Experimental Investigation on use of Artificial Sand in Concrete Production

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Abstract: In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructure growth. In this situation the developing country like India is facing shortage in good quality of natural sand. Now-a-days good sand is not readily available; it is transported from a long distance. The artificial sand produced by proper machines can be a better substitute to river sand. River sand in many parts of the country is not graded properly and has excessive silt and organic impurities and these can be detrimental to durability of steel in concrete whereas Artificial sand has no silt or organic impurities. Mix design has been done for M20 and M25 grade concrete. Various tests were conducted and compared with concrete without natural sand. It is found that compressive and flexural strength of artificial sand is more than natural sand. So, replacement of natural sand gives a proper solution over scarcity of natural sand and also helps in making eco-balance.

Keywords: Artificial Sand, Natural Sand, Compressive Strength, Concrete, Properties, Environmental Protection

1. INTRODUCTION

In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructure growth. In this situation the developing country like India is facing shortage in good quality of natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete and cement mortar. Now-a-days good sand is not readily available, it is transported from a long distance. The artificial sand produced by proper machines can be a better substitute to river sand. The sand must be of proper gradation (it should have particles from 150 microns to 4.75mm).When fine particles are in proper proportion, the sand will have fewer voids. The cement quantity required will be less. Such sand will be more economical. Demand for manufactured fine aggregates for making concrete is increasing day by day as river sand cannot meet the rising demand of construction sector. Because of its limited supply, the cost of natural river sand has sky rocketed and its consistent supply cannot be guaranteed. River sand in many parts of the country is not graded properly and has excessive silt and organic impurities and these can be detrimental to durability of steel in concrete whereas Artificial sand has no silt or organic impurities.

2. MATERIAL USED

2.1 CEMENT

Ordinary Portland cement of grade 53 was used. The tests were carried out as per (IS: 8112-1989) the Indian Standard Specifications. All properties of cement are tested by referring IS 12269-1987 specification of 53 grade Ordinary Portland Cement.

Fig. 1: Cement Used

2.2 NATURAL SAND

The fineness modulus of the natural river sand is 2.44, conforming to zone II as per IS: 383-1970 was used for the experimentation after washing it with clean water. The specific gravity of the natural sand is 2.59. The water absorption and moisture content values obtained for the sand used was found to be 1.51% and 0.7% respectively.

Fig. 2: Natural Sand

2.3 ARTIFICIAL SAND

The crushed sand having fineness modulus of 2.75 and conforming to zone II as per IS: 383-1970 was used for the experimentation after washing it with clean water. The specific gravity of the artificial sand was found to be 2.57. The water absorption and moisture content values obtained for the sand used was found to be 2.26% and 0.9% respectively.

Fig. 3: Artificial Sand

2.4 COARSE AGGREGATE

Coarse aggregate of nominal size of 20mm is chosen and tests to determine the different physical properties as per IS 383-1970. Test results conform to the IS 383 (PART III) recommendations.

Fig. 4: Coarse aggregate

2.5 WATER

Portable fresh water, free from concentration of acid or organic substances was used for mixing concrete.

3. RESULTS AND DISCUSSIONS

3.1 WORKABILITY TEST RESULTS

This test is performed to check the consistency of fresh concrete. It is a term which is used to define the state of fresh concrete. It refers to the lack of difficulty with which concrete flows. It is used to indicate the degree of wetness. The test is performed on a slump cone. Workability reduces significantly with increase in % of manufacturing sand. As the manufacturing sand content workability decreases. As there is a reduction in fineness modulus of cementitious material, quantity of cement paste available is less for providing lubricating effect per unit surface area of aggregate. Therefore, there is a restrain on the mobility.

Fig. 5: Workability test conducted in lab

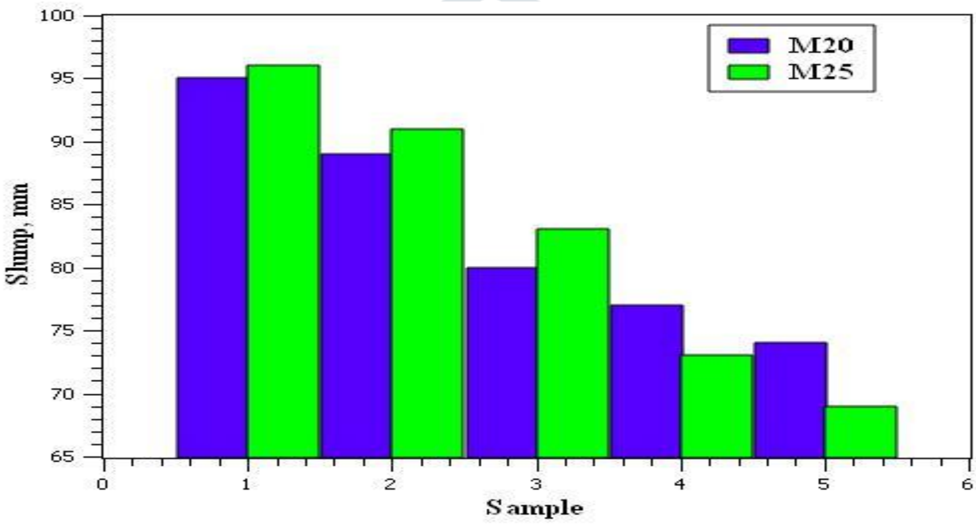

Fig. 6: Workability of Concrete with Varying Proportion of Manufacturing Sand for M20 and M25

3.2 WATER ABSORPTION TEST RESULT

One of the most important properties of a good quality concrete is low permeability, especially one resistant to freezing and thawing. A concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing. Water enters pores in the cement paste and even in the aggregate. The increase in weight as a percentage of the original weight is expressed as its absorption (in percent). The ability of a material to absorb and retain water is known as its water absorption. It mainly depends on the volume, size and shape of pores, present in the material. The completely dried pavement blocks are weighed and immersed in clean water for 24 hours (W_w).The block is then removed from water and then weighed (W_d).

Formula used is Water absorption = $[W_2 – W_1)/W_1]$ x 100%.

Where W_1= dry weight in Kg

W_2= wet weight in Kg

The water absorption values of the concrete for M20 and M25 grade are determined and the results were presented in table below.

Table 5.3: Water Absorption Test as per IS: 15658:2006 for M20 Grade

S.No.	Mix	Wet Weight (W_2) in kg	Dry Weight (W_1) in kg	% Water Absorption (W %)
1	M1	7.45	7.25	2.75
2	M2	7.58	7.32	3.55
3	M3	7.64	7.37	3.66
4	M4	7.72	7.42	4.04
5	M5	7.84	7.48	4.81

Table 5.4: Water Absorption Test as per IS: 15658:2006 for M25 Grade

S.No.	Mix	Wet Weight (W_2) in kg	Dry Weight (W_1) in kg	% Water Absorption (W %)
1	M1	7.48	7.32	2.18
2	M2	7.58	7.41	2.29
3	M3	7.74	7.52	2.92
4	M4	7.85	7.61	3.15
5	M5	7.91	7.66	3.26

3.3 COMPRESSIVE STRENGTH TEST RESULTS

In this study, compressive strength for cubes at various replacement proportions of manufacturing sand with fine aggregate in the three different curing periods with M20 and M25 grade concrete were determined after testing. The Fig. 9 shows the level of strength variation of M25 grade concrete for different replacement level of manufactured sand.

Fig. 8: Compressive strength test

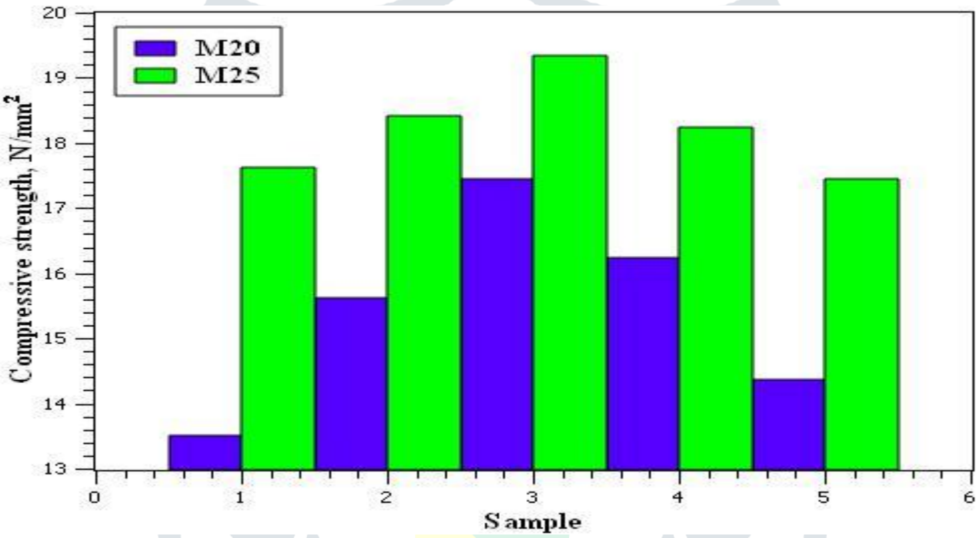

Fig. 9: Variation of compressive strength after 7 days curing for M25

In the above figure 9, the cube compressive strength for sample 1 to sample 5 for different replacement level of fine aggregate with manufactured sand (0%, 25%, 50%, 75% and 100%) at the end of 7 days curing period shown. Sample 3 with 50% natural sand and 50% manufactured sand shows 29.25 % increase in strength over sample 1 with 100% natural sand, whereas other samples shows 15.7 %, 20.22 % and 6.44 % slightly lesser strength compared to sample 1. The compressive strength of concrete with manufactured sand has been increased upto 50% and after 50% of the replacement the strengths are gradually reduced. The maximum values of compressive strength at 50% Natural sand and 50 % Manufactured sand are 17.45 N/mm^2 and 19.35 N/mm^2. The maximum percentage of the natural sand and manufactured sand on the natural sand replacement must therefore be 50 % and 50% when OPC is used.

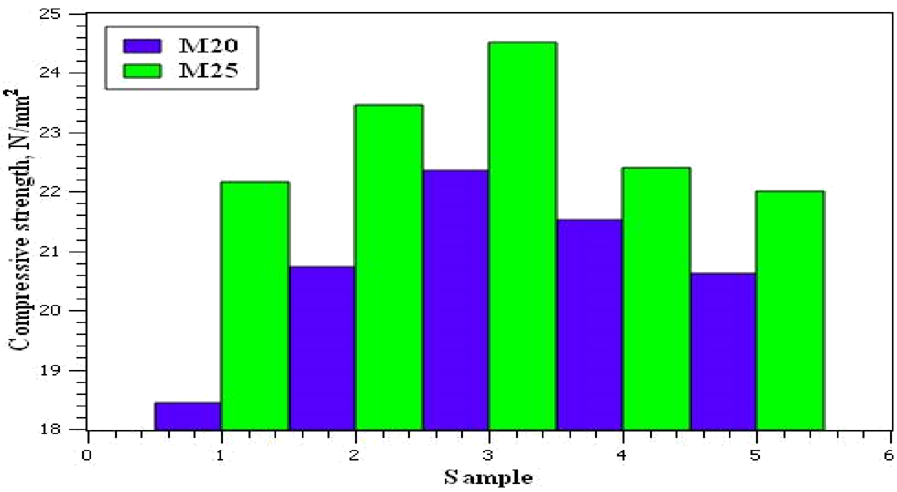

Fig. 10: Variation of compressive strength after 14 days curing for M25

In the above figure 10, the cube compressive strength for sample 1 to sample 5 for different replacement level of fine aggregate with manufactured sand (0%, 25%, 50%, 75% and 100%) at the end of 14 days curing period shown. Sample 3 with 50% natural sand and 50% manufactured sand shows 21.1 % increase in strength over sample 1 with 100% natural sand, whereas other samples shows 5.62 %, 9.66 % and 3.89 % slightly lesser strength compared to sample 1. The compressive strength of concrete with manufactured sand has been increased up to 50% and after 50% of the replacement the strengths are gradually reduced. The maximum values of compressive strength at 50% Natural sand and 50 % Manufactured sand are 22.36 N/mm^2 and 24.51 N/mm^2. The maximum percentage of the natural sand and manufactured sand on the natural sand replacement must therefore be 50 % and 50% when OPC is used.

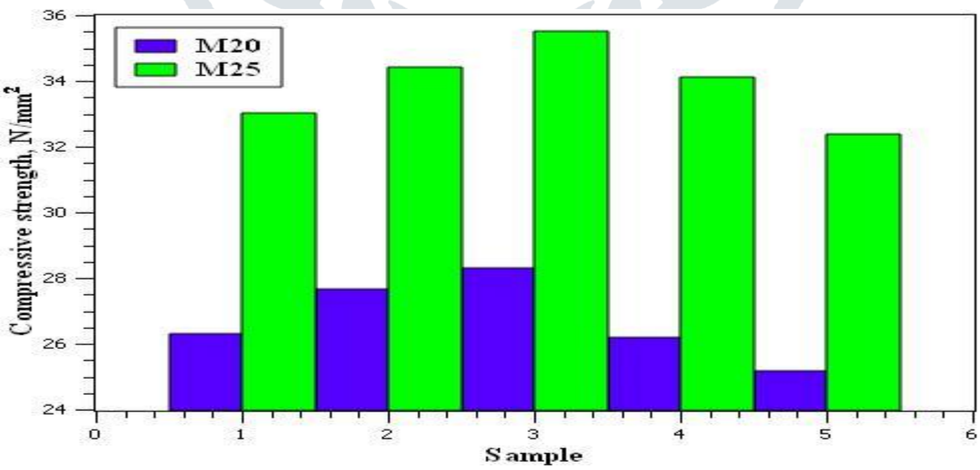

Fig. 11: Variation of compressive strength after 28 days curing for M25

In the above figure 11, the cube compressive strength for sample 1 to sample 5 for different replacement level of fine aggregate with manufactured sand (0%, 25%, 50%, 75% and 100%) at the end of 28 days curing period shown. Sample 3 with 50% natural sand and 50%

manufactured sand shows 17.9 % increase in strength over sample 1 with 100% natural sand, whereas other samples shows 9.55 %, 8.35 % and 5.47 % slightly lesser strength compared to sample 1. The compressive strength of concrete with manufactured sand has been increased up to 50% and after 50% of the replacement the strengths are gradually reduced. The maximum values of compressive strength at 50% Natural sand and 50 % Manufactured sand are 28.32 N/mm^2 and 35.51 N/mm^2. The maximum percentage of the natural sand and manufactured sand on the natural sand replacement must therefore be 50 % and 50% when OPC is used.

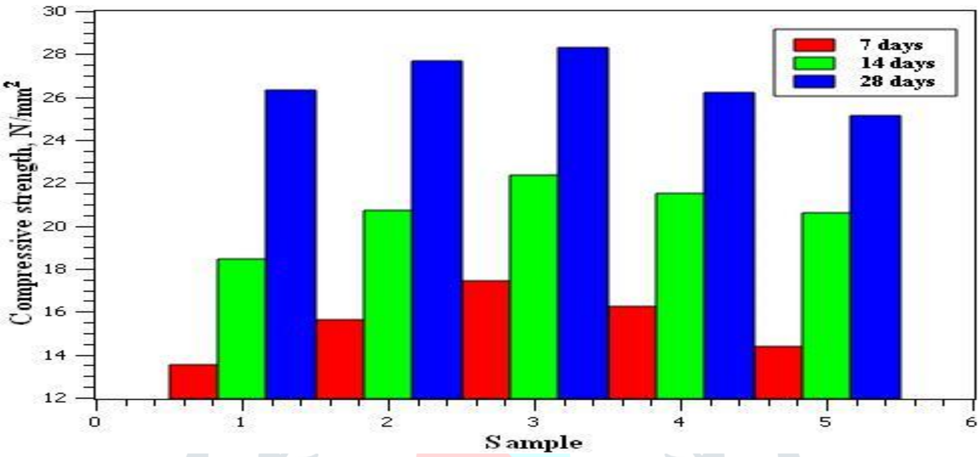

Fig. 12: Comparison of variation of compressive strength after 7, 21 and 28 days of curing for M20

Fig. 12 shows the relationship between the compressive strength of concrete for 7 days, 21 days and 28 days and type of mix made with manufactured sand. It is observed that the compressive strength of concrete is maximum achieved at 28 days and the strength is increased between 7 to 28 days.

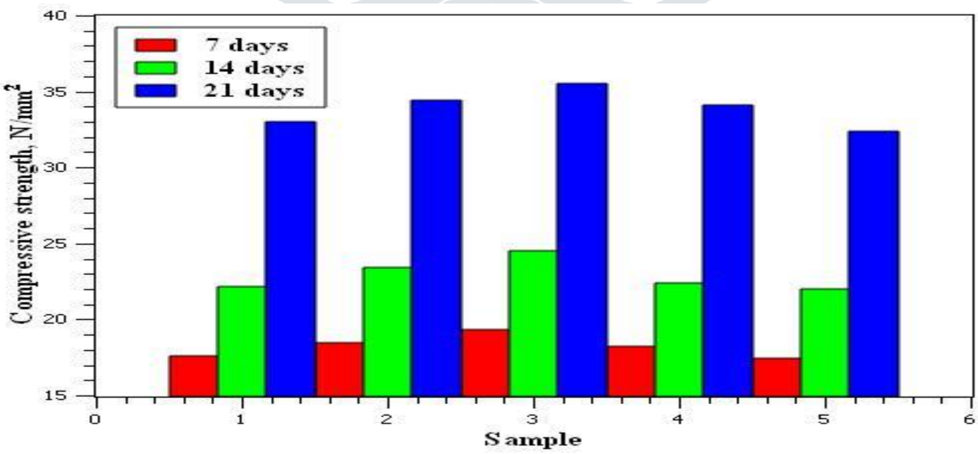

Fig. 13: Comparison of variation of compressive strength after 7, 21 and 28 days of curing for M25

3.4 FLEXURAL STRENGTH TEST RESULT

The flexural strength for beams at various replacement proportions of manufactured sand with fine aggregates in 28 days curing periods for M20 and M25 grade concrete were determined after testing. The Fig 15 shows the level of flexural strength variations of M20 and M25 grade concrete.

The below table shows that at the end of 28 days flexural strength of specimen designation type M2 M4 and M5 decrease by 4.58 %, 11.46 % and 8.71 % respectively whereas M3 increase by 14.22 % compared to M1, sample made with natural sand. In all the cases the strength is achieved and alternate materials not induce any adverse effect on mix by strength reduction.

Fig. 14: Flexural Strength Test

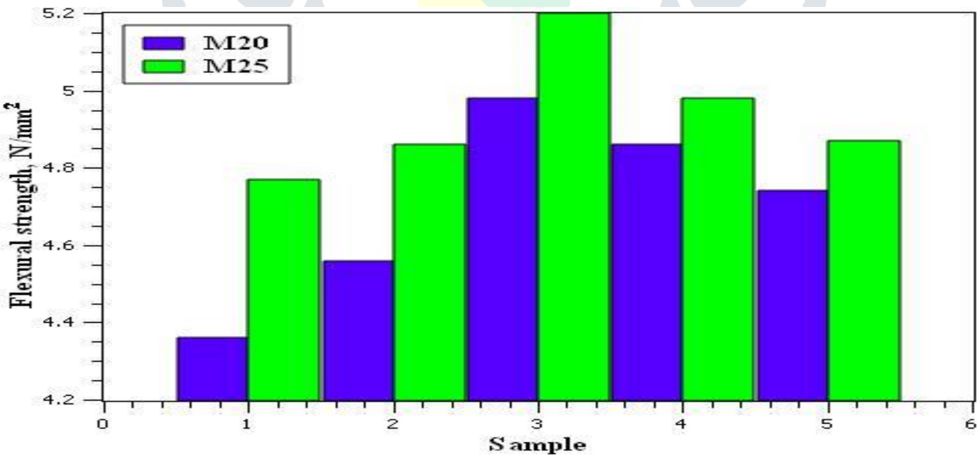

Fig. 15: Flexural strength after 28 days

The figure 15 shows the value of flexural strength at various replacement proportion of natural sand by manufactured sand at the end of 28 days curing period. For sample designation M3 with 50% natural sand and 50% manufactured sand, the flexural strength increase by 14.22 % over sample designation M1 which is of 100% natural sand as fine aggregate.

The maximum 28 days flexural strength of M20 grade of concretes with replacement of natural sand by manufactured sand was 4.98 N/mm^2. Hence the optimum mix for achieving higher tensile strength is 50 % natural sand 50 % manufactured sand.

3.5 SPLIT TENSILE STRENGTH TEST RESULT

The split tensile strength for cylinders at various replacement proportions of manufactured sand with fine aggregates in 28 days curing periods for M25 grade concrete were determined after testing and tabulated in Table 5.9. Fig. 5.8 shows the level of tensile strength variations of M25 grade concrete.

The below table shows that at the end of 7 days tensile strength of specimen designation type M2 M4 and M5 decrease by 11.36 %, 9.65 % and 5.11 % respectively whereas M3 increase by 16.47 % compared to M1, sample made with natural sand. In all the cases the strength is achieved and alternate materials not induce any adverse effect on mix by strength reduction.

Fig. 16: Split Tensile Strength Test

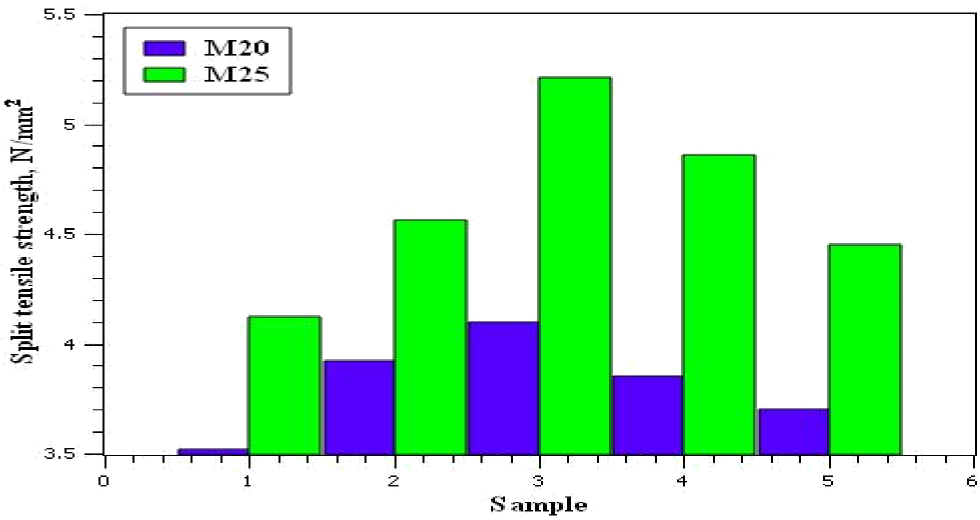

Fig. 17: Split tensile strength after 28 days curing for M25

The figure 17 shows the value of split tensile strength at various replacement proportion of natural sand by manufactured sand at the end of 28 days curing period. For sample designation M3 with 50% natural sand and 50% manufactured sand, the split tensile strength increase by 16.47 % over sample designation M1 which is of 100% natural sand as fine aggregate.

The maximum 28 days split tensile strength of M25 grade of concretes with replacement of natural sand by manufactured sand was 4.10 N/mm^2. Hence the optimum mix for achieving higher tensile strength is 50 % natural sand 50 % manufactured sand.

3.6 COST ANALYSIS

Material estimation includes costs for water, cement, natural sand, manufacturing sand and coarse aggregate for a particular design mix and transportation cost. According to the mix design calculation we achieved the weight of water, cement, natural sand, manufacturing sand and coarse aggregate for concrete. As the water is largely available in India, its costs can therefore be neglected. Current study shows that replacement of natural sand using manufacturing sand can be made as much as 50% (by weight).

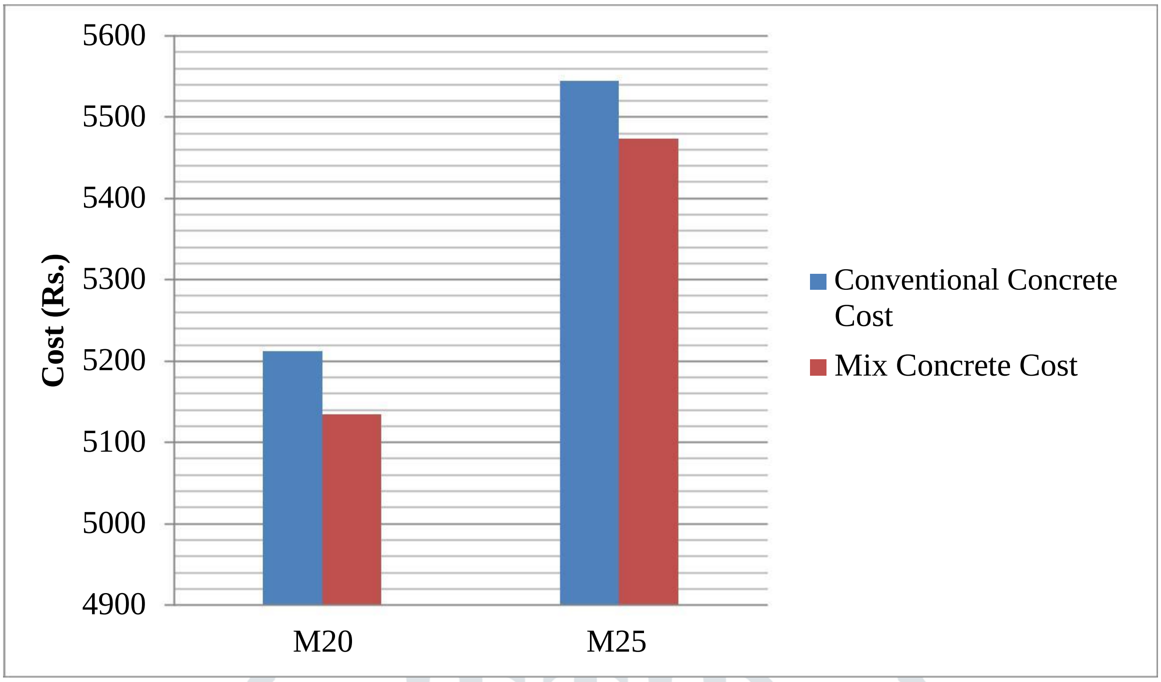

Fig. 18: Cost Comparison for Concrete Grades 20 and 25

4. CONCLUSION

Based on the present study the following conclusions were derived:

1. Workability reduces significantly with increase in % of manufacturing sand. As the manufacturing sand content workability decreases. As there is a reduction in fineness modulus of cementitious material, quantity of cement paste available is less for providing lubricating effect per unit surface area of aggregate. Therefore, there is a restrain on the mobility.
2. It is observed that the manufactured sand content is increased from 0% to 100% water absorption is increasing. But according to IS 15658:2006 the water absorption for concrete is 7%. The water absorption values of specimens are calculated for various mix proportions and the effect of manufactured sand content on water absorption is shown in Fig.3. From the test results, it can be seen that the water absorption values for all the specimens of mix ratios were lower than 7% as per IS: 15658-2006 specifications.
3. The cube compressive strength for sample 1 to sample 5 for different replacement level of fine aggregate with manufactured sand (0%, 25%, 50%, 75% and 100%) at the end of 28 days were tested. Sample 3 with 50% natural sand and 50% manufactured sand shows 17.9 % increase in strength over sample 1 with 100% natural sand, whereas other samples shows 9.55 %, 8.35 % and 5.47 % slightly lesser

strength compared to sample 1. The compressive strength of concrete with manufactured sand has been increased up to 50% and after 50% of the replacement the strengths are gradually reduced. The maximum values of compressive strength at 50% Natural sand and 50 % Manufactured sand are 28.32 N/mm^2 and 35.51 N/mm^2. The maximum percentage of the natural sand and manufactured sand on the natural sand replacement must therefore be 50 % and 50% when OPC is used.

4. At the end of 28 days flexural strength of specimen designation type M2 M4 and M5 decrease by 4.58 %, 11.46 % and 8.71 % respectively whereas M3 increase by 14.22 % compared to M1, sample made with natural sand. In all the cases the strength is achieved and alternate materials not induce any adverse effect on mix by strength reduction.
5. For sample designation M3 with 50% natural sand and 50% manufactured sand, the flexural strength increase by 14.22 % over sample designation M1 which is of 100% natural sand as fine aggregate. The maximum 28 days flexural strength of M20 grade of concretes with replacement of natural sand by manufactured sand was 4.98 N/mm^2. Hence the optimum mix for achieving higher tensile strength is 50 % natural sand 50 % manufactured sand.
6. At the end of 7 days tensile strength of specimen designation type M2 M4 and M5 decrease by 11.36 %, 9.65 % and 5.11 % respectively whereas M3 increase by 16.47 % compared to M1, sample made with natural sand. In all the cases the strength is achieved and alternate materials not induce any adverse effect on mix by strength reduction.For sample designation M3 with 50% natural sand and 50% manufactured sand, the split tensile strength increase by 16.47 % over sample designation M1 which is of 100% natural sand as fine aggregate.
7. The maximum 28 days split tensile strength of M25 grade of concretes with replacement of natural sand by manufactured sand was 4.10 N/mm2. Hence the optimum mix for achieving higher tensile strength is 50 % natural sand 50 % manufactured sand.
8. We note that the use of manufacturing sand in concrete saves money up 1.51 % over the conventional cement concrete. This is a significant saving of money. There are good prospects of obtaining a good concrete strength at relatively.
9. We note that the use of manufacturing sand in concrete saves money up to 1.29 % over the conventional cement concrete. This is a significant saving of money. There

are good prospects of obtaining a good concrete strength at relatively cheaper cost even while replacing part of the sand with manufacturing sand.

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