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Strength Characteristics of High Strength Concrete using M-sand

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Abstract

Background/Objectives: The construction industry mainly aims at sustainable construction with the available natural resources by reducing the negative environmental impacts on environment. Over a period of time, the scarcity of fine aggregate has become one of the most complex and challenging problem in the construction field. In India, the escalation in the price of natural river sand leads to the demand in the alternate construction material by considering Manufactured Sand (M sand) as a fine aggregate which solve the problem of scarcity. The focus of the present investigation is to assess the potential of using Manufactured sand as a replacement to fine aggregate in M60 grade concrete. Fly ash and silica fume also used to reduce the cement content and as a voids filler material. **Methods Statistical Analysis**: In the present investigation, it is aimed at to study 0, 25, 50, 75 and 100% of traditional fine aggregate replaced with M- sand. The test results are obtained by conducting compressive strength test, split tensile strength test and flexural strength test after 3, 14, 28 and 60 days of curing. **Findings:** The strength characteristics of concrete shows higher its strength with the partial and 100% replacement of M-sand in fine aggregate for all the curing period studied. An increase of 6.27% and 14.65 % in compressive and split tensile strength is observed by the full replacement of river sand with M- sand at the curing period of 28th day. **Application/Improvements:** Use of Manufactured sand in high strength concrete serves better alternative for the river sand. The utilization of manufactured sand in concrete as fine aggregate reduces the problem in scarcity of natural sand and reduces the time delay and cost of the construction.

Keywords: Compressive Strength, High Strength, Manufacatured Sand, River Sand

1. Introduction

In construction industry, river sand was widely used as the fine aggregate, mainly in the preparing of concrete and mortar. The availability of river sand has become scarce due to over exploitation and increasing environmental concerns. Restrictions on sand dredging become very stringent for collecting sand from river beds. By considering the long term performances and sustainability of concrete and mortar, demands an alternative material for natural river sand. In this context, different aggregate alternatives such as recycled aggregates[1], residual materials from industries such as blast furnace slag[2,3], copper slag[4,5] etc. are used in different fields, will reduce the demand for river sand and also reduces the environmental burden of river bed erosion. Based on the availability, in many places the granite powder is used as an alternative of fine aggregate[6]. Studies were also conducted on the potential use of crushed rock dust[7,8] as fine aggregate and it acts as a voids filler and helps to minimize all the voids content in concrete, thus it contributes an improvement in the quality of concrete. But, the requirement for the alternate for river sand is not fully replaced by any of the substitutes. Hence the searching of alternate for river sand is continued by the construction industry in terms of quality and economy. Few studies were conducted on concrete to identify the potential use of M-sand[9] as alternative for river sand. M-sand is produced by crushing rock in to suitable sizes to produce as a fine aggregate. In major constructions in India, the concept of M Sand

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as a replacement material for river sand either fully or partially was adopted the conventional practices with low grade concrete for structural works[10–13]. In this line the focus is shown to study the concrete properties with M-sand as fine aggregate in high strength concrete. In this study, the effect of M-sand in high strength concrete (M60) was investigated with the partial (25%, 50%, 75%) and with M-sand and its characteristics are compared with normal sand concrete

2. Materials and Experimental Program

2.1 Binder

The cement used was Ordinary Portland Cement (OPC)[14] of 53 Grade with a specific gravity of 3.1. For the partial replacement of cement flyash and silica fumes are used. Fly Ash (FA) used was classified as Class F fly ash confirming to ASTM Standards and Silica Fume (SF) having a specific gravity of 2.22. The chemical composition OPC, FA and SF are listed in Table 1.

Table 1. Oxide composition of OPC, FA and SF

Chemical Composition	OPC	FA	SF
SiO2	22.38	61.85	2.22
Al2O3	6.73	28.03	87.13
Fe2O3	4.72	5.03	1.96
CaO	59.46	1.06	1.13
MgO	1.02	1.05	7.16
SO3	2.33	0.07	0.33
Na2O	0.021	0.21	0.12
K2O	0.36	1.34	0.09
Cl	0	0.001	0.33
LOI	2.31	0.95	1.52

2.2 Aggregate

The coarse aggregate used in concrete having a maximum size of 12mm and a specific gravity of 2.86. The particle size distribution shows that, the gradation of aggregate particles are within the limits of ASTM C33[15] standard. Fine aggregate and M sand used in this work, constitutes a fineness modulus of 2.5 and 3.0 with specific gravity of 2.57 and 2.78. The particle size distribution of river sand and M Sand with upper and lower limits of zone II according to IS:383[16] is shown in Figure 1. For proper mixing of high strength concrete a poly carboxylic ether based superplasticizer is added with concrete mix mainly to prevent the segregation. Various mix proportions are prepared with M- sand at various percentages of 0, 25, 50, 75 and 100% in mix which are designated as M1, M2, M3, M4 and M5 respectively. The mix proportion corresponding to M1 and M2 as per ASTM C 143[17] was shown a slump value of 100 and remaining mixes M3, M4 and M5 having a value of 115.

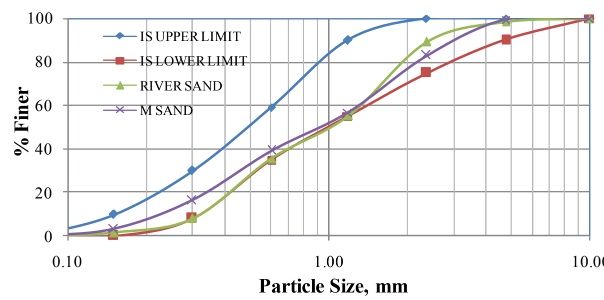

Figure 1. Particle size distribution of river sand and M Sand with upper and lower limits of zone II of IS:383.

3. Results and Discussion

3.1 Compressive Strength

The compressive strength test on concrete was determined by testing concrete cubes specimens of 100mmx100mmx100mm in size. The cubes are tested by applying load without shock and load values are increasing at the rate of 140kg/cm^2. The compressive strength values of cubes prepared from various mixes at 3, 14, 28 and 60 days of curing are listed in Table 2 and the variations in strength attainment are shown in Figure 2. It shows an increase in compressive strength values with the partial replacement of fine aggregate with M sand. Compared to the control mix an increase of 6.27% in compressive strength is observed by the 100% replacement of manufactured sand at 28th day of curing period.

Table 2. Compressive test results for various mixes of concrete

Type of Mix	Compressive Strength, N/mm^2			
	3 days	14 days	28 days	60 days
M1	31.45	41.84	61.59	63.28

M2	33.99	44.55	62.87	64.38
M3	35.43	46.27	63.98	65.58
M4	36.70	47.26	64.12	67.34
M5	37.48	48.53	65.45	69.22

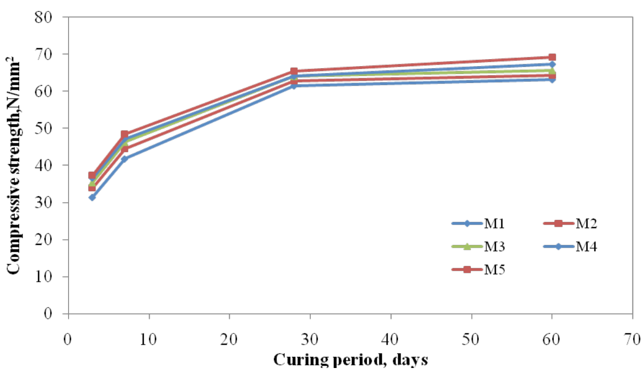

Figure 2. Compressive strength of concrete for various mixes

3.2 Split Tensile Strength

The tensile strength of concrete has been measured by using the indirect tensile strength. The testing cylinder specimens are prepared and used according to IS 5816-1970[18]. These cylinders prepared for testing having a diameter of 100mm and height of 200mm. This test was also carried out in varying mix proportions of 0, 25, 50, 75 and 100% for different curing periods of 3, 7, 28 and 60 days. The test results obtained for various mixes corresponding to the curing periods are Table 3. The test results showing an increase of 14.65 % in split tensile strength by the replacement of manufactured sand up to 100% in concrete mix.

Table 3. Split tensile test results for various mixes of concrete

Type of Mix	Split Tensile Strength, N/mm²			
	3 days	7 days	28 days	60 days
M1	4.23	4.59	5.05	5.39
M2	4.51	4.99	5.28	5.49
M3	4.63	5.03	5.34	5.59
M4	4.75	5.19	5.64	6.30
M5	4.81	5.43	5.79	6.90

Figure 3 shows the variation of split tensile strength for various mixes for increasing curing periods. It was observed that, the strength of concrete mix at 28th day strength shows a marginal value corresponding to various proportions up to 100 % replacement.

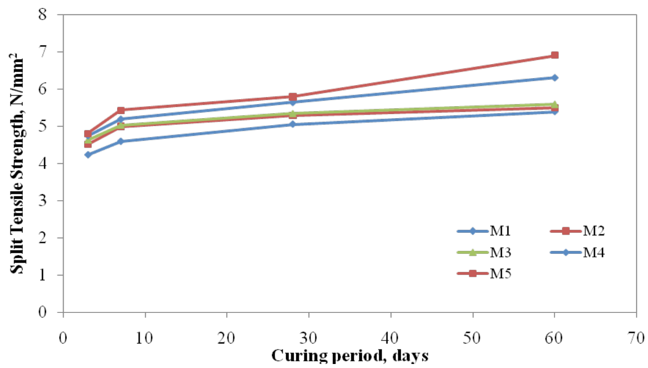

Figure 3. Split tensile strength of concrete various mixes

3.3 Flexural Strength

Flexural strength gives the tensile strength of concrete beam to resist the failure in bending and it is measured by loading (100x100x500 mm) concrete beams. The flexural strength test was conducted on concrete specimens as per the ASTM C 78[19]. Figure 4 presented the schematic diagram of experimental setup with loading conditions for the flexural strength determination of beams for various mixes of concrete.

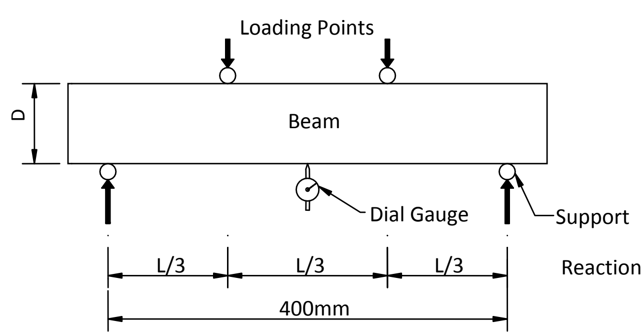

Figure 4. Schematic diagram of experimental setup with loading conditions for beams.

The increases in flexural strength for different concrete mixes were observed at different curing periods and it is shown in Figure 5. The test results resulting in an increase in strength of concrete with M sand and that increase in strength. It was also observed that, the strength got increased upto 32.55% in flexural strength as a result of replacement of manufactured sand up to 100% compared to controlled concrete at the end of 28 days.

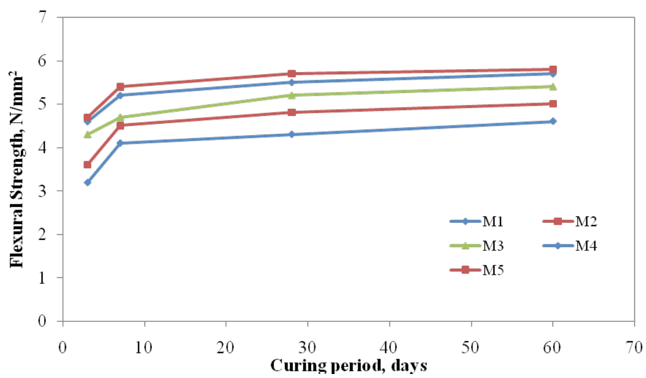

Figure 5. Flexural strength of various concrete mix.

4. Conclusion

From the laboratory studies made, it was found that the concrete with 100% M-sand in high strength concrete shows an intensification in compressive and split tensile strength of 6.27% and 14.65 % respectively at the curing period of 28th day. It indicates the M-sand in M60 grade concrete can be adopted in the construction field.

The development of flexural strength in M60 grade concrete with M-sand was 32.55% more than the concrete with river sand at 28 days.

The results from the study clearly outline the utilization of M-sand in concrete as the fine aggregate will reduces the problem in scarcity of river sand mining. It will also reduce the time delay and cost of the construction.

5. References

1. Mathew P, Jacob J, Stephen L, Paul T. recycled aggregate concrete, a sustainable option from demolition concrete waste- a percentage replacement method. International Journal of Innovative Research in Science, Engineering and Technology. 2014 Feb; 3(2):1–5.
2. RaoM S, Bhandare U. Application of blast furnace slag sand in cement concrete–a case study. International Journal of Civil Engineering Research. 2014; 5(4):453–58.
3. Babu J, Mahendran N. Experimental studies on concrete replacing fine aggregate with blast furnace slags. International Journal of Engineering Trends and Technology. 2014 Apr; 10(8):1–3.
4. Brindha D, Nagan S. Utilization of copper slag as a partial replacement of fine aggregate in concrete. International Journal of Earth Sciences and Engineering. 2010 Aug; 3(4):579–85.
5. Chavan PR, Kulkarni DB. Performance of copper slag on strength properties as partial replace of fine aggregate in concrete mix design. International Journal of Advanced Engineering Research and Studies. 2013 Jul –Sep:95–8.
6. Raghavendra R, Sharada SA, Ravindra MV. Compressive strength of high performance concrete using granite powder as fine aggregate. International Journal of Research in Engineering and Technology. 2015 May; 4(4):47–9.
7. Celik T, Marar K. Effects of crushed stone dust on some properties of concrete. Cement and Concrete Research. 1996 Jul; 26(7):1121–30.
8. Donza H, Cabrera O, Irassar EF. High-strength concrete with different fine aggregate. Cement and Concrete Research. 2002 Nov; 32(11):1755–61.
9. Umamaheswaran V, Sudha C, Ravichandran PT, Rajkumar PRK. Use of M-sand in high strength and high performance concrete. Indian Journal of Science and Technology. 2015 Oct; 8(28):1–8.
10. Nanthagopalan P, Santhanam M. Fresh and hardened properties of self-compacting concrete produced with manufactured sand. Cement and Concrete Composites. 2011 Mar; 33(3):353–8.
11. Mo KH, Alengaram JU, Jumaat MZ, Liu MYJ, Lim J. Assessing some durability properties of sustainable lightweight oil palm shell concrete incorporating slag and manufactured sand. Journal of Cleaner Production. 2016 Jan; 112:763–70.
12. Reddy BV. Suitability of M-sand as fine aggregate in mortars and concretes. CSIC Project; 2012 Jan. p. 1–16.
13. Jadhav PA, Kulkarni DK. An experimental investigation on the properties of concrete containing manufactured sand. International Journal of Advanced Engineering Technology. 2012; 3(2):1–4.
14. IS: 12269. Ordinary portland cement, 53 Grade – specification. Bureau of Indian Standards, New Delhi; 2013.
15. ASTM C 33. Standard specification for coarse aggregate. American Society of Testing and Materials; 2003.
16. IS: 383 (Reaffirmed 2007). Specification of coarse and fine aggregates from natural sources for concrete. Bureau of Indian Standards, New Delhi; 1970.
17. ASTM C 143. Standard test method for slump of hydraulic-cement concrete. American Society of Testing and Materials; 1990.
18. IS: 5816. Splitting tensile strength of concrete – method of test. Bureau of Indian Standards, New Delhi; 1999.
19. ASTM C78 / C78M. Standard test method for flexural strength of concrete (using simple beam with third-point loading); 2010.