A Study on Properties of Self-Compacting Concrete by Partial Replacement of River Sand by Manufactured Sand

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Abstract -- Self-compacting concrete (SCC) is an innovative concrete that does not requires any vibration for placing and compaction. The main objective of this study is to investigate the effect on the properties of self-compacting concrete, when river sand is partially replaced by 50% of manufactured sand. With different locally available material, experimental tests are performed to check the properties of M-20 grade SCC. Several tests, such as Slump test, T50 slump flow test, V-funnel, V-funnel at T-5min, J-ring, L-box test were carried out to determine the properties of fresh concrete. And compression strength test and split tensile strength tests were carried out to determine the properties of hardened concrete.

Indexed Terms: Self-compacting concrete, manufactured sand, fresh concrete properties, hardened concrete properties.

I. INTRODUCTION

Self–compacting concrete (SCC) is as emerging technology to the construction industry, and has been described as the most revolutionary development in concrete construction for several decades. Okamura of the Koche University of Technology (Japan) had first developed SCC in year 1986. Through their definition it can be defined as concrete that is able to flow and consolidate under its own weight, completely fill the formwork even in the presence of dense reinforcement, whilst maintaining homogeneity and without the need for any additional compaction. In order to do this, SCC requires higher paste content and lower coarse aggregate fraction compared to conventional vibrated concrete or non-vibrated concrete, and uses super plasticizer. These would ensure high deformability of paste and resistance to segregation. For SCC, it is generally necessary to use super plasticizer in order to obtain high mobility. Adding viscosity modifying admixture can eliminate segregation. In the current experimental work

The SCC is prepared by replacing the 50% natural sand by manufactured sand. Now a day the construction industry in the India is facing one of the major problems that is natural fine aggregate. Sand is a prime material used for preparation of mortar and concrete and which plays a major role in mix design. Natural sand deposits are being used up and causing serious threat to environment as well as the society. The non-availability or shortage of river sand will affect the construction industry. The main cause of concern is the nonrenewable nature of natural sand and the corresponding increasing demand of construction industry. Therefore looking for an alternative to river sand has become a necessity. The cheapest and easiest alternative to natural sand is manufacturing sand by crushing rocks/stones in desired size and grade by suitable method. Sand produced by such means is known as manufactured/ crusher/artificial sand.

II. MATERIALS USED CEMENT

Portland pozzolana cement was used

Table 1 Physical properties of Portland cement

Slno	Factors	Instrument used	Outcomes	Standard values
1	Fineness test	90µ IS sieve	6%	Less than 10%
2	Specific gravity	Density bottle, kerosene	2.82	Near to 2.9
3	Normal consistency	Vicat's apparatus	35%	-
4	Initial setting time	Vicat's apparatus	30mins	Less than 30minute

5	Final setting time	Vicat's apparatus	190mins	Less than 10hours

A. Aggregates

Natural sand and manufactured sand (M-sand) are two types of fine aggregates used in the experimental work. Specific gravity and % water absorption of river sand is 2.8 and 0.825% respectively. The fineness modulus of river sand is 2.72. The M-sand is brought from the Andral M-sand industry, Gulbarga. Specific gravity and % water absorption of M-sand is 2.74 and 1.6% respectively. The fineness modulus of M-sand is 3.09. The crushed stone aggregate with maximum grain size of 10 mm brought from the local agencies is used in the experimental work. The specific gravity and water absorption of coarse aggregate is found out to be 2.59 and 0.27% respectively. Fineness modulus of coarse aggregate (less than 10mm) is found to be 7.57.

B. Super plasticizer

Hi-Forza 245 is the super plasticizer used in the experimental work. It is a high efficiency Poly-carboxylate based super plasticizer for the production of self-compacting concrete. The dosage of super plasticizer is determined by mixing many numbers of trials concrete mixes by varying doses of super plasticizer.

C. Viscosity modifying admixture

Glenium stream 2 is the viscosity modifying admixture (VMA) used in the experimental work. Glenium stream 2 is a liquid, organic VMA specially developed for producing concrete with enhanced viscosity and controlled rheological properties.

Mix proportion of self-compacting concrete

There is no standard method for SCC mix design and many academic institutions, admixture, ready-mixed, precast and contracting companies have developed their own mix proportioning methods.

Referring table. No. 8.2 of "The European guidelines for SCC (EFNARC)" and the trial mixes from journal paper taking a mix proportion as initial mix proportion for producing M-20 grade concrete. Mixing trial concrete mixes and checking for the standard values of test prescribed by the EFNARC guidelines.

The initial (reference) mix proportion is

1. Cement = 485 kg/m3
2. Fine aggregate = 985 kg/m3
3. Coarse aggregate = 700 kg/m3
4. W/C ratio = 0.8
5. Super plasticizer = 1.14% of cement

The concrete mix is prepared by using the above mix proportions and checked for the fresh properties by performing slump flow, T-50 slump flow and J-ring test as given by table 3.11 of European guidelines. After performing the mentioned tests the mix proportion is found to be inadequate to meet the acceptance criteria for self-compacting concrete.

Now by adjusting the mix and varying one or the other ingredient of concrete and by adding VMA many numbers of concrete mixes have been mixed and checked for acceptance criteria by performing slump flow, T-50c.m slump flow and J-ring tests and obtaining a final mix proportion which satisfied the acceptance criteria of SCC. The mix composition which is obtained by adjusting the initial mix is taken as mix proportion for further experimental work.

The adjusted/ final mix proportion of SCC

1. Cement = 560 kg/m3
2. Fine aggregate = 980 kg/m3
3. Coarse aggregate = 560 kg/m3
4. W/C ratio = 0.65
5. Super plasticizer = 1% by the weight of cement
6. VMA = 0.5% by the weight of cement

Tests conducted on SCC

Tests on fresh concrete properties

1. Slump flow test (filling ability)
2. T_{50} cm slump flow test (filling ability)
3. J-ring test (passing ability)
4. V-funnel test (filling ability)
5. V-funnel test at T5minutes (segregation resistance)
6. L-box test (passing ability)

III. RESULTS AND DISCUSSION

Tests on fresh concrete properties

The concrete is mixed with using the obtained mix proportion by only using the river sand and by fully replacing the river sand M-sand and the following tests are performed which are the slump flow test, T50 slump flow test, J-ring test, V-funnel test, V-funnel test at T-5 mins and L-box tests the results obtained are as follows.

Table 2 Tests on fresh concrete properties

Sl. no	Tests	Conventional Mix (100% River sand+0% M Sand)	Modified Mix 50% river sand + 50% M-sand
1	Slump flow test (mm)	680	660
2	T-50 slump flow test (sec)	2.8	3.2
3	J-ring test Height difference (mm)	7	8
4	V-funnel test (sec)	10.9	11.5
5	V-funnel at T-5 mins. (sec)	3	3.15
6	L-box test (H2/H1) ratio	0.8	0.65

The concrete without M-sand has shown good slump flow results than the concrete having 50% M-sand but the results with these proportions are also meeting the limits given by EFNARC guidelines as shown in Table 3.11. The resistance to segregation of both SCC mixes is found to be good as shown by the V-funnel test at T-5 minutes.

Figure 1 J-ring test

Hardened concrete properties

Compressive strength test

The compressive strength test is carried out on the SCC after 7days and 28 days of curing on concrete cubes.

Figure 2 Compressive strength test

Table 3 Compressive strength test

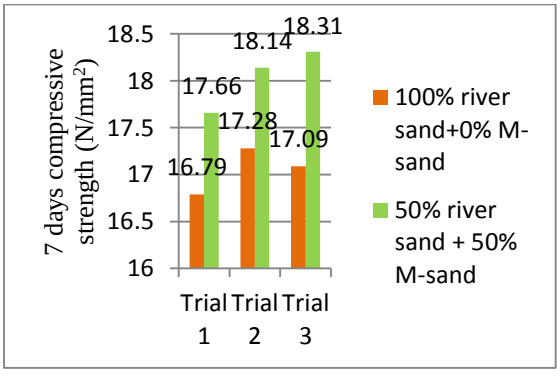

Figure 3 Compressive strength at 7 days

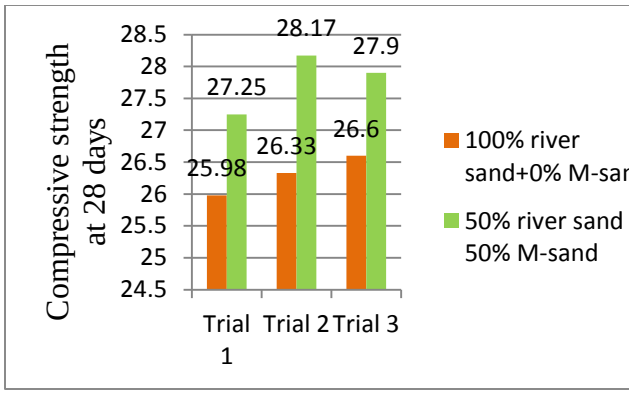

Figure 4 Compressive strength at 28 days.

The mix proportion of SCC has been designed for a compressive strength of 20Mpa. The cubes were casted for the proportions of 100% river sand, 50% river sand+50% M-sand. The concrete cubes made with 50% replacement of river sand with M-sand have shown a better compressive strength than concrete cubes made using only river sand as fine aggregate.

Split tensile strength test

The split tensile strength test is carried out on the hardened SCC after 7days and 28 days of curing on concrete cylinders.

Table 4 Split tensile strength test

Mix ID	Trial No.	Split tensile strength (N/mm^2)	
		At 7 days	At 28days
100% river sand+0% M-sand	1	2.05	2.55
	2	2.08	2.57
	3	2.07	2.58
50% river sand+ 50%Msand	1	2.1	2.61
	2	2.12	2.65
	3	2.14	2.64

Table 5 Compressive Strength

Mix ID	Trial No.	Compressive strength (N/mm2)	
		At 7 days	At 28days
100% river sand+0% M-sand	1	16.79	25.98
	2	17.28	26.33
	3	17.09	26.6
50% river sand + 50% M-sand	1	17.66	27.25
	2	18.14	28.17
	3	18.31	27.9

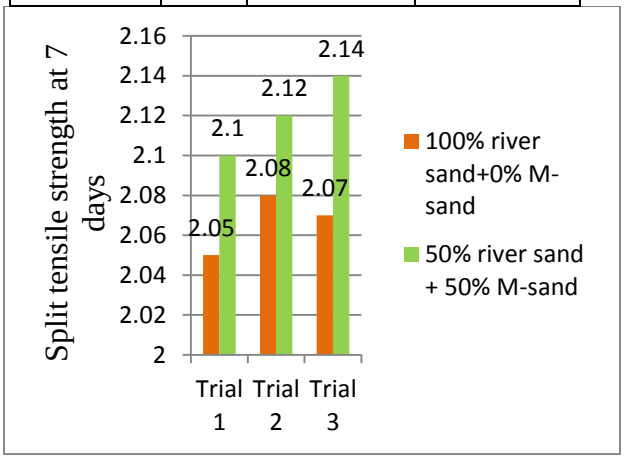

Figure 5 Split tensile strength at 7 days

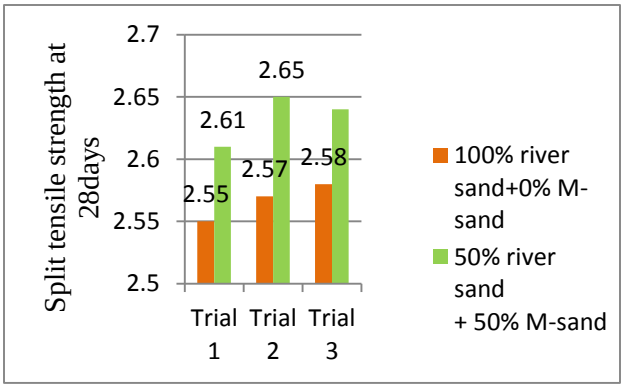

Figure 6 Split tensile strength at 28 days

IV. CONCLUSIONS

The present work investigated the influence of M-sand sand as replacement of fine aggregate (sand) on the properties self-compacting concrete. From the present study, following conclusions are drawn.

1. The concrete with replacement of natural sand by manufactured sand illustrated that with 50% replacement the compressive strength is increased about 5.75% when compared to reference mix i.e., 0% replacement.

2. The concrete with replacement of natural sand by manufactured sand illustrated that with 50% replacement the split tensile strength is increased about 2.46% when compared to reference mix i.e., 0% replacement.

3. Concrete mix becomes harsh with increase in proportion of manufactured sand. The workability of the SCC is slightly reduced with increase in proportion of M-sand but there is increase in compressive strength and tensile strength.

4. Results illustrate that the manufactured sand can be used as partial replacement of natural sand.

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