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INVESTIGATION ON STRENGTH PROPERTIES OF SELFCOMPACTING CONCRETE WITH M-SAND AND METAKAOLIN

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ABSTRACT

Construction projects have been increasing rapidly leading to an enormous rise in the usage of concrete, which has led to the depletion of river sand. Extraction of river sand results in environmental problems like the depletion of the ground water and soil erosion and ecological problems such as the extinction of fauna and flora. Self-Compacting Concrete (SCC) can be really a high-performance concrete that may flow under its own weight, occupies the form work entirely and self-consolidates without the need for vibration[5][6].The laying of this type of concrete can save both labour and time. M Sand is crushed rock (fine aggregates) made out of solid granite rock that is cubically formed with wrought borders, cleaned and rated with consistency to function as an alternative for river sand. Using M Sand could overcome the flaws transpiring in concrete like honey cleaning, segregation, voids, etc[3]. The objective of this work is to study the strength properties of self-compacted M-sand concrete Metakolin. For this purpose, M30 grade concrete was used and tests were conducted for various proportion of sand replaced with M-Sand at 0%, 10%, 20%, 30%, 40%, 50% and Metakaolin was used as an admixture to the concrete. Concrete specimens were tested conforming to Bureau of specifications. The results obtained have been analysed with regard to the control specimens. By the evaluation outcome, it has been found that 30 percent of these traditional fine aggregate (River Sand) can possibly be independently substituted with M-Sand to enhance the mechanical properties of self-compacting concrete.

Keywords: Self-Compacting Concrete, mechanical shaking, honey cleaning, Metakolin.

I. INTRODUCTION

Every time when concrete is placed over a heavily reinforced member, it is really difficult to ensure that the entire form work is completely filled with concrete. The manual compaction of the concrete by means of external vibrators is a challenging task. (Bertil 2001). The conventional method of compaction not only delays progress of the work but is also expensive. These difficulties can be resolved using Self-Compacting Concrete (SCC). (Burak et al., 2007). The SCC has the capability of running between the reinforcements and fill the entire form work. Hence, it does not require the usage of vibrating equipment, thereby reducing the cost of construction. (Chockalingam et al., 2013). The specifications and procedures for the basic parameters of the fresh concrete to satisfy the self-compacting ability are drawn by "European Guidelines for Self-Compacting Concrete" (EFNARC). Therefore, a design mix for M30 self-compacting concrete with M-sand as partial replacement for fine aggregate was prepared and tested for the SCC parameters suggested by EFNARC.

II. MATERIAL PROPERTIES

Cement: The physical properties of cement used are given in Table 1.

Table1: Physical Properties of Cement

Properties	Value
Specific gravity	3.16
Normal Consistency	31.12%
Fineness of cement	2.15%

Coarse Aggregate: The various properties of coarse aggregates were determined and are tabulated in Table 2.

Table2: Properties coarse aggregate

Properties	Value
Specific Gravity	2.681
Moisture Content	0.23%
Water Absorption	0.2%
Bulk Density	1465 kg/m^3
Fineness Modulus	3.44

Fine Aggregate: Fine aggregate used was river sand passing through IS sieves 4.75 mm obtained from a local source. Various properties of fine aggregates are listed in table 3.

Table 3: Properties of fine aggregate

Properties	Result
Specific Gravity	2.632
Moisture Content	2.33%
Water Absorption	0.75%
Bulk Density	1497 Kg/m^3
Fineness Modulus	3.164

M-Sand: M-sand having a specific gravity of 2.85 and fineness modulus of 2.79 was used in this study.

Metakaolin: The physical properties of the Metakaolin used for this investigation is shown in Table 4.

Table 4: Properties of Metakaolin

Property	Result
Specific gravity	2.54
Specific surface area	333 m^2/kg
Loss on ignition	1.06
Color	White

Super plasticizer: To obtain the necessary workability properties for SCC, super plast 840 universally available super plasticizer got from FOSROC Company was employed in this research work.

Water: Water is an important ingredient of concrete. Practically all natural water that is safe to drink and has no distinct taste or smell can be used for making concrete. Some water which may not be fit for drinking may still be harmless for mixing concrete. Potable water available from the local source was used in the work.

III. MIX PROCEDURE

The SCC mix for the M30 grade was prepared for various proportions of fine aggregate replacement by M-Sand. Based on the guidelines stipulated in the EFNARC, the fresh properties of the design mix were checked (Nan et al., 2001). Packing factor was a vital one which affected the self-compatibility of concrete. The packing factor was the ration of the mass of aggregates in the densely packed state of SCC to the loosely packed state of SCC. On trial and error basis the packing factor was assumed to be 1.15 for this research work. The percentage of fine aggregate was replaced by 0%, 10%, 20%, 30% and 40% in the obtained optimum mix and checked for their fresh and hardened properties. Table 5, 6 and 7 represent the standard acceptance criteria and mix proportions of the self-compacting concrete and the fresh concrete properties.

Table 5: Fresh Properties of SCC

Mix	Slump (mm)	Slump 50 (sec)	V funnel (sec)	J ring (mm)	Remark
0%	720	2	6	2	satisfied
10%	695	3	8	3	satisfied
20%	680	4	10	5	satisfied
30%	660	4	12	8	satisfied
40%	620	Not satisfied			

Table 6: Typical Acceptance Criteria for SCC

Test	Typical range		Unit
	Min.	Max	
Filling ability - Slump flow test	650	800	mm
Filling ability - T50cm slump flow	2	5	sec
Filling ability - V-funnel test	8	12	sec

Table 7: Mix Proportion

Mix	Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	M-Sand (Kg/m^3)	Coarse Aggregate (Kg/m^3)	Metakaolin (Kg/m^3)	Water (Liter / Kg)	Super Plasticiser (Kg/m^3)
0%	385.04	924.26	0.00	655.50	42.78	147.26	15.99
10%	385.04	790.80	197.70	655.50	51.34	147.26	15.99
20%	385.04	631.64	421.10	655.50	63.32	147.26	15.99
30%	385.04	446.79	670.19	655.50	80.77	147.26	15.99
40%	385.04	236.25	944.97	655.50	107.40	147.26	15.99

IV. HARDENED PROPERTIES

The SCC specimens were cast for various proportions of M-sand replacements for fine aggregates. (Najim and Hall, 2010). After curing the specimens for variable periods of 7 days, 14 days and 28 days, they were analysed for their performance in hardened strength properties. Table 8, 9 and 10 represent the strength properties of the various design mixes. The results clearly indicate that at 30% replacement of M-Sand for fine aggregate gives optimum results to that of the control specimens.

Table 8: Compressive Strength

Specimen	Compressive strength (N/mm^2)		
	7th day	14th day	28th day
MS 0	28.29	31.07	33.77
MS 10	29.55	32.78	35.82
MS 20	32.09	35.57	40.66
MS 30	33.78	38.00	43.04
MS 40	25.34	29.07	31.83

Table 9: Split Tensile Strength

Specimen	Split tensile strength (N/mm^2)		
	7th day	14th day	28th day
MS 0	1.54	1.70	2.57
MS 10	1.78	2.19	2.76
MS 20	1.90	2.28	3.04
MS 30	1.97	2.58	3.42
MS 40	1.62	1.79	2.28

Table10: Flexural Strength

Specimen	Flexural strength (N/mm^2)		
	7th day	14th day	28th day
MS 0	3.68	4.04	4.37
MS 10	4.11	4.34	5.04
MS 20	4.75	5.35	5.89
MS 30	5.42	5.73	6.18
MS 40	3.61	4.09	4.85

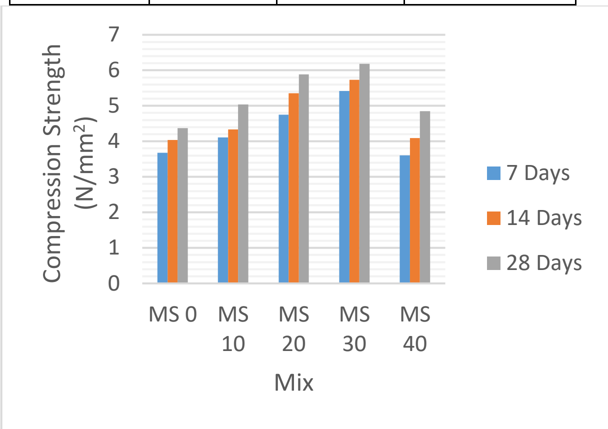

Fig. 1: Compressive Strength Vs M-Sand Percentage Replacement

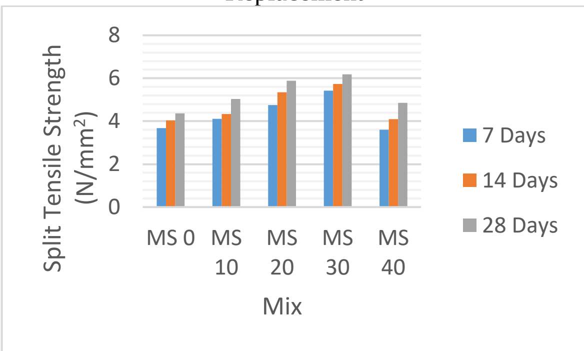

Fig. 2: Split Tensile Strength Vs M-Sand Percentage Replacement

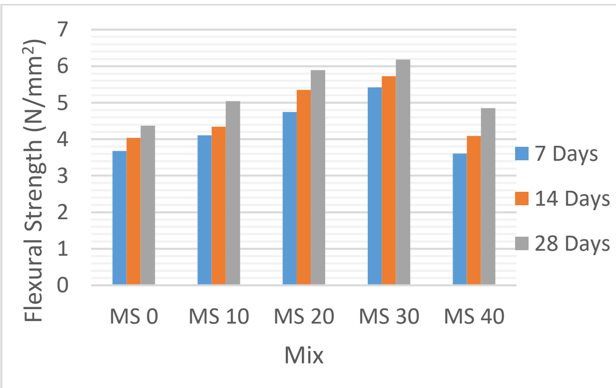

Fig. 3: Flexural Strength Vs M-Sand Percentage Replacement

Figures 1, 2 and 3 show the variation of the strength properties at different proportions of M-Sand replacement for fine aggregate, and it reveals that fine aggregate can efficiently be replaced with M-sand up to 30% without any loss in its hardened strength properties. This improvement in the strength properties is due to the rough surface finish and angular shape of the M-Sand particles. Further, the M-Sand is entirely free from any organic impurities due to the washing process during its manufacturing process.

V. CONCLUSION

1. At 30 % replacement of fine aggregate with M-Sand, the compression strength is found to be 43.04 N/mm^2, which is much higher than that of the of conventional SCC specimens having a strength of 33.77 N/mm^2. Alongside the split tensile strength also showed a similar pattern with 33.07% increase than the control specimens at 30% replacement of fine aggregate with M-sand.
2. Due to the angular and rough surface finish of the M-sand particles, the flexural strength at 30% replacement for fine aggregate is 41.4 % higher than that of the control specimens. Beyond 30% replacement there was a decline in the strength properties. This may be due to the segregation of the M-Sand particles in the SCC mix when the percentage replacements exceed 30%.
3. From these results, it can be concluded that up to 30% of M-Sand can be effectively replacement for fine aggregate without compromising the properties.

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