, tunnels, precast units, etc.

M-SAND AS SUBSTITUTE FOR RIVER SAND

When rock is crushed and sized in a quarry the main aim has generally been to produce coarse aggregates and road construction materials meeting certain specifications. Generally, this process has left over proportion of excess fines of variable properties, generally finer than 5 mm size. The premixed concrete industry has for sometimes find ways to utilise this material as a controlled replacement of natural sand. In order to do this it has been recognised that provided the materials appropriately processed and selected from suitable materials then a sand replacement can be produced to meet the highest quality concrete specification. Manufactured sand is defined as a purpose-made crushed fine aggregate produced from a suitable source material.. In some cases, natural sand may not be of good quality. The quality of the river sand normally depends on its source and most of the time it varies quite a lot. Therefore, it is necessary to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete. Adams Joe et al [1] discussed about the effect of M-Sand in High Performance Concrete. It is proposed to determine and compare the differences in properties of concrete containing river sand and M-sand. It is also proposed to use steel fibres and chemical admixtures to increase the strength and workability of concrete respectively. Arivalagan et al [2] described about the properties of concrete using M-Sand as fine aggregate. KalyaniBhutada et al [3] was found

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Issue 12, December 2015

that compressive strength of the concrete increases with artificial sand. Karugu et al [4] said that Crushed rock sand improved most of the concrete properties. In [5] the authors prescribed that the Split tensile strength of self-cured cylinder specimen is higher than that of conventionally cured specimen.

IMPORTANCE OF SELF CURING

Some specific water-soluble chemicals added during the mixing can reduce water evaporation from and within the set concrete, making it 'self-curing'. The chemical should have abilities to reduce evaporation from solution and to improve water retention in ordinary Portland cement matrix. The self curing concrete has been done by using shrinkage reducing admixture. Here polyethylene glycol (400) is one of the shrinkage reducing admixture used in the concrete to make it as a self curing.

II. MATERIALS USED

GENERAL

The investigation was done on materials that is used in the concrete such as cement, fine aggregate, coarse aggregate, M-Sand. This lead to the use of calculating the mix design, quantity calculation etc.

PROPERTIES OF MATERIAL

The properties of each material in a concrete mix where studied at the early stage. Different tests were conducted for each material as specified by relevant IS codes.

CEMENT

Cement is the product obtained by burning a well proportion mixture of material such as lime stone, argillaceous materials such as clay at very high temperature. It has adhesive and cohesive properties and it is shown in below table 1 . It is a binding material used with stone, brick, building blocks, etc...The cement used for the test specimens is OPC – 53 grade conforming to IS 12269:1987.

Table 1 Properties of Cement

| S.No. | Property | Value |
|-------|----------------------|---------|
| 1 | Specific gravity | 3.15 |
| 2 | Fineness | 97.25 |
| 3 | Initial setting time | 45 Min |
| 4 | Final setting time | 385 Min |
| 5 | Fineness modulus | 6% |

FINE AGGREGATE

Sand is primarily filler for the voids in concrete. Increasing the proportion of sand in the total mix increases cement demand because of the relatively very large surface area that needs to be coated by cement paste. The properties of fine aggregate is shown in below table2. Flat elongated and angular shaped sand such as products from crushed sand, also require more water to produce workable concrete. Hence, cement demand is increased to maintain the same W/C Ratio. Locally available river sand having bulk density 1860 kg/m³ was used. River sand is sieved to 4.75 mm and the passed out sand is used.

Table 2 Properties of Fine Aggregate

| S.No. | Property | Value |
|-------|------------------|--------|
| 1 | Specific gravity | 2.65 |
| 2 | Fineness modulus | 5.2 |
| 3 | Water absorption | 7.0% |
| 4 | Surface texture | smooth |

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

COARSE AGGREGATE

The coarse aggregate properties are shown in below table 3. Beyond this, a smaller sized aggregate may have strength advantages in that internal weak planes may be less likely to exist or would be smaller and discontinuous. A rough angular surface such as in crushed aggregates will increased for a given slump, the water and cement content per cubic meter of concrete are decreased. Coarse aggregate having bulk density 1691 kg/m³. Coarse aggregate is sieved to 20 mm and the passed out is used.

Table 3 Properties of Coarse Aggregate

| S.No. | Property | Value |
|-------|------------------|-------|
| 1 | Specific gravity | 2.68 |
| 2 | Fineness modulus | 6.75 |
| 3 | Water absorption | 2.5% |

MANUFACTURED SAND

Manufactured sand or M-Sand, as it is popularly known is made by powdering hard granite rocks using heavy machinery. It's particles are cubical in shape and finely graded and hence provides greater durability and higher strength to concrete by overcoming deficiencies like segregation, bleeding, honey combing, voids and capillary.

PROPERTIES OF MANUFACTURED SAND:

Greater durability

M-Sand has balanced physical and chemical properties that can withstand any aggressive environmental and climatic conditions as it has enhanced durability, greater strength and overall economy. Usage of M-Sand can overcome the defects occurring in concrete such as honey combing, segregation, voids, etc.

High Strength

The physical properties of sand provide greater strength to the concrete by reducing segregation, bleeding, honeycombing, voids and capillary. Thus required grade of sand for the given purpose helps the concrete more compact and dense, thus increasing the strength of concrete.

Greater workability

Size, shape, texture play an important role in workability of concrete. With more surface area of sand, the demand for cement and water increases to bond the sand with coarse aggregates. The control over these physical properties of manufacturing sand makes the concrete require less amount of water and provide higher workable concrete. The less use of water also helps in increasing the strength of concrete, less effort for mixing and placement of concrete, and thus increases productivity of construction activities at site.

Economy

As discussed above, since usage of M-Sand has increased durability, higher strength, and reduction in segregation, permeability, increased workability, decreased post-concrete defects; it proves to be economical as a construction material replacing river sand. It can also save transportation cost of river sand in many cases.

Eco-friendly

Usage of manufactured sand prevents dredging of river beds to get river sand which may lead to environmental disaster like ground water depletion, water scarcity, to make M-Sand more eco-friendly than river sand. The properties of M-sand is shown in below table 4.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

Table 4 Properties of M-Sand

| S.No. | Property | Value |
|-------|------------------|--------|
| 1 | Specific gravity | 2.55 |
| 2 | Fineness modulus | 4.45 |
| 3 | Water absorption | 6.2% |
| 4 | Surface texture | Smooth |

POLYETHYLENE GLYCOL

Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula $H(OCH_2CH_2)_nOH$, where n is the average number of repeating oxy ethylene groups typically from 4 to 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be the water-soluble nature. Polyethylene glycol is non-toxic, odourless, neutral, lubricating, non-volatile and non-irritating and is used in a variety of pharmaceuticals. The properties of river sand and M-sand is shown in below table 5.

Table 5 Comparison of M-Sand and River Sand

| S.No | Property | River sand | M-Sand |
|------|----------------------|----------------------|-------------------|
| 1 | Shape | Spherical particle | Cubical particle |
| 2 | Gradation | Cannot be controlled | Can be controlled |
| 3 | Specific gravity | 2.65 | 2.55 |
| 4 | Water absorption | 7.0% | 6.2% |
| 5 | Compressive strength | Normal | Marginally higher |
| 6 | Fineness modulus | 5.2 | 4.45 |

III. MIX DESIGN

Concrete is made with the design mix ratio of 1: 1.38: 2.24 with the water cement ratio of 0.4.

IV. PREPARATION OF SPECIMENS

Keep the moulds on a porous surface and apply oil to surface of moulds. Weigh the required quantity of sand and coarse aggregate for given concrete ratio. Mix the sand and cement to form mortar. Then mix this mortar with coarse aggregate. Again mix this dry concrete with required quantity of water to provide a normal consistency. Place the wet concrete inside the mould in layers and compact well. Level the top surface of concrete to top level of mould. Mark the date and number on top surface of concrete. Hence the specimen details are shown in table 6.

Table6 Specimen Details

| S.No | Specimen | Size | Numbers |
|------|----------|---------------------------------|---------|
| 1. | Prism | 500mm x 100mm x 100mm | 81 |
| 2. | Cube | 150mm x 150mm x 150mm | 81 |
| 3. | Cylinder | 150mm Diameter and 300mm Height | 81 |

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

Table 7 Key Words and its Descriptions

| Key words | Descriptions |
|----------------|---|
| M ₁ | 50% M-Sand + added 0.3% PEG by the weight of cement |
| M ₂ | 50% M-Sand + added 0.5% PEG by the weight of cement |
| M ₃ | 50% M-Sand + added 0.7% PEG by the weight of cement |

V. TEST ON HARDENED CONCRETE

COMPRESSIVE STRENGTH

At the end of curing period take the cubes from curing tank and wipe them clean with cloth or waste cotton. Measure the dimension of the compression face one by one. Place the cube in between compression plates of the U.T.M / compression testing machine. After the initial adjustments are over apply the load gradually over the cubes. Note the load scale reading at the time of first crack and at the time of the failure. Repeat the procedure of testing for two or more cubes and take the average values

FLEXURAL STRENGTH

The dimension of each specimen should be noted before testing. The bearing surface of the supporting and loading rollers is wiped and clean and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers. The specimen is then placed in the machine in such manner that the load is applied to the upper most surface as cast in the mould. The axis of specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surfaces of the specimen and rollers. The load is applied without shock and increasing continuously at a rate of the specimen. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded. The magnitude of flexural strength is given by PL/BD^2 where P is the applied load, L is the supported length, B and D are the breadth and depth of the prism.

SPLIT TENSILE STRENGTH

At the end of curing period take the cylinders from curing tank and wipe them clean with cloth or waste cotton. Place the cylinder in between compression plates of the U.T.M / compression testing machine. After the initial adjustments are over apply the load gradually over the cylinder. Test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression test machine and the load is applied until failure of the cylinder along the vertical diameter. The magnitudes of the tensile stress are given by $2P/\pi DL$, where P is the applied load, D and L are the diameter and length of the cylinder respectively.

VI. EXPERIMENTAL RESULTS

GENERAL

After the curing period of 7, 14 and 28 days, the cubes, prisms and cylinders are taken and the respective tests are carried out to show the results and suggestions.

COMPRESSIVE STRENGTH

Three cube samples each for various percentage of river sand replaced by M-Sand and varying percentage of PEG were tested to determine the 7, 14 and 28 days compressive strength using a Compression Testing Machine. The compressive strength test on cubes is conducted as per standards and it is shown in table 8 and table 9.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

Table 8 Compressive strength for standard curing concrete at 7, 14 and 28 days

| Proportions | Avg. Compressive Strength at 7 days (N/mm ²) | Avg. Compressive Strength at 14 days (N/mm ²) | Avg. Compressive Strength at 28 days (N/mm ²) |
|-----------------------|--|---|---|
| Conventional concrete | 16.76 | 19.32 | 25.77 |
| 50% M-Sand | 18.89 | 20.33 | 27.11 |

Table 9 Compressive strength for replacement of 50% M-Sand (Self curing concrete) at 7, 14 and 28 days

| Proportions | Avg. Compressive Strength at 7 days (N/mm ²) | Avg. Compressive Strength at 14 days (N/mm ²) | Avg. Compressive Strength at 28 days (N/mm ²) |
|----------------|--|---|---|
| M ₁ | 21.33 | 21.67 | 28.89 |
| M ₂ | 16.89 | 19.66 | 26.22 |
| M ₃ | 16 | 18.49 | 24.66 |

FLEXURAL STRENGTH

Three beam samples each of the mix with various percentage of M-Sand and various percentage of PEG were tested to determine the flexural strength after 7, 14 and 28 days using a Universal Testing Machine. The tests were conducted as per standard specifications it is shown in table 10 and table 11.

Table 10 Flexural strength for standard curing concrete at 7, 14 and 28 days

| Proportions | Avg. Flexural Strength at 7 days (N/mm ²) | Avg. Flexural Strength at 14 days (N/mm ²) | Avg. Flexural Strength at 28 days (N/mm ²) |
|-----------------------|---|--|--|
| Conventional concrete | 6.6 | 7.4 | 8.7 |
| 50% M-Sand | 6.45 | 8.15 | 8.85 |

Table 11 Flexural strength for replacement of 50% M-Sand (Self curing concrete) at 7, 14 and 28 days

| Proportions | Avg. Flexural Strength at 7 days (N/mm ²) | Avg. Flexural Strength at 14 days (N/mm ²) | Avg. Flexural Strength at 28 days (N/mm ²) |
|----------------|---|--|--|
| M ₁ | 6.15 | 8.7 | 9.18 |
| M ₂ | 5.85 | 8.105 | 8.58 |
| M ₃ | 5.16 | 6.8 | 7.86 |

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

SPLIT TENSILE STRENGTH

Three cylinder samples each of the mix with various percentages of M-Sand and various percentage of PEG were tested to determine the split tensile strength after 7, 14 and 28 day using a Compression Testing Machine. The tests were conducted as per standard specifications it is shown in table 12 and table 13.

**Table 12 Split Tensile strength for standard curing concrete at
7, 14 and 28 days**

| Proportions | Avg. Split tensile Strength at 7 days (N/mm ²) | Avg. Split tensile Strength at 14 days (N/mm ²) | Avg. Split tensile Strength at 28 days (N/mm ²) |
|-----------------------|--|---|---|
| Conventional concrete | 1.84 | 2.73 | 3.11 |
| 50% M-Sand | 1.98 | 2.86 | 3.25 |

**Table 13 Split Tensile strength for replacement of 50% M-Sand
(Self curing concrete) at 7, 14 and 28 days**

| Proportions | Avg. Split tensile Strength at 7 days (N/mm ²) | Avg. Split tensile Strength at 14 days (N/mm ²) | Avg. Split tensile Strength at 28 days (N/mm ²) |
|----------------|--|---|---|
| M ₁ | 2.05 | 3.11 | 3.53 |
| M ₂ | 1.98 | 3.04 | 3.46 |
| M ₃ | 1.70 | 2.73 | 3.11 |

VII. CONCLUSION

- In standard curing method the compressive, split tensile and flexural strength of concrete with 50% replacement of natural sand by M-Sand reveals higher strength as compared to the conventional concrete.
- In self curing method the addition of 0.3 % of PEG 400 by the weight of cement with 50% replacement of M-Sand increases the strength in terms of compression, split tensile and flexural strength of concrete over 0.5% and 0.7% of addition.
- In self curing method the addition of 0.3 % of PEG 400 by the weight of cement with 50% replacement of M-Sand increases the compressive strength of about 12% compared to the conventional concrete.
- In self curing method the addition of 0.3 % of PEG 400 by the weight of cement with 50% replacement of M-Sand increases the flexural strength of about 5% compared to the conventional concrete.
- In self curing method the addition of 0.3 % of PEG 400 by the weight of cement with 50% replacement of M-Sand increases the split tensile strength of about 14% compared to the conventional concrete.
- The self cured M-Sand concrete using PEG 400 was more economical than the conventional concrete.

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International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Issue 12, December 2015

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