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Utilization of Manufactured Sand with Partially Replacement of Natural Sand in Concrete

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ABSTRACT

Natural Sand used in manufacturing concrete is sourced from natural river bed which if not replenished causes environmental concerns. Scarcity of good quality Natural River sand due to depletion of resources and restriction due to environmental consideration has made concrete manufactures to look for suitable alternative fine aggregate. This has prompted researchers to look for alternate material that could potentially replace natural river sand without adversely impacting properties of resulting concrete. A replacement of finer aggregates by a manufactured sand by varying proportions leads to the increase in both engineering & physical properties of concrete constituents which are to be considered in recent trends. In the present study manufactured sand with varying proportions from 0 to 60 % by its weight are mixed with concrete materials as a partial replacement with fine aggregates & analyzed for its physical and engineering properties, with the further analysis an introduction of manufactured sand in a proper proportion will lead to increase in the compressive strength by 15 to 20% for the concrete cubes which are being tested for 7 days, 14 days & 28 days strength.

Keywords-- OPC - Ordinary Portland Cemen, W/C - Water Cement Ratio, % - Percentage, MS - Manufactured Sand, MSC - Manufactured Sand Concrete

I. INTRODUCTION

The river beds are the main sources for the natural sand. These natural resources are being depleted very fast, due to over exploitation and contamination by chemicals and waste from nearby industries. This causes scarcity of natural sand. The natural sand is transported from available places to the construction sites. Transporting river sand to the construction sites increases its sale price significantly. Specifications which are generally guided by Australian and International Standards require sand to have particular physical and chemical characteristics such as particle size distribution limits, hardness, inertness, water absorption limits, density, mineral type, durability and to be free of deleterious matter.

Manufactured Sand

The Manufactured Sand (MS) is a by-product of the crushing and screening process in the quarries. Quarry generates considerable volumes of quarry fines while crushing the rock into aggregates. It is also referred to as crushed rock sand, stone sand, crusher sand and crushed fine aggregate. Quarry fines consist of a graded mix of coarse sand, medium sand and fine sand sized particles, plus clay/silt fraction known as the 'filler' grade. Filler grade material is defined by the industry as the material having less than 0.075mm (75 microns) in size.

II. SURVEY OF LITERATURE

1. Jeevan Kumawat, Er. R.S. Shekhawat: The fine aggregate replacement of M-Sand with river Sand is more cost economical. With 100% replacement of natural sand with manufacture sand, the strength criteria can be fully established. The compressive strength of 28 days for M25 and M30 concrete mix with 100% River sand replacement by M sand yield compressive strength of 33.23 and 38.96 N/mm². The most extreme increment in compressive strength is 5.44% (M25) and 1.72% (M30), flexural strength is 1.29% and 9.95% and Split tensile strength is 6.16% and 6.68% respectively

2. S. Pranavan, G. Srinivasan: The work on this study evaluates the different comparisons of mechanical properties of complete M-sand (MS), complete sea sand (SS) and 50% of M-sand with 50% of sea sand. compressive strength percentage increases on Fully Sea sand based and 50% M-Sand + 50% Sea sand respectively for 28 days is 8.10% & 1.52% compared to Fully M Sand based concrete. split tensile strength percentage decreases on Fully M-Sand and 50% M-Sand + 50% Sea sand respectively at 28 days is 13.33% & 9.47% compared to Fully Sea sand-based concrete. Flexural strength test results percentage observed increasing on Fully Sea sand based and 50% M-Sand+ 50% sea sand is respectively at 28 days is 2.76% & 11.05%

3. Dessalegn Mamaru: This experimental study was conducted by preparing three concrete cubes for each percentage replacement. The replacement was done at 0%, 10%, 20%, 40%, 60%. The maximum compressive and flexural strengths at 40% replacement were 31.25 MPa and 4.37 MPa respectively for the target concrete grade C-35. The workability of fresh concrete was decreased by 33.43% when manufactured sand increases from 10% to 60%.

4. K. Srinivas Reddy: The main objective of this experimentation is to find out the effect of replacement of natural sand by manufactured sand with 20%, 40% and 60% on hardened properties of cement concrete. Results are compared with reference mix of 0% replacement of Natural sand by Robo sand. After 28 days, Compressive strength increase with increase of manufactured sand percentage. With 20% replacement: +1.84 N/mm2.With 40% replacement: + 2N/mm2. & With 60% replacement: +3.77N/mm2.

5. K. Suseela, Dr. T.Baskaran: The workability of concrete decreases while utilizing manufactured sand in Concrete as replacement of river sand. The Compressive stress in concrete increases 40.1% and 64% for respective 7 and 28 days. The split tensile stress in concrete increases 2.5% and 4.4% for respective 7 and 28 days. The percentage weight loss in Sea water of concrete with Manufacture sand is not as much as the concrete with river sand which demonstrates that the Durability of Concrete is improved by utilizing manufacture sand as replacement of river sand. The permeability test increase 4.5mm depth for M1 and M2 mix, which is superior over other mix. The acid resistance test and thermal resistance test evaluated for M1 to M6 mix. • In addition, M-sand is cost and performance effective in replace of river sand.

III. RESEARCH METHODOLOGY

Replace the natural sand with Manufactured sand in various levels (25%,50%,75%,100%) and find perfect replacement of M-sand in concrete grade M-35 & find out the Optimum Percentage replacement level in concrete (M-35)

IV. EXPERIMENTAL SETUP

As the title of the investigation program shows, the work is based on the mechanical and durability of concrete with manufactured sand replaced with natural sand. the aim is to perform replacement of natural sand with m-sand in various levels (25%,50%,75%,100%) in concrete grade M-35. The concrete mix of M35 grade was prepared as per IS:10262-2009. To carry out the experimental investigation total 30 cubes of size 150mm x 150mm x 150mm were casted to determine Compressive strength. 6 cubes were casted to determine the compressive strength of normal concrete without Manufactured sand. Similarly, each set of 6 cubes were casted to determine the compressive strength for 25%, 50%, 75% and 100% replacement of M sand with Natural sand in concrete respectively. From these 6 cubes, each set of 3 cubes were utilized to determine the compressive strength of concrete after 7 days and 28 days of curing. Also 6 cubes were casted to determine the Flexural strength of normal concrete without Manufactured sand. Similarly, each set of 6 cubes were casted to determine the Flexural strength for 25%, 50%, 75% and 100% replacement of M sand with Natural sand in concrete respectively.

Manufactured Sand :

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, capillary etc.

High Strength:

The superior shape, proper gradation of fines, smooth surface texture and consistency in production parameter of chemically stable sands provides greater durability and higher strength to concrete by overcoming deficiencies like segregation, bleeding, honey combing, voids and capillary.

Greater Workability:

The crusher dust is flaky and angular in shape which is troublesome in working. There is no plasticity in the mortar which makes it even difficult for the mason to work, whereas the cubical shape with grounded edge and superior gradation gives good plasticity to mortar providing excellent workability.

Offsets Construction Defects

M-Sand has optimum initial and final setting time as well as excellent fineness which will help to overcome the deficiencies of concrete such as segregation, bleeding, honeycombing, voids and capillary.

Economy

Usage of M-Sand can drastically reduce the cost since like river sand, it does not contain impurities and wastage is NIL. In International Construction Scenario, no river sand is used at all, only sand is manufactured and used, which gives superior strength and its cubical shape ensures significant reduction in the cement used in the concrete.

Eco-Friendly

M-Sand is the alternative to river sand. Dredging of river beds to get river sand will lead to environmental disaster like ground water depletion, water scarcity, threat to the safety of bridges, dams etc. Beside with the Government contemplating ban on dredging of River beds to quarry river sand, as part of the growing concern for environment protection, MSand will be the only available option.

V. MATERIALS & METHODOLOGY

1. Materials

a. Ordinary Portland Cement of 53 Grade.
b. Aggregates of pertaining Sieve size (<20mm) as per IS standards.
c. River Sand of pertaining Sieve size (<4.75mm) as per IS standards.

d. Manufactured Sand of pertaining Sieve size (<4.75mm) as per IS standards

VI. METHODOLOGY

Preliminary tests were conducted on the concrete materials as per IS standards & specifications for its physical & engineering properties, cubes were casted in the standard metallic moulds & vibrated to obtain the required sample size of specimen. The moulds were cleaned initially and oiled on all the sides before concrete sample is poured into it. Thoroughly mixed concrete is poured into the moulds in three equal layers and compacted using vibrating table for a small period of 5 minutes. The excess concrete is removed out of the mould using trowel and the top surface is finished with smooth surface. After 24 hours the samples were demolded and put in curing tank for the respective periods of 7, 14 and 28 days a set of 5 samples were prepared for each stage of curing. The temperature of curing tank was maintained about 25 degree during the analysis of compressive strength were tabulated.

The main aim of the methodology is to-

To calculate the compressive strength of M35 grade plain concrete by laboratory experiments as per IS specifications. To find the percentage of River sand replaced in concrete with manufactured sand as an admixture that gives maximum characteristic compressive strength.

1. Tests (Physical Properties) Conducted on Concrete Materials

1. Test on Cement

- Fineness of cement.
- Normal Consistency of cement.
- Soundness test.
- Specific gravity.
- Initial setting time of cement.
- Final setting time of cement.

Table 1: Test on Cement

SR NO	TEST	METHOD OF TEST	AVERAGE RESULT	PERMISSIBLE VALUE
1	Fineness of cement	IS 269-1976	8%	Max 10%
2	Normal consistency	IS:4031-Pt-4	27%	26 to 33%
3	Soundness	IS:4031-Pt-3	4mm	<10mm
4	Specific gravity	IS:2720-Pt-3	3.0	3.12 to 3.19
5	Initial setting time	IS 4031-1968	35mins	Min 30 mins
6	Final setting time	IS 4031-1968	295mins	Max 600 mins

2. Tests on Coarse Aggregates

- Sieve analysis.
- Specific gravity.
- Water absorption.
- Aggregate shape test.
- Aggregate crushing test.
- Aggregate impact test.

Table 2: Test on Course Aggregate

SR NO	TEST	METHOD OF TEST	AVERAGE RESULT	PERMISSIBLE VALUE
1	Sieve analysis	IS:2720-Pt-4	Fineness modulus = 3.0	2.3 to 3.1
2	Specific gravity	IS:2386-Pt-3	Bulk specific gravity = 2.6	2.5 to 3.2
3	Water absorption	IS:2386-Pt-3	1.0	<2%
4	Aggregate shape test Flakiness index Elongation index	IS 2386-1 (1963)	20% 21%	<30%
5	Aggregate crushing test	IS:2386-Pt-4	18.44%	<30%
6	Aggregate impact test	IS:2386-Pt-4	15%	<24%
7	Los Angeles abrasion test	IS: 2386- (Part IV) – 1963	20%	<30%

3. Test on Fine Aggregates – River Sand (Size <4.75mm)

- Specific gravity and Water absorption test

Table 3: Test on Fine Aggregates (River sand**)**

SR NO	TEST	METHOD OF TEST	AVERAGE RESULT	PERMISSIBLE VALUE
1	Specific gravity	IS:2720-Pt-3	Bulk specific gravity = 2.50	2.53 to 2.67
2	Water absorption	IS:2386-Pt-3	0.8	<2%

4. Test on fine aggregates – Manufactured Sand (Size <4.75mm)

- Specific gravity and Water absorption test.

Table 4: Test on Fine Aggregates (Manufactured Sand)

SR NO	TEST	METHOD OF TEST	AVERAGE RESULT	PERMISSIBLE VALUE
1	Specific gravity	IS:2720-Pt-3	Bulk specific gravity = 2.60	2.53 to 2.67
2	Water absorption	IS:2386-Pt-3	01%	<2%

5. Tests (Engineering Properties) Conducted on Plain Concrete

Test on Concrete

- Slump test.
- Compaction factor.
- Compressive strength of concrete.

Table 5: Test on Concrete

SR NO	TEST	METHOD OF TEST	AVERAGE RESULT	PERMISSIBLE VALUE
1	Slump test	IS-7320-1974	True slump for 0.4 water cement ratio	--
2	Compaction factor	IS-1199-1959	0.9	--
3	Compressive strength of plain concrete (7 days)	IS 1489-1991	18.44 N/mm2 check	Min 17 N/mm2 check
4	Compressive strength of plain concrete (14 days)	IS 1489-1991	22.0 N/mm2	Min 22 N/mm2
5	Compressive strength of plain concrete (28 days)	IS 1489-1991	25.3 N/mm2	Min 25 N/mm2

6. Tests (Engineering Properties) Conducted on M35 Grade Concrete with Partial Replacement of M-sand

Test on Concrete

- Slump test.
- Compaction factor.

Compressive strength of concrete

Table 6: Test on M35 Grade Concrete with Partial Replacement of M- Sand

SR NO	TEST	METHOD OF TEST	AVERAGE RESULT
1	Slump test	IS-7320-1974	True slump for 0.6 water cement ratio
2	Compaction factor	IS-1199-1959	0.9
3	Compressive strength of plain concrete (7 days)	IS 1489-1991	18.5 N/mm2 check
4	Compressive strength of plain concrete (14 days)	IS 1489-1991	29.40 N/mm2
5	Compressive strength of plain concrete (28 days)	IS 1489-1991	43.25 N/mm2

VI. EXPERIMENTAL DESIGN MIX DESIGN

Volumetric batching is done for the material mix to analyse the amount of quantity required for casting each cube specimen considering the design mix as M35 grade (cement: fine aggregate: coarse aggregate) is 1:1.632:2.753 as per IS 383-1970 & IS 456-2000 specifications. The aggregates with cement mix are varied up to 35% of porosity by varying the materials having minimal or zero number of fine aggregates & is mixed with cement for a water cement ratio of 0.45 to cast the moulds for analyzing the compressive strength of 7,14 & 28 days strength for an average of 5 specimens.

The percentage of manufactured sand is varied from 0 % to 60% & is added to the concrete mix as an admixture & is tested for its compressive strength for varying 7, 14 & 28 days strength.

The obtained results are tabulated as a comparison of characteristic strength between plain concrete mix & M sand as an admixture for the concrete mix of M35 grade for an average of 5 specimens.

VII. RESULTS & DISCUSSION

Relation between characteristic compressive strength for the plain concrete mix for 7, 14 & 28 days With the volumetric batching for the plain concrete material mix is done to analyse the amount of quantity required for casting each cube specimen considering the design mix as M35 grade (cement: fine aggregate: coarse aggregate) is 1:1.632:2.753 as per IS 383-1970 & IS 456-2000 specifications & tested for its strength for 7, 14 & 28 days strength in which the compressive strength by testing under compressive testing machine has given an average values of 18.43 N/mm2 & 25.34 N/mm2 which are more than permissible limits as per specifications respectively.

Table 7: Detailed M35 Mix Proportions of Manufactured Sand Concrete (MSC)

W/C ratio	0.45
Cement (kg/m3)	414
Water (kg/m3)	186
Coarse aggregate (kg/m3)	1140
Fine aggregate (kg/m3)	676
proportions	1:1.632:2.753

Table 8: Comparison of Compressive Strength in Concrete Specimens of M35 for 7, 14 days & 28 days in N/mm2

S. No	Average strength at 7 days (N/mm2)	Average strength at 14 days (N/mm2)	Average strength at 28 days (N/mm2)
1	18.40	26.40	42.25
2	18.55	27.10	43.37
3	18.54	29.40	43.70

Table 9: Comparison of Compressive Strength for Various specimens with Varying % in Manufactured Sand of M35 for 7, 14 & 28 days in N/mm2

S. No	% of manufactured sand	Average strength at 7 days (N/mm2)	Average strength at 14 days (N/mm2)	Average strength at 28 days (N/mm2)
1	20	19.10	28.40	41.22
2	30	19.50	28.50	43.37
3	40	20.10	29.10	43.80

VIII. CONCLUSION

Based on the various laboratory tests as per IS standards for the porous concrete by varying the composition the following conclusions are drawn:

1. Mechanical behavior of concrete cubes prepared without chemical admixtures were studied for compressive strength test with curing time of 7 days, 14 days and 28 days which shows characteristic increase in its strength behavior.
2. It can be noticed that 10% replacement of cement with manufacture sand in mild condition are showing an increase in compressive strength for 28 days & with up to 40% replacement of cement with manufactured sand in mild condition are showing a variation in its compressive strength.
3. With the presence of manufactured sand as an admixture, it has been concluded that it can be very effective in assuring good cohesiveness between mortar and concrete.
4. From the above study, it can be concluded that the manufactured sand can be used as a replacement material for filler material and up to 40% replacement will give an excellent result both in strength & quality aspects.
5. Also with increase in percentage of M sand up to 40% will lead to the improvement in properties related to durability & workability of concrete.
6. The mix prepared with 20% replacement of fine aggregate by M sand is most economical and gives high compressive strength when compared to conventional mix

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