An Investigation on SCC with Partial Replacement of Fine Aggregate by M-Sand

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Abstract: Self compacting concrete (SCC) of M30 grade as per EFNARC guidelines was designed. The binder in SCC consists of OPC and fly ash in the ratio of 75:25. In this study, river sand was replaced by manufactured sand (M-sand) at replacement levels of 20%, 40% and 60%. In each trial mix, the fresh concrete properties were studied such as filling ability, passing ability and segregation resistance through slump flow test, J-Ring test, V-funnel test, U-box test and L-box test. The satisfied trial mixes in fresh state were cast for the study of hardened concrete properties such as compressive strength, split tensile strength and flexural strength. The cube compression test, flexural test and split tensile test were carried out at 7 and 28 days of curing periods. The increase in partial replacement of sand by M-Sand improved fresh and hardened concrete property up to the range of 40%. Better results were observed in split tensile and flexural strength up to the mix proportion of 25% of fly ash and 40% of M-sand.

IndexTerms **- SCC, M-Sand, Fly ash, Super plasticizer, Flow ability, Passing ability,**

1. Introduction

Making concrete structures without vibration have been done effectively in the past. Mass concrete, and shaft concrete can be successfully placed without vibration. In places of congested reinforcement, it is difficult to achieve effective compaction without vibrators. Originally developed in Japan, SCC technology was made possible by much earlier development of super plasticizers for concrete. SCC is a concrete, which is able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration, whilst maintaining homogeneity. Modern application of Self Compacting Concrete (SCC) is focused on high performance, better and more reliable and uniform quality.

River sand is the constituent to be used, for production of concrete is now become vital. Due to the scarcity of river sand the cost is increased. The cost and conveyance of river sand increases the cost of construction which requires an alternative material for natural river sand for the present scenario. The alternative material used in this study was M-sand, which is manufactured with crushing the boulders with vertical shaft impact crusher. The durability of the concrete is the ability to resist weathering action, chemical attack or any other process of deterioration.

In designing the mix, it is most useful to consider the relative proportions of the key components by volume rather than by mass. Indicative typical ranges of proportions and quantities in order to obtain self - compactability are given below. Further modifications will be necessary to meet strength and other performance requirements.

- Water/powder ratio by volume of 0.80 to 1.10
- Total powder content - 160 to 240 litres (400-600 kg) per cubic meter.
- Coarse aggregate content normally 28 to 35 per cent by volume of mix.
- Water cement ratio was selected based on requirements in EN 206.
- The water content does not exceed 200 litre/m3 typically.
- The sand content balances the volume of the other constituents

2. LITERATURE REVIEW

1. **Praveen kumar M et al., 2016** attempt has been made to make a comparative study on the fresh and hardened properties of M40 grade of plain concrete mixes to self-compacting concrete. An experimental investigation were carried out to study the properties of SCC by manufacture sand and partially replacing cement with percentage of Lime stone of (0%, 10%, 20%, 30%, 40%). Further workability test (Slump, V-funnel, L-Box, U-Box, J-Ring and T50) and mechanical properties such as compressive strength, split tensile strength, flexural strength were studied on this SCC mix proportions. The cube compressive strength after 7 and 28 days had shown an increase in strength with increase in percentage of lime stone from 0 - 20%. It was maximum at 20%. Thereafter there was a decrease in compressive strength for 30% and 40% replacement.

2. **S.R. Vaniy et al., 2016** experimentally done to use of manufactured sand in SCC. The use of alternative aggregate like manufactured sand is a natural step in solving part of depletion of natural aggregates. The investigation on alternative material for self- compacting concrete making started in recent times. Concrete made from manufactured sand waste as fine aggregate will be studied for workability, compressive strength, split tensile strength and flexural strength. Further, study of its durability will ensure greater dependability in its usage. So here in this project, manufactured sand has been used as replacement of fine aggregate by different percentage for making concrete of M-25 and M-30. The percentage replacement will be 0%, 10%, 20%, 30%, 40%, 50% with natural fine aggregates. Cubes, beams and cylinders will be casted and tested compressive strength, Split tensile strength, and flexural strength as well as for durability properties. Optimum replacement of manufactured sand can be used in structural concrete.

3. **K Praveen Kumar et al., 2016** investigated on engineering properties of self-compacting concrete (SCC) with Fly Ash and Manufactured Sand. The binder in SCC consists of OPC and fly ash in the ratio of 65:35. River sand was replaced by manufactured sand (M-sand) at replacement levels of 20, 40, 60, 80 and 100%. An attempt was made to evaluate the workability and strength characteristics of self-compacting concrete with river sand and manufactured sand as fine aggregates. For each replacement level, constant workability was maintained by varying the dosage of super plasticizer. T50 flow time, V Funnel time, V-funnel T5 time as well as compressive, split tensile and flexural strength of SCC were found at each replacement level of M-sand. They were compared to SCC with river sand. Results indicate favorable use of M-sand in preparation of Self Compacting Concrete.

4. **Praveenkumar S R et al., 2016** attempt has been made to prepare a high strength SCC of grade M60 by partially replacing the cement content with the untreated industrial byproducts like fly ash & ground granulated blast furnace slag (GGBS) and also by replacing 100% of natural sand with manufactured sand (M-Sand). With the use of these industrial byproducts, it results in an eco-friendly environment and also solves the problem of its disposal. This work dealt with the comparative study on mechanical properties like compressive strength, split tensile strength and flexural strength of SCC for various percentages of powder contents with the use of glass fibers at 0%, 0.1% & 0.2% to the total volume of the concrete mix. In this study two types SCC mixes were prepared namely, Conventional SCC in which cement content was replaced by 30% with fly ash and Triple blended SCC in which cement content was reduced to 50% & the rest of the cement content was replaced with fly ash & GGBS by 25% each. The specimens are casted, cured & tested for the required number of days.

5. **B.K. Tuljarams et al., 2015** studied an effort has been made to investigate the potential usage of M-sand in powder based SCC and to carry out partial replacement by M-sand for natural sand till flow ability and passing ability of SCC are in favorable limits. It was found that up to 30% of replacement by M-sand for natural sand was found to be optimum replacement. Fresh properties such as slump flow, T500 mm test, L-box, U-box, J-ring, V-funnel test are tested and hardened properties such as compressive strength and bond strength by pull out test for cylindrical specimens embedded with 20mm bars have been tested and results are compared.

6. **Purumani Supriya 2016**, Concrete is the most widely used construction material because of its mould ability into any required structural form and shape due to its fluid behavior at early ages. Thorough compaction, using vibration, is normally essential for achieving workability, the required strength and durability of concrete. Inadequate compaction of concrete results in large number of voids, affecting strength and long term durability of structures. Self-Compacting Concrete (SCC) provides a solution to these problems. As the name signifies it is able to compact itself without any additional vibration. However, wide spread applications of SCC have been restricted due to lack of standard mix design procedure and testing methods. It is gaining wide acceptability because no vibration is needed and noise pollution is eliminated.

3. EXPERIMENTAL DETAIL

3.1 Cement

Cement is used in construction is a substance and a binder, that sets and can bind other materials together and hardens. Ordinary Portland cement of 53 grade was used for this study which purchased from local vendor. The specific gravity of the cement was experimented as 3.06 which conforms EN 197-1: 2000.

3.2 Fly ash

Generally fly ash is used as a filling material. In this investigation, it has been used as a binder material. The specific gravity of fly ash was determined as 2.152. It was collected from the nearby industries.

3.3 River Sand

Locally available natural river sand was collected at Karur confirming to Grading zone II of IS: 383-1989 with specific gravity of 2.56 and fineness modules of 3.98 was used as fine aggregate.

3.4 M- Sand

M-sand is manufactured in vertical shaft impact crushers. The physical properties confirming to IS 383-1989 with specific gravity of 2.53 and fineness modulus of 3.72 was used as fine aggregates for replacement of conventional sand. The properties of M- sand were accords the values of river sand and it was collected from local industries.

3.5 Coarse Aggregate

Coarse aggregate of maximum size 20 mm was used in this experimental study. The specific gravity of coarse aggregate was determined as 2.73.

3.6 Water

The water used for this study was free from acids, organic matters, suspended solids, alkalis and durability of concrete. Potable water with the pH value of 7 confirming to IS: 456-2000.

3.7 Chemical Admixture

The admixture of CONPLAST SP430 was used which procured from local vendor. It is a chloride free, super plasticising admixture based on selected sulphated naphthalene. It is supplied as a brown solution which instantly disperses in water.

3.8 Mix Proportion

The mix proportions of different types of replacement mixes of fine aggregate in percentage with M-Sand and obtained quantities were presented in Table 1. The fly ash was replaced for the cement by 25 %, fine aggregate of river sand was replaced by M-Sand from 0 to 60 % and the coarse aggregate remains same for the study. For conventional mix and all the replacements, the super plasticizer was added for 2.5 % by weight of powder content and water – powder ratio was kept constant as 0.4.

Table 1. Mix Proportion of replacement of materials on SCC

Material/ Mix	Powder content		Fine Aggregate		Coarse Aggregate
	Cement	Fly ash	River Sand	M-Sand	
Conventional	25%		42%		33%
	75%	25%	100%	0%	100%
	435.44 kg	99.60 kg	922.9 kg	0 kg	707 kg
SCC-1	25%		42%		33%
	75%	25%	80%	20%	100%
	435.44 kg	99.60 kg	738.33 kg	182.41 kg	707 kg
SCC-2	25%		42%		33%
	75%	25%	60%	40%	100%
	435.44 kg	99.60 kg	553.73 kg	364.82 kg	707 kg
SCC-3	25%		42%		33%
	75%	25%	40%	60%	100%
	435.44 kg	99.60 kg	369.15 kg	547.24 kg	707 kg

3.9 Preparation and Casting of Specimen

To examine the compression test on concrete, a trial mixes were prepared and the cube samples were casted (150 x 150 x 150 mm). The curing was done for the casted samples for 7 and 28 days and then the samples were tested for compressive strength. For the spilt tensile strength test, the cylinders with 150 x 300 mm size were casted and prisms of 500 x 100 x 100 mm were casted for flexural strength test.

4. RESULTS AND DISCUSSION

4.1 Testing on SCC (Fresh Concrete)

In overall, a change of workability depends on ratio of binder to aggregate which conform EFNARC standards; by this the filling and passing ability tests for workability were accompanied. SCC should fulfill both workability and strength conditions. Slump flow and V-funnel tests are responsible for filling ability of SCC whereas J-ring and L-box test are responsible for passing ability of SCC. In the V-funnel, for segregation resistance of SCC should attain at 5 minutes. According to theory, M-Sand should enhance the workability but experimentally the workability decreases when percentage of M-Sand increases. The results of properties of fresh SCC are presented in Table 2.

Table 2. Properties of Fresh SCC

SCC Properties	Test	Conventional Mix	SCC-1	SCC-2	SCC-3	Acceptance Criteria as per EFNARC
Flow ability	Slump Flow (Diameter of flow)	750 mm	746 mm	735 mm	720 mm	650 – 800 mm
Filling ability	V-Funnel (Time)	8 sec	8 sec	9 sec	11 sec	8-12sec
Passing ability	L-Box (H_2/H_1)	0.95	0.95	0.95	0.90	0.8 – 1
	J-Ring	2 mm	2 mm	2 mm	3 mm	0 mm-10 mm
	U-box (H_2-H_1)	14 mm	14 mm	15 mm	17 mm	0-30 mm

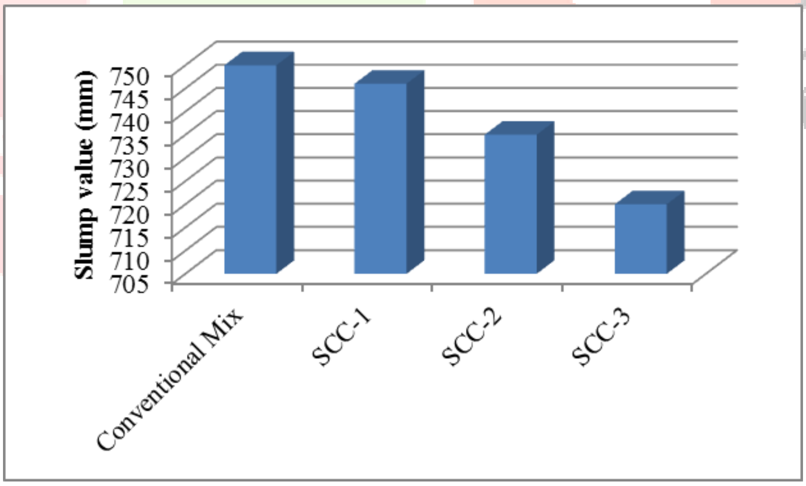

Fig.1. Workability of different mix of SCC

4.2 Testing on SCC (Hardened Concrete)

4.2.1 Compression Test

The variation of compressive strength of self-compacting concrete with various replacement of M- sand after 7 and 28 days curing is presented in Table 3. From the Fig. 2, it was observed that the compressive strength decreases with increase in amount of replacement of M-sand at both 7 and 28 days testing. For 60% replacement by M-sand, the compressive strength was 20% lower than that of SCC with river sand.

Table 3. Compressive Strength Test Results of various mixes

Concrete Mix	Average Compressive Strength (N/mm^2)	
	At 7 days	At 28 days
Conventional mix	29.38	39.68
SCC 1	27.47	38.58
SCC 2	25.91	37.29
SCC 3	23.24	31.95

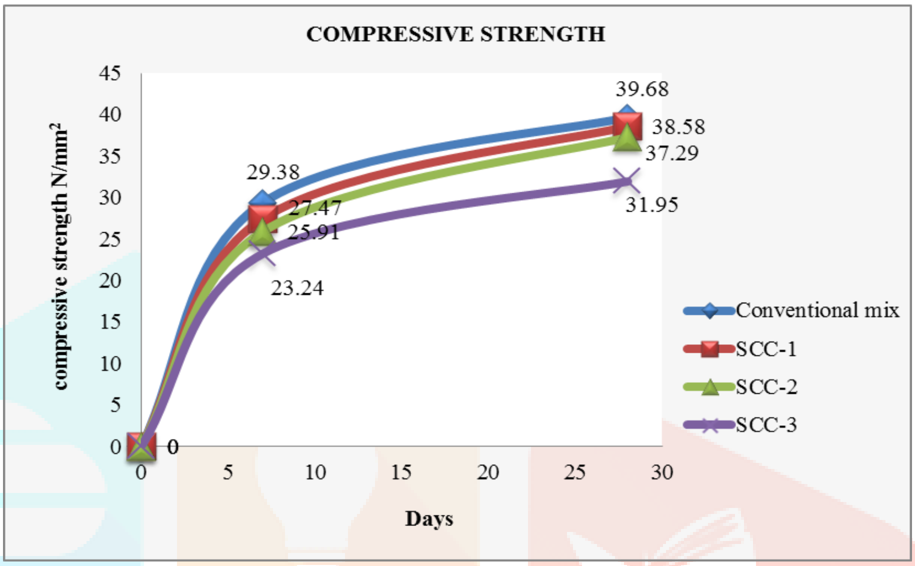

Fig. 2. Compressive Strength Test Results

4.2.2 Spilt Tensile Strength Test

The desired no. of cylinders were cast and tested in the laboratory after the curing period of 28 days for split tensile strength. From the Fig. 3, it was observed that the split tensile strength of mix SCC-1 and SCC-2 are more when compared to conventional mix. Maximum split tensile strength was observed in concrete with 80 % river sand and 20% M-sand, which is 9.5 % higher compared to concrete with natural sand. The increase in strength of concrete with M-sand may be due to the rough surface texture of M-sand when compared to natural sand.

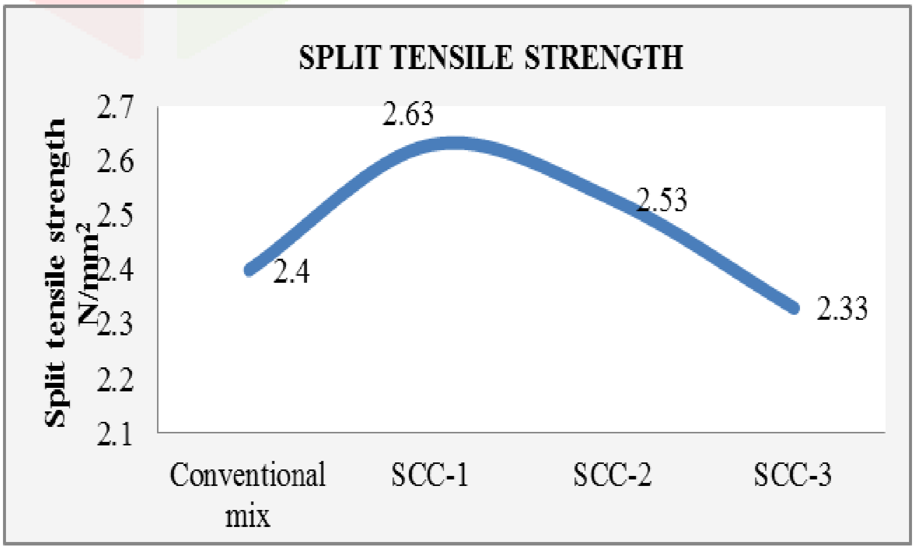

Fig. 3. Spilt Tensile Strength Test

4.2.3 Flexural Strength Test

For the flexural strength test, the specimen before and after loading in testing machine is shown in Fig. 4. The results of flexural strength tests for the M-Sand in concrete mixtures SCC-1, SCC- 2, and SCC- 3 are illustrated in Fig. 5. These results show that the flexural strength of concrete mixtures at 28days curing age is become to decrease with the increase of the M-Sand ratio in these mixtures. The flexural strengths of the SCC-1, SCC- 2, and SCC- 3 are compared to conventional is high. The variation of flexural strength with various replacement levels of M-sand when compared to concrete with natural sand is marginal. Hence M-sand can be used for pre casting concrete pavement slabs

(a)

(b)

Fig. 4. Flexural Strength Test (a) Before loading, (b) After loading

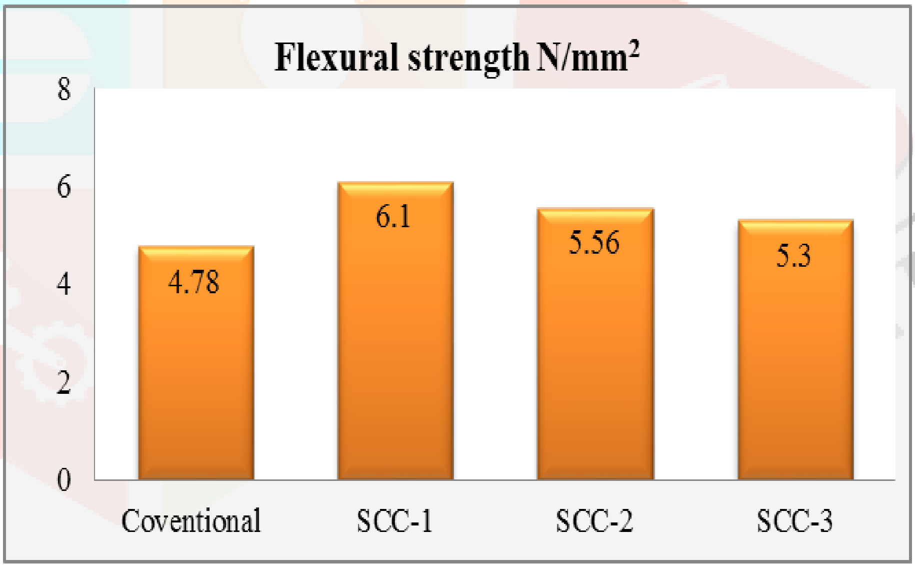

Fig. 5. Flexural Strength Test

5. CONCLUSION

Based on the results obtained on SCC, the following conclusions have been arrived it.

- There is not much more difference in slump of 60% M-Sand concrete and normal concrete.
- Compressive strength of SCC decreases as the percentage of replacement of sand by M-Sand increases, for various percentages of mixes.
- Up to 40% replacement of fine aggregate with manufactured sand has not much more reduction in compressive strength of concrete.
- Split tensile strength of SCC 1 and 2 were more when compared to conventional mix because of texture of M-Sand.
- By the replacement of manufactured sand in concrete, flexural strength was increased from 0% to 20% and then decreased in 40% & 60% compared to 20%.
- Flexural strength of all SCC mix were more compared to SCC with river sand. Therefore the M-sand can be used for precasting concrete pavement slabs.

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