Self Compacting Concrete with Recycled Coarse Aggregates

Sija K Sam, Student
Civil Engineering Department
MBITS, Nellimattam
Kerala, India

Deepthy Varkey,
Assnt.Proffessor
Civil Engineering Department
MBITS, Nellimattam
Kerala, India

Dr. Elson John,
Assnt. Proffessor
Civil Engineering Department
MACE, Kothamangalam
Kerala, India

Abstract— **Self Compacting Concrete (SCC) is an innovative concrete that does not require any vibration for compaction. The study was carried out by replacing various percentages (10%, 20%, 30%) of natural aggregates in SCC with recycled coarse aggregates and the properties of SCC were evaluated. A comparison of SCC with concrete compacted using conventional method was also included in the study. The additive used in SCC for the study was Fly ash. The mix designs arrived for an M-30 mix. To reduce the water- binder ratio and to get sufficient flowability for SCC a polycarboxylic based superplasicizer was used. Mix design for SCC was carried out as per 'European Guidelines for SCC' based on 'Nan Su et-al method' of mix design. Fresh properties including Slump flow test, T-500 test, V-funnel and L-box test were carried out for SCC. Hardened properties of concrete like Compressive Strength, Flexural Strength, Split tensile Strength and Water absorption test were carried out for traditional concrete and SCC. By comparing the strength parameters of different mixes it was observed that SCC is a good alternative of traditional concrete with and without using recycled aggregates.**

Keywords—***Fresh Properties, Hardened Properties, Recycled coarse aggregates, Self Compacting Concrete, Water absorption***

I. INTRODUCTION

Concrete is a widely used construction material around the world, and its properties have been undergoing changes through technological advancement. Numerous types of concrete have been developed to enhance the different properties of concrete. When large quantity of heavy reinforcement is to be placed in a reinforced concrete (RC) member, it is difficult to ensure that the formwork gets completely filled with concrete that is, fully compacted without voids or honeycombs. Compaction by manual or by mechanical vibrators is very difficult in this situation. The typical method of compaction, vibration, generates delays and additional cost in the projects. Underwater concreting always required fresh concrete, which could be placed without the need to compaction; in such circumstances vibration had been simply impossible. This problem can now be solved with self-compacting concrete (SCC).

SCC is an innovative concrete that does not require any vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. SCC has favorable characteristics such as high fluidity, good segregation resistance and the distinctive self compatibility without any need for vibration during the placing process and so noiseless construction. The unique characteristics of SCC are a rapid rate of concrete placement with very less time. SCC offers a very high level of homogeneity; minimize the concrete void spaces and have uniform concrete strength and also provides the superior level of finishing and durability of structure. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete.

SCC poured in the same way as ordinary concrete but without vibration. It is very fluid and can pass around obstructions and fill all the nooks and corners without the risk of either mortar or other ingredients of concrete separating out, at the same time there are no entrapped air or rock pockets.

The hardened concrete can be crushed and reused as a partial replacement for natural aggregate in new concrete construction. The hardened concrete can be sourced from the demolition of concrete structures at the end of their life. Recycling or recovering concrete materials has two main advantages that it conserves the use of natural aggregate and the associated environmental costs of exploitation and transportation, and it preserves the use of landfill for materials which cannot be recycled.

The primary objective of the study is to evaluate different properties of SCC including fresh and hardened properties. Objectives of project work also includes the effect of using fly ash as an addition to SCC and study the compatibility of using recycled coarse aggregates in SCC.

II. MATERIALS AND MIX PROPORTIONS

A. *Material Properties*

The materials used for concrete were Binder materials, Fine aggregate (FA), Coarse aggregate (CA), superplasticizers and water. Different binders used in this study were Cement and fly ash (FYA). Cement used for the study was Ordinary Portland Cement (OPC) of grade 53. The manufacturer of the cement is Ramco. Fly ash used in the study was of Class-F grade. Fine aggregate used was M-sand from Poabs, Angamaly. Coarse aggregate were 12.5mm and 20mm crushed granite stones from a local quarry (CA12.5 and CA20) and recycled aggregate from 15 year old concrete building. MasterGlenium SKY 8233 was used as superplasticizer for the study. It is an admixture based on modified polycarboxylic ether. Properties of different aggregates were tabulated in TABLE.I

B. *Mix Proportioning*

The mix design for traditional concrete was carried out as per IS 10262: 2009 [1] for an M 30 mix for a slump of 100mm. The mix composition for SCC was chosen to satisfy all performance criteria for the concrete in both the fresh and hardened states as per EFNRC guidelines [2]. The mix design was carried out as per Nan su et-al method [3]. The Nomenclature used in the study is in TABLE.II

Different trial mixes were carried out by changing the paste volume, size and ratio of aggregates and superplastisizers. The mix which satisfied all the specifications of EFNRC was selected as the mix for the study. Different mixes were prepared by changing the recycled coarse aggregate (RCA) percentage in the standard mix. The mix design of different mixes are in TABLE.III

III. RESULT AND DISCUSSION

Fresh and hardened properties of concrete were studied for NVC and SCC with different percentages of RCA. Slump-flow, T-500, V-funnel and L-box tests [2] were carried out in the laboratory as per EFNRC guidelines to determine the fresh properties of SCC. Fresh properties of concrete obtained in the lab tabulated in TABLE.IV. The values obtained are within the range specified in EFNRC guidelines.

The slump-flow is the mean diameter of slump flow test by using a slump cone, expressed to the nearest 10 mm. The T500 time is the time in seconds the concrete has flowed to a diameter of 500 mm in the slump flow test. The time taken for the concrete to flow out of the V-funnel is measured and recorded in second is the V-funnel flow time.

TABLE I. PROPERTIES OF AGGREGATES

	Specific gravity	Impact value (%)	Crushing value (%)	Water absorption (%)	Fineness modulus
M-sand	2.74	-	-	1.2	2.72
RCA	2.26	30.8	28.78	3.1	-
CA12.5	2.74	29.8	27.78	1.2	-
CA20	2.74	29.8	27.78	1.2	-

TABLE II. NOMENCLATURE

No	Mix	Concrete Mix Proportion
1	***NVC***	M30 – Conventionally Vibrated Concrete
2	***SCC***	M30 – SCC with FYA as addition
3	***SCC-R10***	M30 – SCC with FYA and 10% replacement of RCA
4	***SCC-R20***	M30 – SCC with FYA and 20% replacement of RCA
5	***SCC-R30***	M30 – SCC with FYA and 30% replacement of RCA

For J-box test, height of the horizontal section of the box measured as H2 mm. The depth of concrete immediately behind the gate measured as H1 mm.

$$\text{Passing ability, PA} = H2/H1 \qquad (1)$$

The mechanical properties such as compressive strength, flexural strength, split tensile strength [4] and water absorption test were carried out in the laboratory. The compressive strength is measured using cube of size 150mm × 150mm × 150mm on 3, 7 and 28 days of curing on a compression testing machine. The Split tensile strength is conducted on cylinders of size 300 mm × 150 mm on 7 and 28 days of curing on compression testing machine. The flexural strength of concrete is conducted on beam of size 100 mm × 100 mm × 500 mm on 7and 28 days of curing on flexural testing machine.

Graphical Representation of compressive strength with variation in RCA in SCC and comparison with NVC was shown in Fig. 1. Which shows that even if the early age strength is less for SCC it developed comparable strength in 28 days. The compressive strength decreases with increase in percentage of RCA in SCC.

Graphical Representation of Split Tensile strength with variation in RCA in SCC and comparison with NVC was shown in Fig. 2. Which shows that SCC gives the highest split tensile, but with replacement of CA the strength of SCC reduces.

Graphical Representation of Flexural strength with variation in RCA in SCC and comparison with NVC was shown in Fig. 3. Which shows that SCC gives the highest flexural strength. With replacement of CA the strength of SCC reduces but having results equal to that of NVC.

Water absorption of different concrete mixes was carried out after 28 days of water curing. Fig. 4 shows the variation of water absorption in SCC and in NVC. Water absorption was found to be less in NVC when compared with SCC. Also water absorption percentage increases with increase in percentage of RCA.

TABLE IV. FRESH PROPERTIES OF SCC

Property / Mix	Slump flow (mm)	T500 (sec)	V-funnel time (sec)	L-box (PA)
SCC	620	4	21	0.91
SCC-R10	620	5	21	0.91
SCC-R20	615	5	22	0.83
SCC-R30	610	6	23	0.83

TABLE III. MIX PROPORTIONS

Mix	Cement (kg)	FYA (kg)	FA (kg)	CA20 (kg)	CA12.5 (kg)	RCA (kg)	Water (kg)	W/C	SP (%)
NVC	400	-	790	1073	-		192	0.43	0.5
SCC	350	200	758	-	758	-	240	0.42	0.4
SCC-R10	350	200	750	-	675	75	242	0.42	0.4
SCC-R20	350	200	742	-	594	142	243	0.42	0.4
SCC-R30	350	200	734	-	514	220	244	0.42	0.4

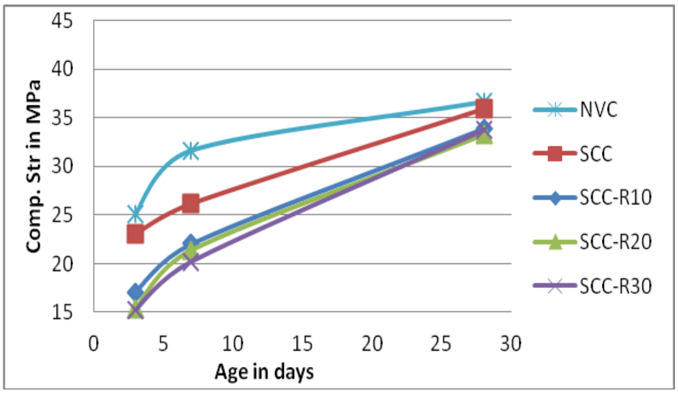

Fig. 1. Graphical Representation of Compressive Strength

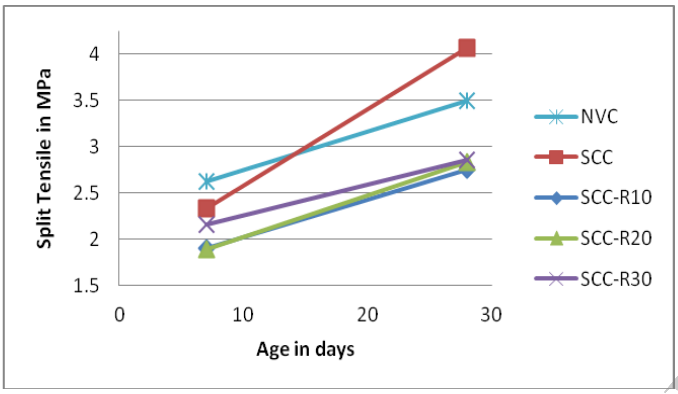

Fig. 2. Graphical Representation of Split Tensile Strength

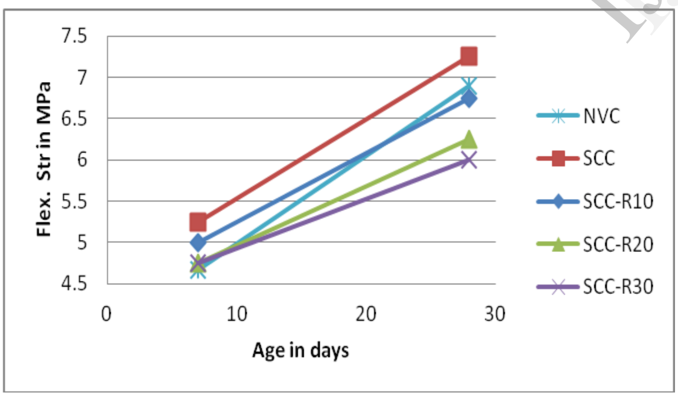

Fig. 3. Graphical Representation of Flexural Strength

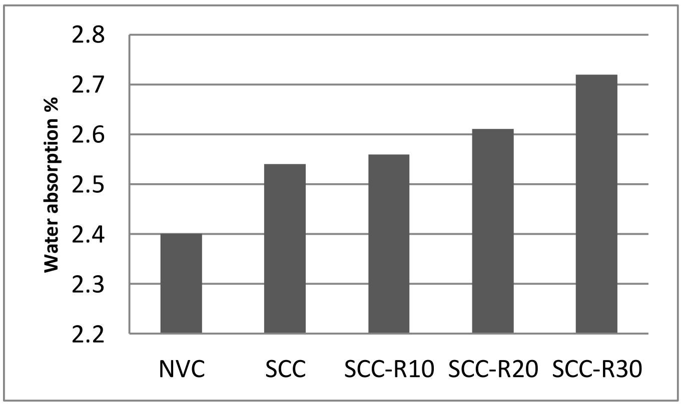

Fig. 4. Graphical Representation of Water Absorption

IV. CONCLUSION

It is desirable to use SCC because of its advantages like faster rate of construction and superior level of finish and also it can be used in congested reinforcement very well. Since the strength is not much reduced with recycled aggregates and flow properties were good recycled aggregate can be effectively used in SCC. Early age strength was less in SCC compared to traditional concrete. While comparing the Split tensile strength SCC gave highest result. But with coarse aggregate replacement gives a less value. When Flexural strength was studied all concrete mixes gave similar to that of traditional concrete. The water absorption increased in SCC with recycled aggregate was due to the higher water absorption in RCA. But it is within satisfactory limits. So RCA is a good alternative of CA in SCC. SCC with more percentage of RCA is to be studied..

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