

Performance of Self Compacting Concrete with Partial Replacement of Coarse Aggregate with Recycled Coarse Aggregate

L. Rajitha, M. Durga Rao

Abstract-Self Compacted Concrete (SCC) is an advanced approach for the purpose of placing of concrete. It is a concrete which does not require any external force, vibration or compaction and which is highly flowable, formwork is filled without any compaction and resistance to segregation. Workability tests for SCC in fresh state are Slump-flow, L-Box, J-Box, V-Box are carried out. By using recommended EFNARC guidelines the mix proportion of concrete was prepared for M40 grade concrete is 1:1.75:1.87. Water cement ratio of 0.35 is constant. In this paper Natural Coarse Aggregate (NCA) is partially replaced upto 50% with 10% interval by Recycled Coarse Aggregate (RCA). RCA is prepared by crushing of cubes which are taken from concrete technology lab. Construction and Demolition waste is also used as RCA. RCA is submerged in water for 24 hours before using for the concrete mix, this is because RCA absorbs more water due to adhered cement mortar to aggregate. The various tests and their results are shown in this paper.

Key words: Natural Coarse Aggregate (NCA), Recycled Coarse Aggregate (RCA), Self Compacting Concrete (SCC), Workability, Fresh Concrete, Hardened concrete.

I. INTRODUCTION

SCC can also be called as self consolidated concrete. The properties of SCC are passing ability, filling ability, high fluidity, resistance to segregation and self-compatibility without any external compaction or vibration for the placing process and hence it is having noiseless construction. SCC achieved similar engineering properties as normally vibrated concrete. The capacity of SCC mainly depends on the preparation of the fresh mix. In this paper RCA is manufactured by crushing the cubes from the concrete technology lab. Recycling is processing the waste material for the purpose of generating a new useful product. RCA is having lower density than natural coarse aggregate and have greater water absorption value, this is due to adhered mortar to RCA. Depending on the aggregate demolished method properties and quality of RCA can be identified. For this accurate identification proper mix design is carried out. By using these RCA, it is economical and eco friendly.

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II. MATERIALS USED

A. Cement

53 grade OPC of ultratech brand confirming to IS 12269-1987 was used throughout the study.

Table 1: Cement properties

S. No	Properties	Values
1	Specific Gravity	3.12
2	Normal Consistency	32%
3	Initial Setting Time	45 min
	Final Setting Time	480 min
4	Fineness Modulus	5%

B. Fine Aggregate

The locally available river sand which is in zone II confirming to IS 383-1987 is used.

Table 2: Fine aggregate tests

S. No	Tests	Values obtained
1	Fineness modulus	2.81
2	Specific gravity	2.66
3	Zone	II

C. Coarse Aggregate

Aggregates of size 10mm to 12.5mm are used for SCC throughout the project.

Table 4: Coarse aggregate tests

S.No	Tests	Values
1	Fineness modulus	7.29
2	Specific gravity	2.93
3	Crushing value(%)	20.15
4	Density(kg/m ³)	1560

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D. Recycled coarse aggregate

It is prepared by crushing the cubes which are taken from the concrete technology lab. RCA can be collected from different sources like construction and demolition waste, tested specimens which are available in the concrete technology labs and dumped waste concrete materials.

Table 4: Recycled coarse aggregates tests

S.No	TESTS	VALUES OBTAINED
1	Specific gravity	2.58
2	Fineness modulus	6.89
3	Density(kg/m ³)	1353
4	Crushing value(%)	29.12

E. Super Plasticizer

In this study we use master glemium sky B233 as a super plasticizer. The main reason of using super plasticizer in SCC is to give good flowability with high slump which can be used in heavily reinforced structural member.

F. Viscosity Modifying Agent

In this study Aura mix V200 obtained from Fosroc chemicals is used as viscosity modifying agent. In SCC VMA increases the stability, segregation resistance and reduces bleeding from concrete mix

G. Water

Fresh water can be used for curing and mixing for the entire project.

III. FRESH STATE PROPERTIES

A. Slump Flow Test

It is tested for the filling ability requirements of SCC. It is able to resist the segregation. The minimum and maximum values of slump as per EFNARC guide lines are 650 mm and 800mm respectively. The higher the value of slump, the greater will be the ability to flow.

B. L-Box Test

This is used to know the passing ability of SCC. The minimum and maximum values of L-Box test as per EFNARC guide lines are 0.8 and 1.0 respectively.

C. V-Funnel

This test is carried out for the filling ability requirements of SCC. It is able to resist the segregation and blocking. The minimum and maximum values of V-funnel test as per EFNARC guide lines are 8 seconds and 12 seconds respectively.

D. U-Box

It is a test for the passing ability requirements of SCC. The typical range of values of U-box are 0 to 30mm.

Table 5: Limitations for different tests for SCC

S. No	Method	typical range of values		Values Obtained
		Min	Max	
1	Slump flow	650	800	680 mm
2	L-Box	0.8	1	0.87
3	V-Funnel	8	12	7 sec
4	U-Box	0	30	8 mm

IV. DURIBILITY INVESTIGATIONS

A. Water absorption

In this process the weight of saturated specimens (W1) is noted. Then the specimens were oven dried at 105°C till constant weight was obtained (W2).

Now the water absorption was calculated as

$$= [(W1 - W2) / V] * 100$$

V = Volume of specimen

B. Acid attack

The cubes are immersed in 4% sulphuric acid solution for 90 days. Loss in weight and compressive strength are measured which are shown in table 11.

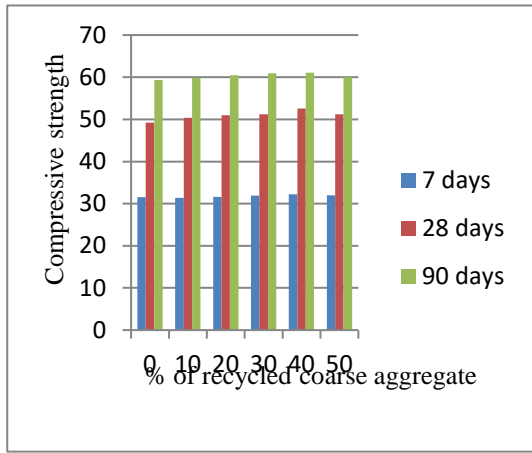
V. RESULTS AND DISCUSSIONS

A. Compressive strength

The cubes of size 150mm*150mm*150mm are used. Compressive strengths for 7 days, 28 days and 90 days are shown in table 7 and fig 1 with different percentage replacements. The strength is optimum at 40% replacement of RCA.

Table 6: Results for Compressive strength

S. No	RCA (%)	7 days	28 days	90 days
1	0	31.54	48.29	59.33
2	10	31.61	48.33	59.58
3	20	31.66	48.48	59.67
4	30	31.72	48.63	59.89
5	40	31.92	48.89	59.96
6	50	30.96	47.82	58.98



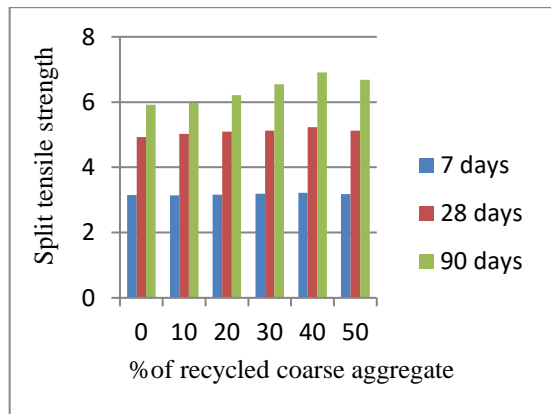
Graph 1: Compressive strength

B. Split Tensile Strength

The cylinders of size 300mm*150mm are used. Table no 8 and fig 2 shows the results of 7days, 28days and 90 days Split tensile strength which is optimum at 40% replacement of RCA.

Table 7: Results Split tensile strength

Sl.No	RCA(%)	7 days	28 days	90 days
1	0	3.16	4.81	5.92
2	10	3.17	4.82	5.95
3	20	3.19	4.85	5.96
4	30	3.20	4.87	5.97
5	40	3.21	4.89	5.99
6	50	3.09	4.78	5.85



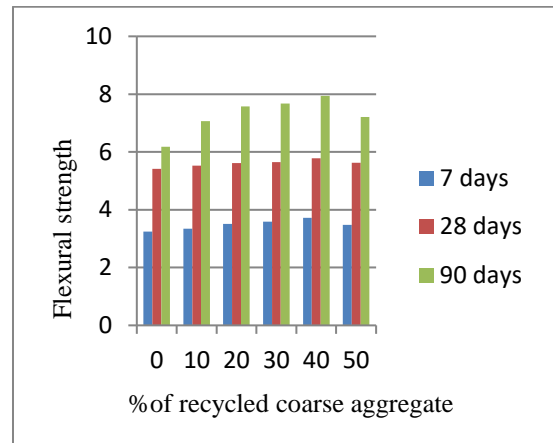
Graph 2: Split tensile strength

C. Flexural Strength

The beams of size 500mm*100mm*100mm are used. The strength is optimum at 40% replacement of RCA. The below fig 3 and table 9 shows the Flexural strengths for 7days, 28days and 90days with different percentage replacements of RCA.

Table 8: Results for Flexural strength

Sl. No	RCA (%)	7 days	28 days	90 days
1	0	3.43	5.32	6.59
2	10	3.44	5.33	6.61
3	20	3.46	5.35	6.63
4	30	3.48	5.37	6.65
5	40	3.49	5.38	6.68
6	50	3.34	5.28	6.39



Graph 3: Flexural strength

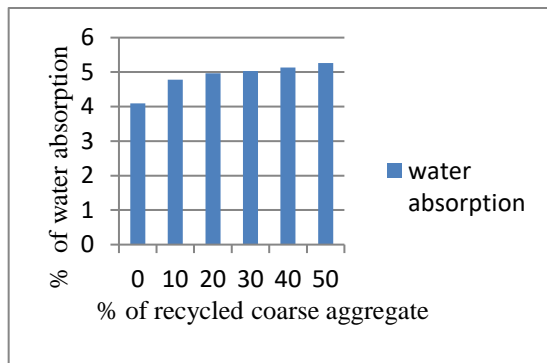
D. Water Absorption

The increase in water absorption values are shown in the below table no 10.

Table 9: Results of water absorption test

Mix Type	% Water Absorption
RCA WITH 0%	4.09
RCA WITH 10%	4.78
RCA WITH 20%	4.97
RCA WITH 30%	5.03
RCA WITH 35%	5.13
RCA WITH 40%	5.26

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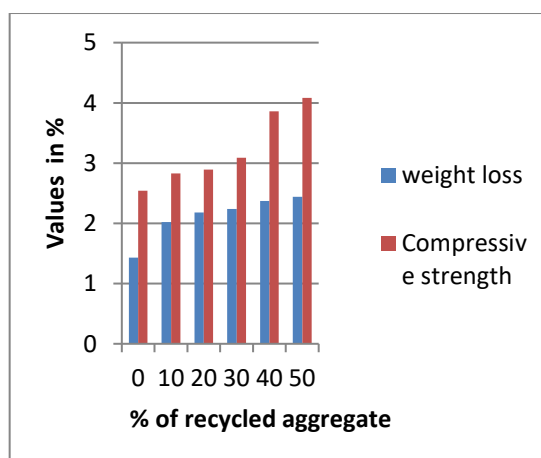
Graph 4: Values of water absorption (%)

E. Acid attack

It is identified that the loss in weight and compressive strength are increased with percentage increase in RCA. As RCA is having adhered mortar containing high alkalinity which cannot resist to acids and finally reduces the resistance power of acids.

Table 10: Results of Acid attack

Mix Type	% of Weight loss	% of loss in compressive strength
RCA WITH 0%	1.43	2.54
RCA WITH 10 %	2.02	2.83
RCA WITH 20%	2.18	2.89
RCA WITH 30%	2.24	3.09
RCA WITH 35%	2.37	3.86
RCA WITH 40%	2.44	4.08



Graph 5: Results of weight loss, compressive strength

VI. CONCLUSION

- 1) In this study recycled Coarse aggregate are used for replacing natural coarse aggregate upto 50%. Workability of SCC is also achieved using recycled coarse aggregate for M40 grade concrete. The test results on fresh concrete are within the limits of EFNARC guide lines.
- 2) Use of Recycled coarse aggregate reduces cost which is economical and pollution is controlled as disposed waste is reused.
- 3) SCC mixes with RCA achieves quick early strength due to presence of partially hydrated cement which is attached to recycled aggregate.
- 4) As the RCA is having adhered mortar which contains high alkalinity and finally reduces the resistance power of acids. As RCA absorbs more water, it gains higher water absorption values.
- 5) This paper investigated that there is slight increment in strength properties upto 40% replacement of coarse aggregate by recycled coarse aggregate.

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