ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 2, August 2017

Strength and Workability of High Strength Self Compacting Concrete M60 with M-Sand and Steel Fibers

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Abstract-In recent times SCC has become a revolution in construction industry. All major projects which have dense reinforcement meshes are major applications of SCC due to its passing ability and flow ability. The viscosity and flow ability to SCC is imparted through increase in its powdered content or use of viscosity modifying agents (VMA). To make concrete highly flow able fine aggregate content is increased higher than coarse aggregates. Due to high fine aggregate content it is advisable to replace river sand by M-Sand. High Strength Self-Compacting Concrete (M60) was designed based on Nan-Su trial and error mix design procedure. In the present study partial replacement of river sand by M-Sand is incorporated. River sand was partially from 10% to 40% with interval of 10% by M-Sand. With increase in percentage of M-Sand passing ability and flow ability decreased continuously. For strength and workability 30% replacement of river sand with M-Sand was found to be optimum. Steel fibers were incorporated in the mix to improve compressive strength, Flexural strength. Steel fibers were varied as volume fraction from 0.5% to 2.5% with interval of 0.5%. For 2% volume fraction of steel fibers there was distinct peak in compressive and flexural strength. With fibers it was also observed that crack formation and crack growth considerably reduced.

Index Terms—**EFNARC, GGBS, M-Sand, SCC, Steel fibers.**

I. INTRODUCTION

Self-Compacting Concrete (SCC) is a special type of high performance concrete with great deformability and segregation resistance. It is type of concrete which can flow through and fill the gaps of reinforcement without any vibration or compaction (1).SCC has some favorable characteristics such as good segregation resistance, high fluidity and distinctive self-compacting ability without the need of vibration and compaction during placing. Major work involves arriving at the mix design for High Strength Self-Compacting Concrete (M60). In this study Nan-Su method of mix design was used as a basis to arrive at the mix design for High strength SCC (1). Final mix design is being arrived at through trial and error method. In this study river sand was partially replaced by Manufactured Sand (M-Sand). Steel fibers are varied as volume fraction at an interval of 0.5% from 0% to 2.5%. Manjunatha M. partially replaced River Sand by M-Sand till 50% and concluded that Cement mortar for 50% replacement with M-Sand gave higher strength. In this study Copper Slag, Granite powder and Fly ash fiber were also used to replace River Sand and their effect on compressive strength was studied (2). Pendhari Ankush partially replaced River Sand by Waste Foundry Sand and concluded that 30% replacement with Waste Foundry Sand gave maximum compressive strength (3). Abbas Al Ameeri varied Steel Fibers as volume fraction in SCC and determined its effect on mechanical properties of concrete. He concluded that inclusion of Steel Fibers led to marginal increase in compressive strength but significant increase was observed in flexural and split tensile strength (4).

II. MATERIALS AND EXPERIMENTATION

- Cement: In this experimental work OPC 43 grade with specific gravity 3.15 was used confirming to IS: 8112: 2013.
- Fine aggregates: Sand used in this experimental work was locally procured and was confirming to zone II. Specific gravity was determined to be 2.65.
- M-Sand: Manufactured sand was procured from local source was confirming to zone II. Water absorption was determined to be 5%.
- Coarse aggregates: Locally available crushed angular coarse aggregate having the maximum size of 12.5 mm were used in the present work. The specific gravity of coarse aggregate was 2.82 and bulk density 1550 Kg/m^3.
- Mineral admixture: In this experimental work ground granulated blast furnace slag (GGBS) was used as mineral admixture. The specific gravity was found to be 2.88.
- Water: Potable tap water was used for experimental works and also for curing specimens.
- Super plasticizer: Conplast SP 430 was used which imparted high degree of workability and retention time required.
- Steel fibers: Flat Crimped steel fibers of Length: 38mm, Thickness: 0.75mm, Aspect ratio: 50.66, Density: 7850Kg/m^3.

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In this experimental work high strength SCC mix design is arrived at through trial and error. Nan-Su method is used as a basis to arrive at the final mix design. SCC was designed for M60 grade (1).

Table 1: Mix proportion of SCC

Particulars	Quantity(Kg/m^3)
Powder(Cement+GGBS)	600
Fine aggregates	920
Coarse aggregates	780
Water	165
Super Plasticizer	10

Cement, GGBS and Fine aggregates were mixed dry until the mixture was thoroughly blended in the case of control mix. The coarse aggregate was then added and mixed to distribute it uniformly. Initially 70% of water was added to the dry mixture to attain homogeneity and then the remaining 30% suspension of super plasticizer prepared in water was added and the mixing was continued to obtain homogeneous mix. Cube specimens of size 150 mm and Flexural strength is calculated by preparing beam specimens of size 100×100×500 mm.

TESTING

Tests on fresh SCC were determined by conducting a) Slump flow test b) V-funnel flow test c) U- box test d) L- box test and all these values were checked for suitability in EFNARC guidelines for workability of SCC. The effect on workability due to percentage replacement of river sand by M-Sand was determined by these tests. Tests on hardened properties were determined by conducting compressive strength and Flexural strength tests (6). Compressive strength was determined for M-Sand as well as Steel fiber reinforced SCC. Flexural strength was determined for different volume fractions of steel fibers.

III. RESULTS AND DISCUSSION

A. Fresh properties

Effect of variation of M-Sand on workability of High Strength SCC was determined using workability tests such as Slump flow, V-Funnel, U-Box, L-Box. The results are tabulated in Table 3.

TABLE 3: VARIATION OF WORKABILITY DUE TO PARTIAL REPLACEMENT OF RIVER SAND BY M-SAND

Sr.no	Tests	EFNARC Limits	Reference mix	Percentage replacement of river sand by M-Sand			
			0%	10%	20%	30%	40%
1	Slump flow	600-800mm	680	670	650	620	590
2	V-funnel	8-12sec	9	10	11	13	16
3	U-Box	0-30mm	24	26	29	32	36
4	L-Box	0.8-1.0	0.96	0.92	0.88	0.86	0.78

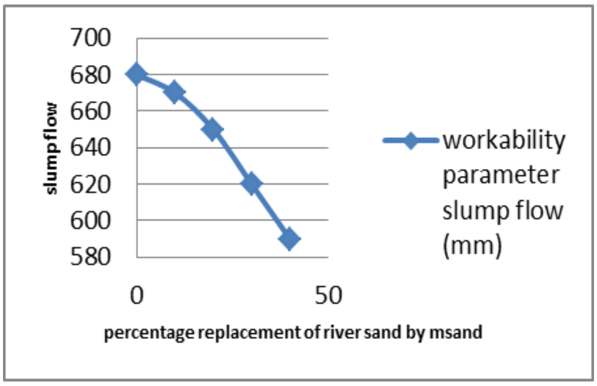

Fig 1: Slump flow for partial replacement of river sand by M-Sand

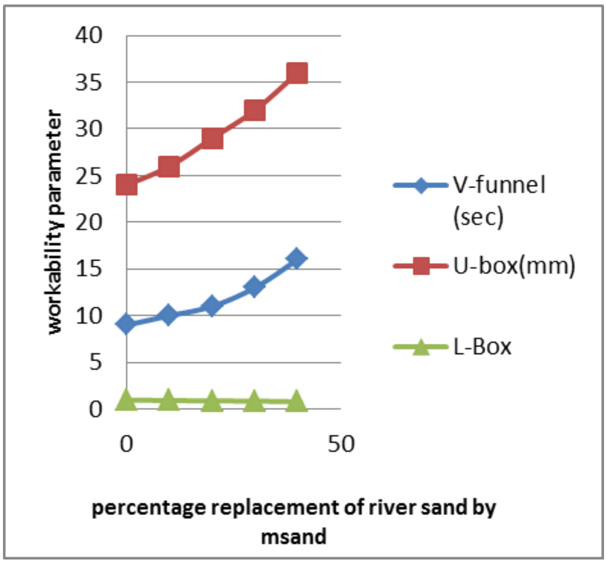

Fig 2: Workability parameters (V-Funnel, U-Box, L-Box) for percentage replacement of river sand by M-Sand.

From Table 3 and Figure 1 and 2 it is observed that the passing ability and flowability of SCC considerably reduced for 40% replacement of river sand by M-Sand for a given mix proportion. This may be due to the presence of finer fragments in M-Sand which possess rock forming elements such as alumina, silica etc. These fragments make the mix cohesive and restrict the flow of concrete which leads to the reduction in workability. M-Sand being finer material compared to river sand has greater surface area which leads to higher water demand to attain same workability as that of reference mix (0% M-Sand).

B. Hardened properties

Table 4: Variation of compressive strength for various percentage replacement of river sand by manufactured sand.

Percentage replacement of river sand by M-Sand	Compressive strength in N/mm^2	
	7days	28days
0(reference mix)	39.11	61.35
10	40.25	62.43
20	41.26	64.13
30	42.74	66.43
40	42.15	65.71

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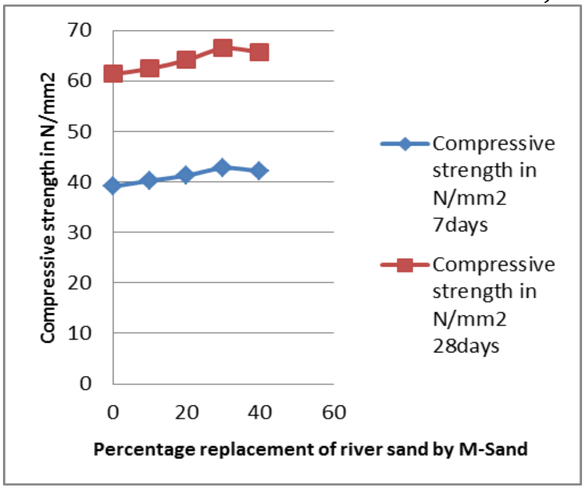

Fig 3: Variation in compressive strength for various percentage replacement of river sand by M-Sand.

From Table 4 and Figure 3 it is observed that compressive strength increased with increase in the percentage replacement of river sand by manufactured- sand. Highest strength was observed for 30% replacement of river sand by M-Sand. The increase in strength may be due to the fact that M-Sand is produced by crushing coarse aggregates which leads to formation of particles of irregular shape. As a result of this there may be better packing among the particles which leads to lesser voids. The concrete so formed will be denser hence less permeable.

Table 5: Variation of compressive strength for percentage variation of volume fraction of steel fibers for M-Sand optimized SCC.

Percentage variation of volume fraction of steel fibers	Compressive strength in N/mm^2	
	7days	28days
0	42.74	66.43
0.5	43.15	67.22
1	43.94	68.86
1.5	44.68	70.47
2	44.94	71.08
2.5	44.83	70.92

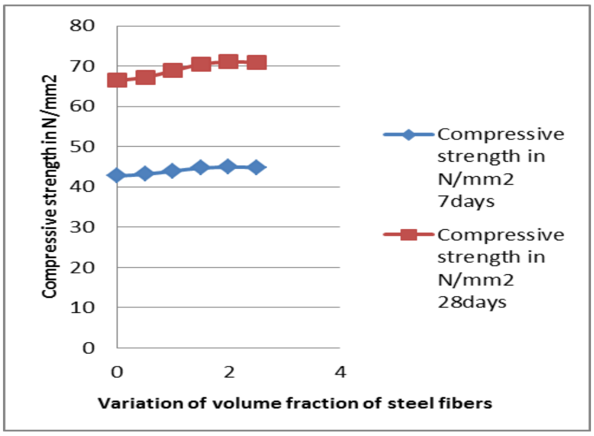

Fig 4: Variation of compressive strength for percentage variation of steel fibers for M-Sand optimized SCC.

From Table 5 and Figure 4 it was observed that the inclusion of steel fibers in the mix leads to marginal increase in compressive strength of SCC. The optimum dosage of steel fibers was found to be 2% volume fraction. The increase in strength could be due to increase in density of concrete due to the inclusion of steel fibers. The concrete so formed was may be less permeable.

Table 6: Variation of flexural strength due to percentage variation of volume fraction of steel fibers for M-Sand optimized SCC.

Percentage variation of volume fraction of steel fibers	Flexural strength(N/mm^2)
0	5.4
0.5	6
1	6.4
1.5	7.2
2	7.7
2.5	6.8

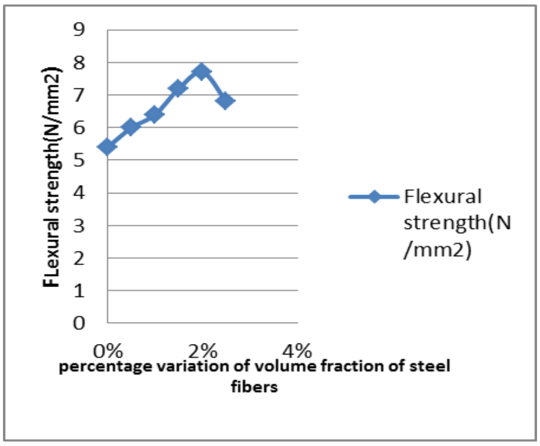

Fig 5: Variation of flexural strength due to percentage variation of volume fraction of steel fibers for M-Sand optimized SCC.

From Table 6 and Figure 5 it was observed that inclusion of steel fibers significantly increases the flexural strength of SCC compared to increase in compressive strength. For 2% percent volume fraction of steel fiber maximum flexural strength 7.7 N/mm^2 was observed. A more ductile failure was observed after the addition of steel fibers to the mix. Increase in flexural strength may be due to the fact that steel fibers influence the way cracks are developed in concrete, also impart better crack growth resistance and increase in surface roughness of cracks. For 2% volume fraction of steel fibers 42% increase in flexural strength was observed from reference mix.

IV. CONCLUSIONS

1. As the replacement of river sand with M-Sand increased the compressive strength also increased. For 30% replacement of river sand by M-Sand it showed highest strength.
2. The passing ability and flow ability of SCC decreased as the percentage of M-Sand increased from 0% to 40%.
3. For M-Sand optimized SCC further reinforced with steel fibers. There was marginal increase in compressive strength with increase in percentage of steel fibers up to 2% volume

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fraction beyond which there was reduction in strength. Maximum compressive strength was observed at 2% volume fraction of steel fibers.

4. Steel fibers significantly increased the flexural strength of concrete. The maximum flexural strength was observed for 2% volume fraction of steel fibers.

V. FUTURE EHANCEMENTS

1. Study on the effect of Hybrid fibers on Durability properties of High Strength SCC.
2. To study the micro-structural properties of High Strength SCC due to Chloride penetration.
3. Study on the comparison of different methods of mix design of High Strength SCC.
4. Study on the effect of blending of metakaolin, silica fumes, fly ash for the production of High Strength Self-Compacting Concrete.
5. Study on the fire behavior of High Strength Self-Compacting Concrete.

REFERENCES

[1]. Nan Su, "A simple mix design method for self-compacting concrete" Cement and Concrete Technology, Cement and Research, 2001,Vol.31, No.12, pp.1799-1807.

[2]. Narayan Suresh, Manjunatha M. "Effect of different types of fine aggregates on mechanical properties of concrete" Indian Concrete Journal, June 2016, Vol.17, No.1, pp.69-72.

[3]. Demse Dhananjay G. Nikam Madhuri, "Partial replacement of Sand by Waste Foundary Sand", International Research Journal of Engineering and Technology (IRJET), May-2017, Vol.4, No.05, pp.2771-2776.

[4]. Abbas Al Ameeri, "The effect of steel fiber on some mechanical properties of self-compacting concrete" American Journal of Civil Engineering, 2013, Vol.1, No.3, pp.102-110.

[5]. D.Indu, R. Elongovan, "Optimum mix proportioning of high strength self-compacting concrete" International journal of Engineering trends and Technology, July 2016, Vol.37, No.6, pp.342-349.

[6]. Biswadeep Bharali, "Experimental study on self-compacting concrete (SSC) using GGBS and fly ash" International journal of core engineering and management, September 2015, Vol.2, No.6.

[7]. S.N Manu, P. Dinakar, "Concrete mix design for high strength self-compacting concrete using Metakaolin" Materials and Design, April 2014, Vol.60, pp.661-668.

[8]. Jacek Golaszewski, Tomasz Ponikiewski, "Properties of steel Reinforced self-compacting concrete for optimal rheological and mechanical properties in precast beams" Procedia Engineering, Concrete and Concrete structures, 2013, Vol.65, pp.290-29.

[9]. Burak Felekoglu, Selcuk Turkel, Bulent Baradan, "Effect of water/cement ratio on the fresh and hardened properties of self-compacting concrete" Building and Environment, January 2006, Vol.42, No.4, pp.1795-1802.

[10]. Moncef Nehdi, Jennifer Duquette Ladanchuk "Fiber Synergy in Fiber-Reinforced Self-Consolidating Concrete" ACI Materials Journal, December 2004, Vol.101, No.6, pp.508-517.

[11]. EFNARC May 2005: European guidelines for Self-Compacting Concrete.

[12]. IS: 516-1959: "Method of tests for strength of concrete", Bureau of Indian Standards, New Delhi, India.