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An Experimental Analysis on the Effects of Manufactured Sand on the Compressive Strength of Concrete

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ABSTRACT

Natural river sand is widely used as fine aggregates in preparation of conventional cement mortar. Due to extraction in excess, natural sand has become a scarce material and it has to be preserved. Manufactured sand (M-sand) has very high potential to replace the natural sand in preparation of cement mortar. This research paper presents a study on replacement of natural sand in cement mortar by M-sand at different percentages. Strength and workability characteristics of 1:6 cement mortar using natural sand and M-sand as fine aggregate at various replacement levels were evaluated and compared. The workability of the cement mortar increases with the increase in M-sand content up to certain level, whereas the strength increases with the increase of manufactured sand. Hence M-sand can be recommended for the replacement of natural river sand in cement mortar.

Keywords: M-Sand, Mortar, Workability; etc.

I. INTRODUCTION

Conventional cement mortar is a composite material obtained by mixing cement, fine aggregate and water. Aggregates have a significant influence on mechanical as well as rheological properties of cement mortars. Physical properties such as particle size distribution, specific gravity, shape and surface texture markedly influence various properties of mortar in their fresh state. Mineralogical composition, modulus of elasticity, toughness and degree of alteration of aggregates are generally found to affect their properties in the hardened state. Keeping in view the ill effects and ecological imbalances resulting out of removal of sand from river beds, the authorities have banned sand mining. This has led to skyrocketing of cost of natural sand. Under these circumstances search for a suitable alternative material to natural river sand without compromising strength and durability aspects of mortar becomes important to support the infrastructural growth and to save the environment.

Various researchers have conducted experimental studies on cement mortars and reported that M-sand mortar is less workable due to angular shaped particles and rough surface texture when compared to natural river sand. Generally M- sand contains high fines, whereas lesser amount of clay and silt. Rock dust is the major component of these fines. The effects of particle texture and shape of fine aggregates are more predominant than effects of coarse aggregates in concrete. Better interlocking of particles can be achieved by using angular shape of fine aggregates, which could lead to improvement in strength of cement concrete. M-sand possesses high angularity and when used in cement concrete produces less workability due to increased surface area. This results in increase of segregation in fresh state due to gap gradation. Dosage of admixtures as per manufacturers recommendations are not much effective in manufactured.

Sand mortars, as in case of mortars with natural sand fine aggregates, which even when used in high dosages, failed to attain the flow-ability or air content observed in natural sand mortar. Porosity of M-sand cement mortar was found to be higher than that with natural sand whereas the compressive strength of M-sand mortar is higher than that of natural sand mortar. Replacement of natural river sand with crushed limestone sand enhances the long term performance of mortars exposed to chemical solutions. Concrete with manufactured sand shows higher compressive strength when compared to the concrete with natural river sand. Bond strength of concrete with m-sand is more and hence development length of rebar can be reduced, leading to economy in construction. There is no comprehensive study reported on the comparison of flow and workability of mortar with and with different percentages of M-sand. In the present study properties of M- sand cement mortar is evaluated at various replacement levels for flow and compressive strength.

Manufactured sand is a substitute of river for construction purposes sand 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 manufactured sand (M-Sand) is less than 4.75mm.

1.1 Why Manufactured Sand is used?

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost. Since this sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed.

Thus, the cost of construction can be controlled by the use of manufactured sand as an alternative material for construction. The other advantage of using M-Sand is, it can be dust free, the sizes of m-sand can be controlled easily so that it meets the required grading for the given construction.

VSI Crushed Sand –Cubical Jaw crushed sand-Flaky

Only, sand manufactured by VSI crusher/Rotopactor is cubical and angular in shape. Sand made by other types of machines is flaky, which is troublesome in working. The Jaw crushers are generally used for crushing stones in to metal/aggregates. Manufactured sand from jaw crusher, cone crusher, and roll crusher often contain higher percentage of dust and have flaky particle.

1.2 Advantages of Manufactured Sand (M-Sand) are:

- ✓ It 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, increase water requirement as in the case of river sand which impair bond between cement paste and aggregate. Thus, increased quality and durability of concrete.
- ✓ M-Sand is obtained from specific hard rock (granite) using the state-of-the-art International 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 ON ROCK process which is synonymous to that of natural process undergoing in river sand information.
- ✓ Modern and imported machines are used to produce M-Sand to ensure required grading zone for the sand.

1.3 Environmental Impact:

The River sand lifting from river bed, impact the environment in many ways:

- ✓ Due to digging of the sand from river bed reduces the water head, so less percolation of rain water in ground, which result in lower ground water level.
- ✓ The roots of the tree may not be able to get water.
- ✓ The rainwater flowing in the river contents more impurities.
- ✓ Erosion of nearby land due to excess sand lifting.
- ✓ Disturbance due to digging for sand & lifting, Destroys the flora & fauna in surrounding areas.
- ✓ The connecting village roads will get badly damaged due to over- loading of trucks, hence, roads become problem to road users and also become accidents prone.
- ✓ Diminishing of Natural Rivers or river beds, not available for future generations.

II. LITERATURE REVIEW

Many researchers have studied the effect addition of M-sand to concrete which increases the mechanical and durability properties of OPC concrete.

Shanmugapriya et al. (2012) 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%.

Saeed Ahmad et al. (2008) have found that compressive strength of various mix ratios increased from 7% to 33% whereas workability decreased from 11% to 67% with increasing proportion of manufactured sand.

Shyam Prakash et al. (2007) says that manufactured sand satisfies the requirements fine aggregates such as strength, gradation, shape angularity. It is also possible to produce manufactured sand falling into the desired grade. They say that the mechanical properties of manufactured sand depend upon the source of its raw material, i.e., parent rock. Hence the selection of the quarry is very important to quality fine aggregate.

Mahendra R Chitlange et al. (2010) experimentally proved that due to addition of steel fiber to natural sand concrete and manufactured sand concrete there is a consistent increase in flexural and split tensile strength whereas there is only a marginal rise in compressive strength.

Ho et al. explained that the granite fines can be used in the SCC production. However, it is important to spot out that, as a waste material, the properties of stone fines are likely to vary with time. Then, after that, the fineness of granite fines could solve durability problems, such as silica-alkali reactions. These two issues would require to be addressed if the material is to be used with assurance.

III. MATERIALS AND METHODOLOGY

3.1 Materials used:

3.1.1 Cement:

Cement as it commonly known, is a mixture of compounds made by burning limestone and clay together at very high temperature ranging from 1400 to 1600 c. although there are other cements for special purposes, this project will focus solely on Portland cement and its properties.

3.1.2 Water:

Water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregates together. The water causes the hardening of concrete through a process called hydration. Hydration is a chemical reaction in which the major compounds in cement form chemical bonds with water molecules and become hydrates or hydration products. The water needs to be pure in order to prevent side reactions from occurring, which may weaken the concrete or otherwise interfere with the hydration process. The role of water is important because the water to cement ration is the most critical factor in the production of "perfect" concrete. Too much water reduces concrete strength, while too little will make the concrete unworkable. Concrete needs to be workable so that it may be consolidated and shaped in to different forms (I.e. walls, domes, etc). Because concrete must be both strong and workable, a careful balance of the cement to water ratio is required when making concrete. Portable water is considered satisfactory for mixing concrete. The water should be colourless and free from any smell. The presence of chlorides and sulphates are injurious to reinforcing bars as they may be corroded.

3.1.3 Aggregates:

Aggregates are chemically inert, solid bodies held together by the cement. Aggregates come in various shapes, sizes and materials ranging from fine particles of sand to large course rocks. Because cement is the most expensive ingredient in making concrete, it is desirable to minimize the amount of cement used. 70 to 80% of the volume of concrete is aggregate keeping the cost of the concrete low. The selection of aggregate is determined, impart by the desired characteristics of the concrete. For example, the density of the aggregate determines the density of concrete. Soft, porous aggregates can result in weak concrete with low wear resistance, while using hard aggregates can make strong concrete with a high resistance to abrasion.

Aggregates should be clean, hard and strong. The aggregate is usually washed to remove any dust, silt, clay, organic matter or other impurities that would interfere with the bonding reaction with the cement paste. It is then separated in to various sizes by passing the materials through a series of screens with different size openings.

3.1.4 Fine Aggregates:

The fine aggregate locally was used in this investigation. The aggregate was sieved through IS sieve. The fine aggregate or sand may be natural or crushed. It may be available in a riverbed or in a quarry. The sizes of sand particles vary from a maximum of 4.75mm down to 150micron i.e. 0.150mm. Good sand must contain all the particles with in the above range that is and it should be graded sand. The sand may be sieved through the Indian standards sieves: 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron and 150 micron. The sand may be classified as VERY COURSE (ZONE 1), MEDIUM COURSE (ZONE 2), COURSE (ZONE 3) and FINE (ZONE 4) depending upon its grain size distribution.

3.1.5 Fine Aggregate

Natural Sand: Locally available River sand having bulk density 1.71 kg/m3 was used and the specific gravity is 2.65. The Fineness modulus of river sand is 5.24.

Manufactured Sand: M-Sand was used as partial replacement of fine aggregate. The bulk density of Manufactured sand was 1.75 kg/m3, specific gravity and fineness modulus was found to be 2.73 and 4.66, respectively. The percentage of particles passing through various sieve were compared with natural sand and it was found to be similar.

3.1.6 Course Aggregate:

The course aggregate may be natural or crushed gravel. It may have a maximum size of 20 mm down to 4.75 mm and should be graded. It should be clean, and free from dust and other impurities. It should be stored separately from sand or lime etc. on a hard surface. If necessary, the aggregate may be washed and dried for 72 hours before use. Moist or wet aggregate should be used in construction. The aggregate consists of over 75% of concrete mix. Therefore save cement by using clean and graded aggregate having proper shape and size

3.1.7 Admixture:

Conplast SP420 is a chloride free, superplasticising admixture based on selected sulphonated naphthalene polymers. It is supplied as a brown solution which instantly disperses in water.

Conplast SP420 disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively. The very high levels of water reduction possible allow major increases in strength to be obtained.

3.1.8 Uses:

- ✓ To provide excellent acceleration of strength gain at early ages and major increases in strength at all ages by significantly reducing water demand in a concrete mix.
- ✓ Particularly suitable for precast concrete and other high early strength requirements.
- ✓ To significantly improve the workability of site mixed and precast concrete without increasing water demand.
- ✓ To provide improved durability by increasing ultimate strengths and reducing concrete permeability.
- ✓ In screeds it reduces the water content required to give suitable workability for placing and compaction.

IV. BASIC TESTS PROCEDURE

The standard tests are conducted on cement, fine aggregate and course aggregate. The tests are conducted and then the results are tabulated.
The different tests are

- **Cement**:
  1. Fineness test
  2. Specific gravity test
  3. Standard consistency & setting time
  4. Compressive test

- **Fine aggregate**:
  1. Specific gravity test
  2. Field moisture content

- **Coarse aggregate**:
  1. Specific gravity test
  2. Impact test
  3. Water absorption test

- **Concrete**:
  1. Slump test
  2. Compaction factor test

V. EXPERIMENTAL RESULT

4.1 Compressive strength test results:
For each concrete mix, the compressive strength is determined on three 150×150×150 mm cubes at 7 and 28 days of curing.

Following tables give the compressive strength test results of control concrete and Steel Fibre Reinforced concrete produced with 0.5, 1.0, 1.5, 2.0 percentages of Fibre.

Table 4.1. Compressive strength of of MS concrete for 7 days

Mix Designation	**Curing period**	**Compressive strength (N/mm^2)**	**Avg Compressive strength (N/mm^2)**
M0	7 days	28.88	27.25
		30.66	
		22.22	
M1	7 days	27.55	28.21
		28.44	
		28.66	
M2	7 days	32.88	32.58
		31.55	
		33.33	
M3	7 days	35.55	35.70
		36.00	
		35.55	
M4	7 days	29.77	28.88
		28.00	
		28.88	

Table 4.2. Compressive strength of of MS concrete for 28 days

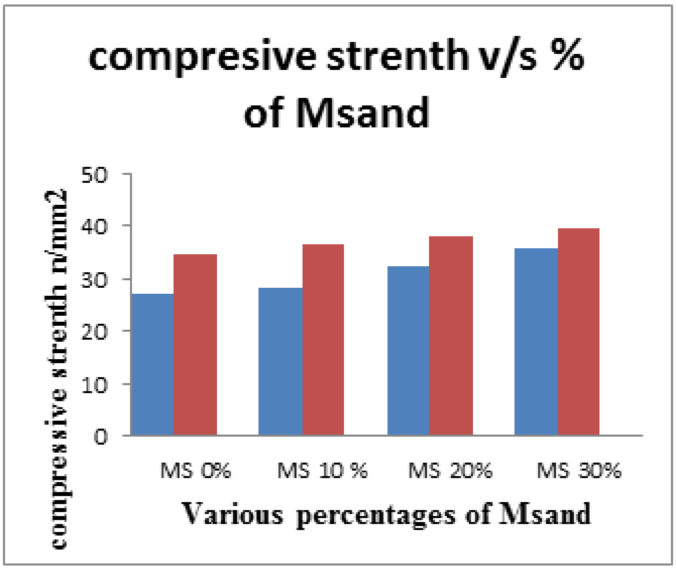
Mix Designation	Curing period	Compressive strength (N/mm^2)	Avg Compressive strength (N/mm^2)
M0	28 days	25.77	34.68
		26.66	
		28.88	
M1	28 days	34.66	36.45
		34.66	
		35.11	
M2	28 days	36.00	38.1
		37.77	
		45.33	
M3	28 days	38.22	39.5
		39.11	
		46.22	

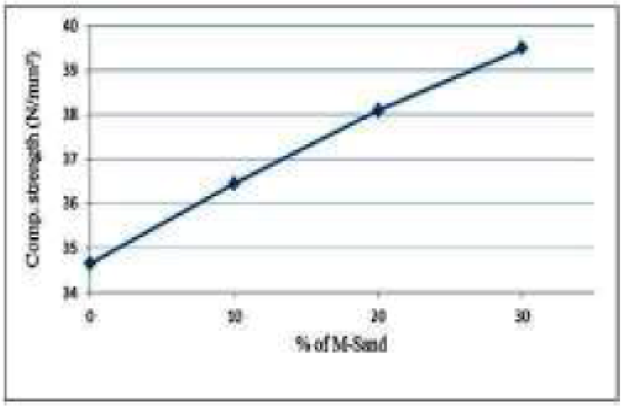
Overall results of compressive strength

Following table gives the overall results of compressive strength of MS produced with different percentages of MS The variation of compressive strength is depicted in the form of graph as shown in figure 4.4 and 4.5

Table 4.4. Overall results of compressive strength

Mix Designation	Compressive strength (N/mm^2)	
	Percentage replacement	28 Days Curing
M0	0	34..68
M1	10	36.45
M2	20	38.1
M3	30	39.5





It can be observed that compressive strength increases with age as expected. The strength of the cement mortar increases with increase in percentage replacement of M-sand. Compressive strength of cement mortar with 30% manufactured sand is 73% more when compared to cement mortar with natural sand as fine aggregate. From the results of 28 days compressive strength it can be observed that as the percentage of replacement by M-sand for Natural sand increased the strength increased continuously when compared to reference mix. M-sand acts as inert material and as percentage of M-sand.

VI. CONCLUSIONS

All the mixes of concrete formed by replacement of natural sand by manufactured sand when compared to reference mix i.e., 30% replacement reveal higher compressive strengths.

- ✓ In 20% replacement with admixture the compressive strength increases by 5.7%.
- ✓ In 30% replacement of natural sand by crushed sand, the compressive strength increases by 7.03%, which is maximum.
- ✓ Concrete mix becomes harsh with increase in proportion of manufactured sand.
- ✓ Results show that the river sand can be fully replaced by manufactured sand.

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