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Study on Mechanical Properties of Concrete with Manufactured Sand and Bagasse Ash

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Abstract

Background/Objectives: In the construction of structures river sand used as fine aggregate in concrete for centuries. River sand is not a renewable natural resource. In most of the area, river sand has been excessively exploited, which has endangered the stability of river banks and the safety of bridges, and creates an environmental problem. Hence, minimization of the use of river sand inevitable. **Methods:** In this study, the Manufactured sand (M-sand), produced by crushing rock depositions as a fine aggregate used in concrete. The M-sand is more angular and has rougher surface texture than river sand. In the M60 grade concrete, M-sand is used as fine aggregate and Bagasse Ash (BA) used as a pozzolanic material for the partial replacement of cement. Bagasse ash has partially replaced by the ratio of 0%, 10%, 20%, 30% and 40% by volume of cementation material in concrete. M-sand has been replaced by fully by volume of fine aggregate. In this investigation, to study the properties of concrete test likes Compressive Strength, Tensile Strength, Flexural Strength, Young's modulus and Workability of concrete were carried out. The effects of M-sand on mechanical properties, studies with and without partial replacement of Bagasse ash were studies at the age of 7, 28 days. **Findings:** The test results show that the incorporation of Bagasse Ash up to 20% replacement level increases the mechanical properties of concrete. The variation in use of M-sand in concrete as compared to the river sand with the Bagasse Ash shows the minimum variation in the strength properties. **Applications/Improvement:** From this study, it is observed that the use of M-sand in high strength concrete can be use for the replacement of fine aggregate in M60 concrete. Use of Bagasse ash up to 20-30 % can be effectively used in concrete with or without the addition of M-sand, where the Bagasse ash available in plenty.

Keywords: Bagasse Ash, Compressive strength, Manufactured Sand

1. Introduction

In modern construction field purposes, the modification in traditional cement concrete has become essential to meet all requirements. In this situation, an alternate for good binding material in concrete with adequate quantity for the development of a blended concrete is inevitable. The use of by-products from industries in concrete proved an economical solution with significant results in various construction applications. In this view a study on the use of Sugarcane bagasse ash which is the byproduct of burned sugarcane Bagasse Ash (BA) used as the binding material for the partial replacement of cement in concrete. The BA contains more pozzolanic material produces good effects to the concrete with better binding and reduces the emission of CO_2 from cement, which mainly results in global warming. Many researchers had studied the effects of different binding materials, such as fly ash[1–4], silica fumes[5,6], Ground Granulated Blast Furnace slag[7,8] etc. in concrete. Similarly, in the construction industry the scarcity of river sand was also becoming a serious issue. Many extensive researches are done the study in partial replacement of fine aggregate with many alternatives such as blast furnace slag, copper slag[9–11] and M sand,[12–15] etc., on low-grade

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concrete develops in improvement in strength characteristics of concrete. This study is mainly presenting on the effects of BA content as the partial replacement of cement on physical and mechanical properties of high strength hardened Manufactured sand (M sand) and River sand (R sand) concrete.

2. Materials Used

2.1 Binder

Ordinary Portland Cement (OPC 53 grade) and is conforming to Indian Standard IS: 12269[16] and the supplementary materials Silica fume confirmed to IS: 15388[17] and GGBS are used in this study. The specific gravity of the cement and silica fume was obtained as 3.15 and 2.20 respectively. Sugar Cane Bagasse Ash (SCBA) which is having a specific gravity of 2.74 is used as the partial replacement material for binder is used in varying percentages (IS: 12089)[18]. GGBS is non-metallic product essentially with silicates and aluminates of lime and other bases which impart more strength to the concrete mix.

2.2 Aggregate

Coarse aggregates of two different sizes– 20 mm and 12.5 mm were used to achieve maximum particle packing density. The aggregates were sourced from Nallambakkam. Sieve analysis results, particle size distribution of coarse aggregates, 20 mm and 12.5 mm are given in Table 1. The specific gravity of 20 mm and 12.5 mm coarse aggregate found out was 2.80 while the water absorption for 20 mm was 0.57 and that for 12.5 mm was 0.60.

Table 1. Gradation of coarse aggregate of 20 mm and 12.5 mm

Particle size, mm	% Finer	
	20mm	12.5mm
25.00	99.48	-
20.00	90.68	-
16.00	26.54	100.00
12.50	4.66	96.55
10.00	0.38	50.40
6.30	0.08	1.45
4.75	0.08	0.35
2.36	-	0.20

Fine aggregates used in the study conforming to the requirements of IS: 383[19]. River sand was sourced from Chengalpattu while M Sand was sourced from Nallambakkam. The sand was air dried and sieved to remove any foreign particles before to mixing. Specific gravity, fineness modulus, water absorption were determined. The particle size distribution of river sand and M Sand along with upper and lower limits of zone II of IS: 383 requirements is presented in Table 2. Based on the sieve analysis, both river sand and M Sand were found conforming to Zone II requirements as per IS: 383. Values of specific gravity, water absorption and fineness modulus of both river sand and M sand are given in Table 3.

Table 2. Gradation of M sand and river sand

Particle size (mm)	% Passing		Zone II Limits as per IS: 383 (1970)	
	M Sand	River sand	Upper Limit	Lower Limit
10.00	100	100	100	100
4.75	99	98	100	90
2.36	83	89	100	75
1.18	57	55	90	55
0.60	39	36	59	35
0.30	16	8	30	8
0.15	3	2	10	0

Table 3. Specific gravity, water absorption, fineness modulus of M sand and river sand

Properties	River Sand	M Sand
Specific Gravity	2.60	2.70
Water Absorption	1.18	1.80
Fineness Modulus	3.12	3.02
Particle size, mm		
Finer (0.075 – 0.425), %	20	27
Medium (0.425 – 2.0), %	60	50
Coarser (2.000 – 4.750), %	20	23

Potable water, clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel, was used in this study for mixing and curing.

For the experimental study, the PCE based chemical admixture having the following properties; pH 7.20, Solid Content 33.72%, Chloride ion content 0.0079% and Relative Density at 25˚ is 1.08 g/cc was used.

3. Test Methods and Discussion of Results

The experimental study planned to be conducted to find the suitability, acceptance and viability of using M sand as fine aggregate and to the SCBA as a partial replacement by 10, 20, 30 and 40 % binder material for the cement in concrete. The mechanical properties of concrete with river sand and M sand for the various replacement percentages of SCBA on cement are studied.

3.1 Compressive Strength Test Results

The compressive strength test was carried out on concrete cubes at different percentage of bagasse ash (0, 10, 20, 30 and 40) as partial replacement of cement in R sand and M sand concrete specimens as per Indian Standards[20]. Cubes of size of the 100 x 100 x 100 mm size were tested using a digital compression testing machine having a maximum capacity of 2000 kN, at a rate of 2.3 kN/s. The compressive strength of mixes at 7 and 28 days are listed in Table 4. The compressive test results revealed that the increase in compressive strength of SCBA blended concretes was observed up to 20% and decreases after the addition of 30% SCBA. The similar trend was observed in concrete with M sand also. The variations in the compressive strength of concrete at ages of curing are shown in Figure 1. It can be viewed that rate of increase in the compressive strength attains the maximum value in range of 50% with the increase of curing period from 7 to 28 days curing. The experimental study confirms that the concrete mixes of both R sand and M sand with SCBA up to 20% develops compressive strength in specimens. The Concrete with the M sand shows higher compressive strength value than river sand in both the curing periods for all the percentages of SCBA replacement studied. Results also show that the concrete with M sand gives higher strength than river sand with OPC and OPC with the bagasse ash.

Table 4. Compressive strength values at various curing periods

Mix Designation	SCBA	R-Sand		M-Sand	
		7 Days	28 Days	7 Days	28 Days
M1	0%	42.13	63.06	43.62	66.74
M2	10%	44.37	64.17	45.37	67.22
M3	20%	45.02	67.62	46.48	69.77
M4	30%	41.27	60.66	42.86	63.62
M5	40%	38.53	55.11	39.33	57.44

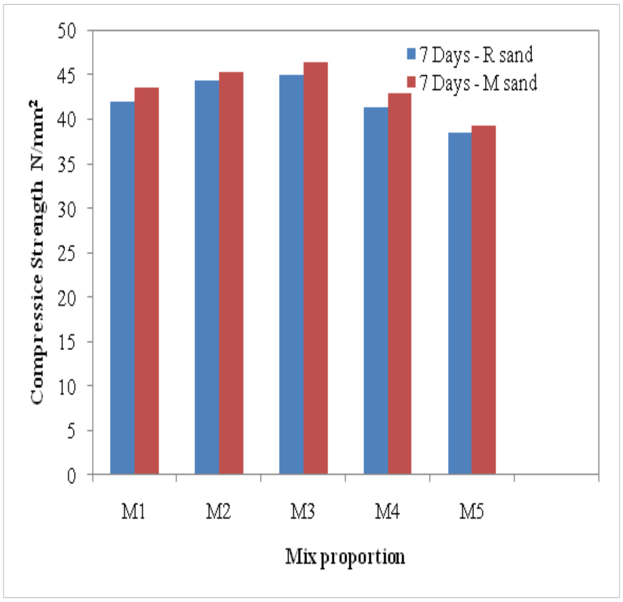

Figure 1. Compressive strength results for various mixes at different curing periods.

3.2 Split Tensile Strength Test

In this test the cylindrical concrete specimens with R sand and M sand of various trial mixes at 7 days and 28 days were placed horizontally between the loading surfaces of the compression testing machine and the load was applied until the failure of the cylinder, along the vertical diameter[21]. The test was carried out in various mixes at 7 and 28 curing days, and the results are listed in Table 5. The split tensile strength is increased to 6.41 N/mm^2 and 6.99 N/mm^2 at 28 days from the values of 5.64 N/mm^2 and 5.69 N/mm^2 at seven days strength in R sand and M sand concrete respectively. Strength development also confirms that the strength attainment in M sand concrete is more than the R sand concrete. The variations in split tensile Strength of various mixes of concrete consists of SCBA with R sand and M sand are shown in Figure 2.

Table 5. Split tensile strength values at various curing periods

Mix Designation	SCBA	R-Sand		M-Sand	
		7 Days	28 Days	7 Days	28 Days
M1	0%	4.41	5.97	4.79	6.31
M2	10%	4.85	6.23	5.13	6.67
M3	20%	5.34	6.41	5.69	6.99
M4	30%	5.06	6.35	5.23	6.65
M5	40%	4.55	5.90	4.84	6.1

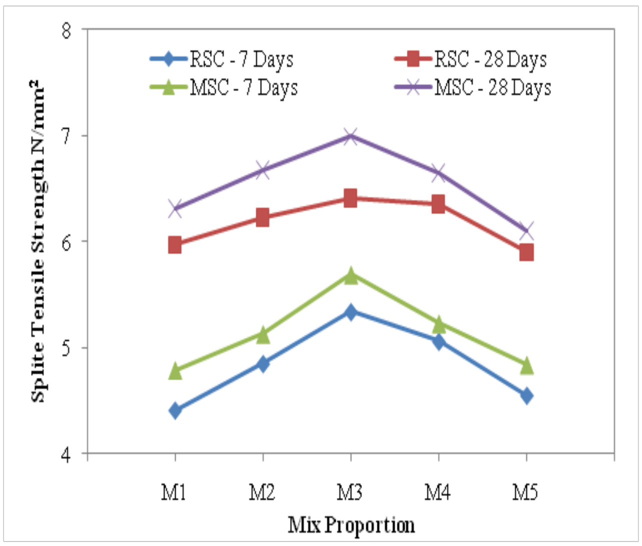

Figure 2. Split tensile strength results for various mixes at different curing periods.

3.3 Flexural Strength Test

The view of the flexural test set up and the loading of the test specimen is shown in Figure 3. Flexural strength results for all the mixes at 7 and 28 days curing are determined as per IS 516 and are shown in Table 6. The influence of SCBA on the various concrete mixes was examined, and it results in the decrease of the development of strength beyond 20% of SCBA in mixes. The variations in flexural strength for various mixes observed from the experimental investigations are shown in Figure 4.

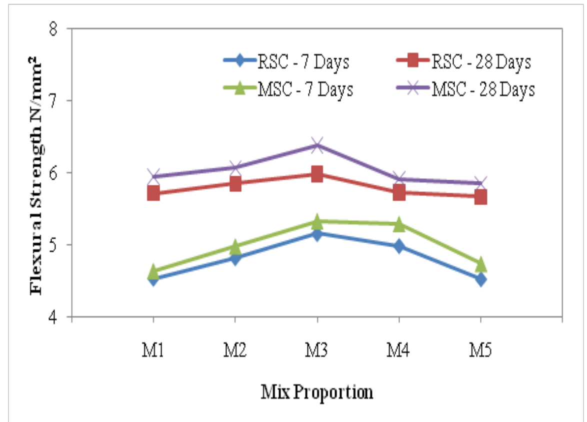

Figure 4. Flexural strength results for various mixes at different curing periods.

Table 6. Flexural strength test results at various curing periods

Mix Designation	SCBA	R-Sand		M-Sand	
		7 Days	28 Days	7 Days	28 Days
M1	0%	4.52	5.71	4.63	5.94
M2	10%	4.81	5.84	4.97	6.06
M3	20%	5.15	5.97	5.32	6.38
M4	30%	4.98	5.72	4.98	5.91
M5	40%	4.51	5.66	4.63	5.74

4. Conclusion

From the experimental study of M60 grade concrete on river sand and M sand with and without addition of bagasse ash the followings were observed:

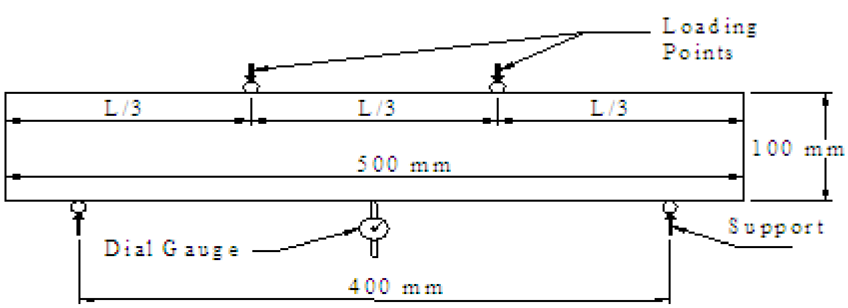

Figure 3. Flexural test set up for specimens.

The compressive strength of concrete at 28 days with M Sand shows higher the strength than the R sand.

The bagasse addition up to 20% in concrete with M sand and R sand gives the more strength; further addition of bagasse ash shows the decrease in trend in the strength of the concrete.

The developments of split tensile strength were 6.41 N/mm^2 and 6.99 N/mm^2 at 28 days from the values of 5.64 N/mm^2 and 5.69 N/mm^2 at seven days strength in R sand and M sand concrete mixes. A Similar trend was observed in flexural strength, and it confirms that the optimal quantity of SCBA content was attaining at 20% replacement of cement in concrete.

SCBA utilization as the partial replacement of cement for M60 grade concrete provides a satisfactory solution to environmental concerns and problems associated with the construction industry.

Use of M sand in the M60 grade concrete shows the good results with and without the addition of bagasse ash.

5. References

1. Patel R, Kinney F, Schumacher G. Green concrete using 100% fly ash based hydraulic binder. International Concrete Sustainability Conference, National Ready Mixed Concrete Association; 2012. p. 1–15.
2. Patel YH, Patel PJ, Patel JM, Patel HS. Study on durability of high performance concrete with alccofine and flyash. International Journal of Advanced Engineering Research and Studies. 2013 Apr-Jun; 2(3):154–7.
3. Kumar BGA. Effective utilization of fly ash and supplementary cementitious materials in construction industry. International Journal of Advanced Technology in Civil Engineering. 2012; 1(2):1–8.
4. Mathew BA, Sudha C, Rajkumar PRK, Ravichandran PT. Investigations on tensile properties of high strength steel fibre reinforced concrete. Indian Journal of Science and Technology. 2015 Oct; 8(28):1–6.
5. Sharmaa U, Khatrib A, Kanoungoc A. Use of micro-silica as additive to concrete-state of art. International Journal of Civil Engineering Research. 2014; 5(1):9–12.
6. Ajay V, Rajeev C, Yadav RK. Effect of micro silica on the strength of concrete with ordinary portland cement. Research Journal of Engineering Sciences. 2012 Jun; 1(3):1–4.
7. Rughooputh R, Rena J. Partial replacement of cement by ground granulated blast furnace slag in concrete. Journal of Emerging Trends in Engineering and Applied Sciences. 2014; 5(5):340–3.
8. Kumar PM, Mahesh Y. The behaviour of concrete by partial replacement of fine aggregate with copper slag and cement with ggbs - an experimental study. Journal of Mechanical and Civil Engineering. 2015 May-Jun; 12(3):51–6.
9. Awasare V, Nagendra MV. Analysis of strength characteristics of GGBS concrete. International Journal of Advanced Engineering Technology. 2014 Apr-Jun; 5(2):82–4.
10. Rao MV, Bhandare U. Application of blast furnace slag sand in cement concrete–a case study. International Journal of Civil Engineering Research. 2014; 5(4):453–8.
11. 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.
12. Cortes DD, Kim HK, Palomino AM, Santamarina JC. Rheological and mechanical properties of mortars prepared with natural and manufactured sand. Cement and Concrete Research. 2008 Oct; 38(10):1142–7.
13. Jadhav PA, Kulkarni DK. An experimental investigation on the properties of concrete containing manufactured sand. International Journal of Advanced Engineering Technology. 2012 Jan; 3(2):1–4.
14. Villalobos S, Lange DA, Roesler JR. Evaluation, testing and comparison between the crushed manufactured sand and natural sand [Technical note]. Department of Civil and Environmental Engineering, University of Illinois; 2005 Apr. p. 1–6.
15. Sudha C, Ravichandran PT, Krishnan KD, Rajkumar PRK, Anand A. Study on mechanical properties of high performance concrete using M-sand. Indian Journal of Science and Technology. 2016 Feb; 9(5):1–6.
16. IS: 12269, specification for 53 grade ordinary portland cement. New Delhi: Bureau of Indian Standards; 2013.
17. IS: 15388, silica fume- Specification. New Delhi: Bureau of Indian Standards; 2003.
18. IS: 12089, specification for granulated slag for the manufacture of Portland slag cement. New Delhi: Bureau of Indian Standards; 1987.
19. IS: 383, specification for coarse and fine aggregates from natural sources of concrete. New Delhi: Bureau of Indian Standards; 1970.
20. IS: 516, methods of test for strength of concrete. New Delhi: Bureau of Indian Standards; 1959.
21. IS: 5816, splitting tensile strength of concrete- Method of test. New Delhi: Bureau of Indian Standards; 1999.