COMPARATIVE STUDY ON SELF COMPACTING CONCRETE BY PARTIAL REPLACEMENT OF RECYCLED AGGREGATES

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Abstract: This paper presents the influence of different amounts of recycled coarse aggregate (RCA) obtained from a demolished building on the properties of self-compacting concrete (SCC) and compared the results with self- compacting concrete (SCC) containing 100% natural coarse aggregate (NCA). Important properties such as physical and mechanical properties of natural and recycled aggregates are carried out. NCA is partially replaced with RCA by an amount 5%,10%,15%, 20%,25%, 30%,35% and 40%. The effect of RCA on the properties of SCC in green state (e.g. Slump flow test, V-Funnel test and L-Box Test) and properties of concrete in hardened state (e.g. compressive strength, flexural strength, and Split tensile Strength) are studied. The mix design was carried out for M30 grade of concrete. The present study recommends SCC marginally achieves required compressive strength up to 40% replacement of RCA. This paper is to study the effect of utilizing recycled coarse aggregate as partial replacement for natural coarse aggregate on the properties of SCC in fresh and hardened state.

Keywords – Self-compacting concrete, Recycled aggregate, Fly ash.

I. INTRODUCTION

Self-compacting concrete:

Self-compacting concrete (SCC) is a kind of concrete with excellent deformability and segregation resistance, was first developed at Japan in 1980. It is able to flow under its own weight and can completely fill the formwork even within congested reinforcement. SCC has favourable 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. SCC also achieves same engineering properties and durability as traditional vibrated concrete. The use of SCC has gained a wider acceptance in recent years.

Properties of Self-Compacting Concrete:

Self-compacting concrete (SCC) has three essential fresh properties: filling ability, passing ability and segregation resistance. Additional properties, such as robustness and consistence retention, are also important in applications of SCC. Robustness refers to the ability of SCC to retain its fresh property when the quality and quantity of constituent materials and the environmental conditions change. Consistence retention refers to the period of duration of the fresh properties. A number of commonly used tests are subsequently described for evaluating the fresh properties. There is no difference in test methods for hardened properties (strength, stiffness, and durability etc.) between SCC and self-compacting concrete with recycled aggregate. Both fresh and hardened properties are key to the successful application of SCC. SCC therefore can be designed by fresh or hardened requirements.

2.LITERATURE REVIEW

K.C. Panda, P.K. Bal, had studied on Important properties such as physical and mechanical properties of natural and recycled aggregates are carried out. NCA is partially replaced with RCA by an amount 10%, 20%,30% and 40%. The effect of RCA on the properties of SCC in green state (e.g. Slump flow test, V-Funnel test and L-Box Test) and properties of concrete in hardened state (e.g. compressive strength, flexural strength, and Split tensile Strength) are studied. The mix design was carried out for M25 grade of concrete. The experimental results indicate that the compressive strength, flexural strength and split tensile strength of the SCC with 100% natural aggregate is less than the normal vibrated concrete (NVC) with 100% natural aggregate and the strength of SCC decreases with an increase in recycled aggregate (RA) replacement ratios.

Prashant O. Modani, had studied on use of recycle aggregate in SCC. In this study coarse recycled aggregate (RCA) are used in the production of self-compacting concrete (SCC) in varying percentage replacements of natural coarse aggregate (NCA) from 0% to 100% with increment of 20%. This investigation is an attempt to examine the influence of recycled aggregate on strength of self-compacting concrete. It is observed that recycled aggregate can be

effectively used in the production of SCC without any significant reduction in strength and durability. This has encouraged the use of recycled aggregate in concrete which not only allows for a more efficient life cycle of natural resources but also contributes to environmental protection leading to sustainable development.

3.Materials and their properties Cement

Ordinary Portland cement, 53 Grade can be used care is taken that it is freshly produced and from a single producer. A cement is a binder. A substance used for construction that sets, hardens, and adheres to other materials to bind them together.

Table-1 properties of cement

SL.No	Properties	Results
1	Fineness	4%
2	Specific gravity	3.15
3	Normal consistency	28%
4	Initial setting time	30 mins
5	Final setting time	600 mins

Fly Ash:

Fly Ash is a by-product of a thermal power station, after combustion of coal and production of power. Flyash is generated from coal fired generation units. the physical properties and chemical properties of fly ash used are shown in table-2.

Table-2 properties of flyash

SL.No	Properties	Results
1.	Specific gravity	2.52

CHEMICAL COMPOSITION OF FLY ASH

S.NO.	DESCRIPTION OF PROPERTY	AVERAGE RANGE OF VALUES (%)
1.	SiO_2	60.98
2.	Al_2O_3	27.5
3.	TiO_2	1.27
4.	Fe_2O_3	4.1
5.	MgO	0.78
6.	CaO	1.65
7.	K_2O	0.15
8.	Na_2O	0.17
9.	LOI	5.35

Fine aggregate:

Fine aggregates can be natural or manufactured. The grading must be uniform throughout the work. According to IS 383-1970 fine aggregate falls under zone II. The moisture content or absorption characteristics must be closely monitored, as quality of SCC will be sensitive to such changes. Particles smaller than 0.125mm are considered as Fines, which contribute to the fine content.

Table-3 properties of fine aggregate

SL.No	Properties	Results
1.	Specific gravity	2.64
2.	Bulk density	32%
3.	Fineness modulus	3.2

Coarse aggregate:

Aggregate of size 10-12mm is desirable for structures having congested reinforcement. Wherever possible aggregates of size higher than 20mm could also be used. Well-graded cubical or rounded aggregates are desirable. Aggregates should be of uniform quality with respect to shape and grading.

Recycled coarse aggregates:

Recycled aggregates (RA) are produced from the re-processing of mineral waste materials, with the largest source being the construction and demolition waste. The density of the RA is lower than natural aggregates and RA have a greater water absorption value compared to natural aggregates. As a result, proper mix design is required for obtaining the desired qualities for concrete made with RA.

Table-4 physical properties

SL.No	Properties	Natural coarse aggregate	Recycled aggregate
1.	Specific gravity	2.7	2.3
2.	Bulk density	1560 kg/m^3	1050 kg/m^3
3.	Fineness modulus	5.6	2.81

Superplasticizer:

In present days Superplasticizers are powerful enough to keep a concrete mix highly workable for more than one hour with much less water. It is free from chloride and low alkali in nature. Dosages of plasticizer evaluated by trail mixes.

Water:

This is the least expensive but most important ingredient in concrete. The water, which is used for making concrete, should be clean and free from harmful impurities such alkali, and acid etc. in general, the water is fit for drinking, should be used for concrete. Water confirming to IS 456-2000.

S.no	Mix designation	Cement in kg	Fly ash kg (5%,)	Fine aggregate in kg	Coarse aggregate in kg	Recycled aggregate Kg (5%,10%,15%, 20%,25% 30%,35%,40%)	Superplasticizer (grams)	w/c ratio
1.	SCC	1.283	0.106	3.685	6.02	0	20	0.45
2.	SCC-R5	1.283	0.106	3.685	5.711	0.30	20	0.45
3.	SCC-R10	1.283	0.106	3.685	5.41	0.60	20	0.45
4.	SCC-R15	1.283	0.106	3.685	5.11	0.90	20	0.45
5.	SCC-R20	1.283	0.106	3.685	4.80	1.20	20	0.45
6.	SCC-R25	1.283	0.106	3.685	4.50	1.50	20	0.45
7.	SCC-R30	1.283	0.106	3.685	4.20	1.80	20	0.45
8.	SCC-R35	1.283	0.106	3.685	3.90	2.10	20	0.45
9.	SCC-R40	1.283	0.106	3.685	3.60	2.40	20	0.45

Mix Design of M30 Grade Concrete

4. Mix design

Cement	Coarse aggregate	Fine aggregate	water
400 kg/m3	1134.3 kg/m3	695.2176 kg/m3	160
1	1.73	2.86	0.45

TABLE 5 MIX DESIGN RATIO

S.no	Mix designation	Cement in kg	Fly ash kg (5%,)	Fine aggregate in kg	Coarse aggregate in kg	Recycled aggregate Kg (5%,10%,15%, 20%,25% 30%,35%,40%)	Superplasticizer (grams)	w/c ratio
1.	SCC	1.283	0.0675	2.346	3.828	0	15	0.45
2.	SCC-R5	1.283	0.0675	2.346	3.637	0.192	15	0.45
3.	SCC-R10	1.283	0.0675	2.346	3.4475	0.383	15	0.45
4.	SCC-R15	1.283	0.0675	2.346	3.254	0.574	15	0.45
5.	SCC-R20	1.283	0.0675	2.346	3.062	0.765	15	0.45
6.	SCC-R25	1.283	0.0675	2.346	2.87	0.957	15	0.45
7.	SCC-R30	1.283	0.0675	2.346	3.67	1.148	15	0.45
8.	SCC-R35	1.283	0.0675	2.346	2.488	1.334	15	0.45
9.	SCC-R40	1.283	0.0675	2.346	2.294	1.531	15	0.45

Table 6 QUANTITIES OF MATERIAL FOR CUBES

S.no	Mix designation	Cement in kg	Fly ash kg (5%,)	Fine aggregate in kg	Coarse aggregate in kg	Recycled aggregate Kg (5%,10%,15%, 20%,25% 30%,35%,40%)	Superplasticizer (grams)	w/c ratio
1.	SCC	1.9	0.1	3.685	5.672	0	56.7	0.45
2.	SCC-R5	1.9	0.1	3.685	5.38	0.28	56.7	0.45
3.	SCC-R10	1.9	0.1	3.685	5.10	0.56	56.7	0.45
4.	SCC-R15	1.9	0.1	3.685	4.82	0.85	56.7	0.45
5.	SCC-R20	1.9	0.1	3.685	4.53	1.13	56.7	0.45
6.	SCC-R25	1.9	0.1	3.685	4.25	1.41	56.7	0.45
7.	SCC-R30	1.9	0.1	3.685	3.97	1.70	56.7	0.45
8.	SCC-R35	1.9	0.1	3.685	3.68	1.98	56.7	0.45
9.	SCC-R40	1.9	0.1	3.685	3.40	2.26	56.7	0.45

TABLE 7 QUANTITIES OF MATERIALS FOR CYLINDERS

S.no	Mix Designation	Cement in kg	Fly ash kg (5%,)	Fine aggregate in kg	Coarse aggregate in kg	Recycled aggregate kg (5%,10%,15%, 20%,25% 30%,35%,40%)	Superplasticizer (grams)	w/c Ratio
1.	SCC	1.9	0.1	3.685	5.672	0	56.7	0.45
2.	SCC-R5	1.9	0.1	3.685	5.38	0.28	56.7	0.45
3.	SCC-R10	1.9	0.1	3.685	5.10	0.56	56.7	0.45
4.	SCC-R15	1.9	0.1	3.685	4.82	0.85	56.7	0.45
5.	SCC-R20	1.9	0.1	3.685	4.53	1.13	56.7	0.45
6.	SCC-R25	1.9	0.1	3.685	4.25	1.41	56.7	0.45
7.	SCC-R30	1.9	0.1	3.685	3.97	1.70	56.7	0.45
8.	SCC-R35	1.9	0.1	3.685	3.68	1.98	56.7	0.45
9.	SCC-R40	1.9	0.1	3.685	3.40	2.26	56.7	0.45

TABLE 8 QUANTITIES OF MATERIALS FOR BEAMS

5. EXPERIMENTAL METHOD

The methodology of the present thesis work contains collection of raw materials, determining the physical properties of the collected materials and confirming the raw results to the standard values. With M30 grade mix designs desired mix proportion is determined and further work was continued using those proportions by increasing the percentage of fly ash and recycled aggregate used as a partial replacement of cement and coarse aggregate respectively. Hardened concrete tests like compressive test, flexural test and tensile test were conducted and results were determined.

MIX	SLUMP FLOW (MM)	T 50 CM SLUMP FLOW (SEC)	L BOX (H_2/H_1)	U -BOX	J – RING
0%	705	4.76	0.92	27	4.76
5%	702	4.66	0.89	26.8	4.72
10%	699	4.53	0.85	26.5	4.64
15%	697	4.44	0.84	26.4	4.62
20%	696	4.36	0.83	26.2	4.59
25%	694	4.32	0.82	26	4.54
30%	691	4.24	0.81	25	4.52
35%	685	4.11	0.80	25	4.36
40%	682	4.10	0.80	25	4.24

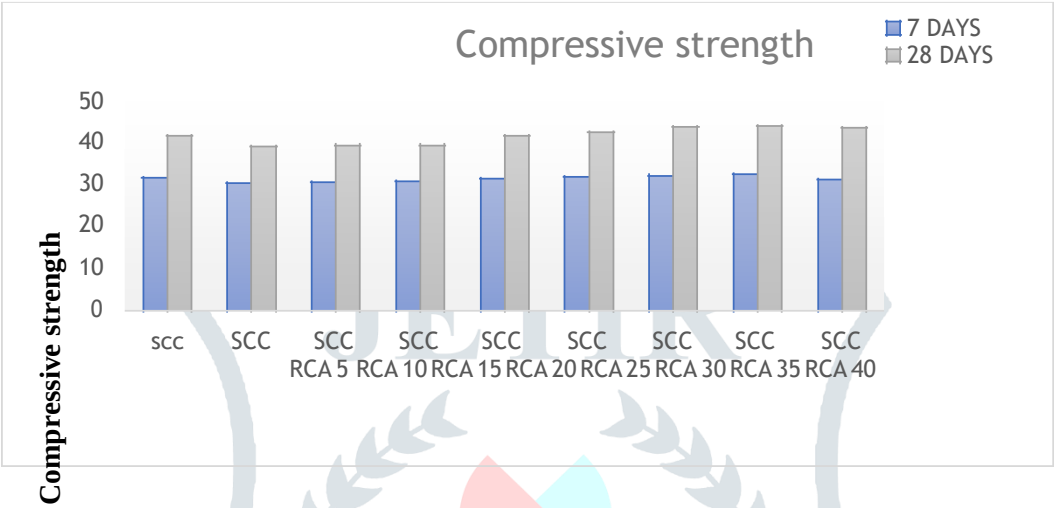
Table 9: Tests on fresh concrete properties

COMPRESSIVE STRENGTH:

The compressive strength is measured using both cube specimens. The size of the cube specimen is 150 mm × 150 mm × 150 mm and size of the cylindrical specimen is 100 mm diameter and 300 mm height. The compressive strength of three cubes and three cylinders are measured after 7, 28 days.

Mix	7-days Compressive Strength (N/mm^2)	28-days Compressive Strength (N/mm^2)
SCC	**31.65**	**41.70**
SCC-RCA 5	30.51	39.2
SCC-RCA 10	30.72	39.48
SCC-RCA 15	30.87	39.48
SCC-RCA 20	31.52	41.65
SCC-RCA 25	31.95	42.56
SCC-RCA 30	32.25	43.85
SCC-RCA 35	32.65	44.05
SCC-RAC 40	31.36	43.55

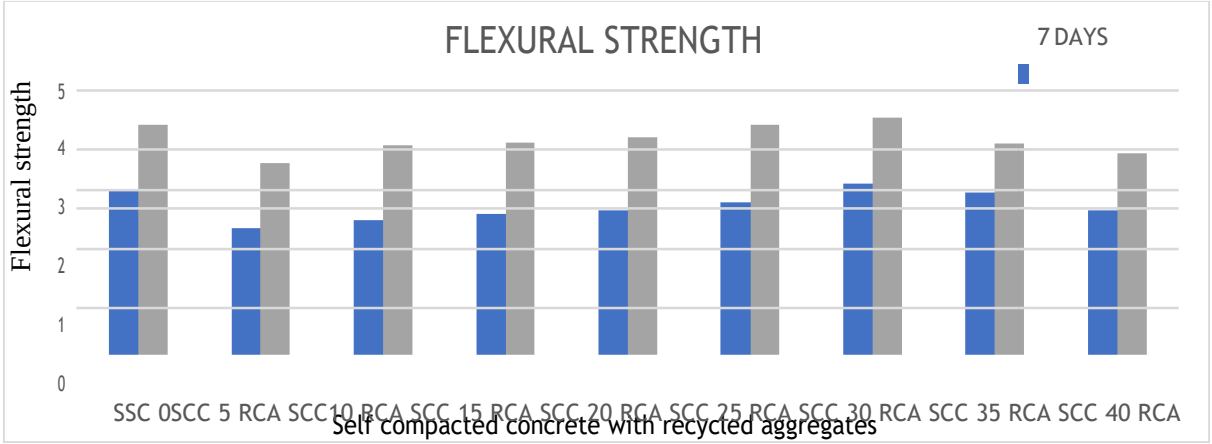
Table 10: Compressive Strength



GRAPH 1 COMPRESIVE STRENGTH FLEXURAL STRENGTH:

Specifications	7-days Flexural Strength (N/mm^2)	28-days Flexural Strength (N/mm^2)
SCC	**2.8**	**3.90**
SCC-RCA 5	2.14	3.25
SCC-RCA 10	2.28	3.55
SCC-RCA 15	2.39	3.60
SCC-RCA 20	2.45	3.69
SCC-RCA 25	2.59	3.89
SCC-RCA 30	**2.89**	**4.01**
SCC-RCA 35	2.75	3.58
SCC-RCA 40	2.45	3.41

Table11: Flexural strength

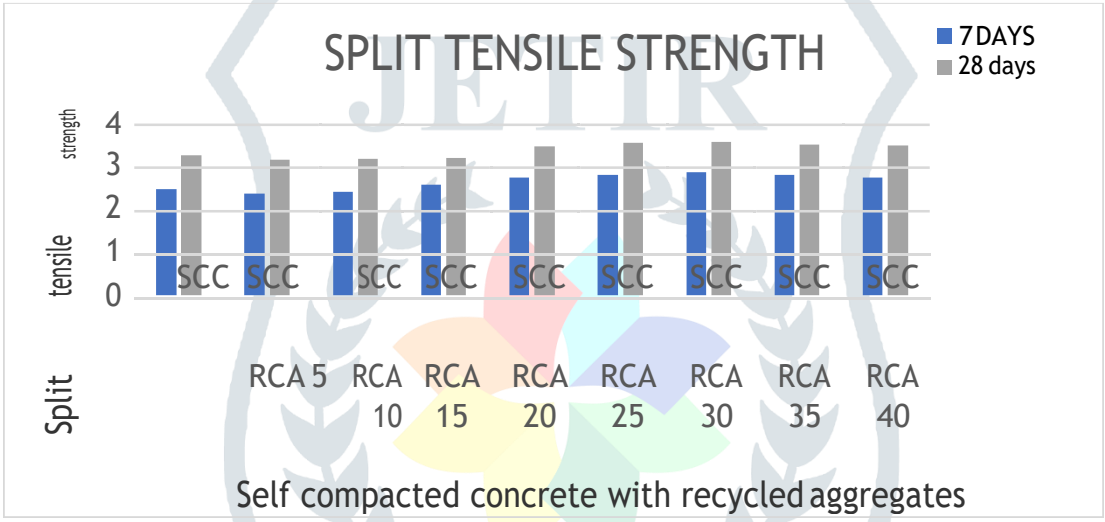


Graph 2 FLEXURAL STRENGTH

SPLIT TENSILE STRENGTH:

Specifications	7-days Split tensile strength (N/mm^2)	28-days Split tensile strength (N/mm^2)
SCC	**2.53**	**3.55**
SCC-RCA 5	2.31	3.00
SCC-RCA 10	2.45	3.15
SCC-RCA 15	2.55	3.33
SCC-RCA 20	2.70	3.41
SCC-RCA 25	2.86	3.6
SCC-RCA 30	**2.90**	**3.75**
SCC-RCA 35	2.77	3.42
SCC-RCA 40	2.56	2.95

Table .12: Split tensile strength



Graph 3 SPLIT TENSILE STRENGTH

9.CONCLUSION

- The test results indicate that the compressive strength, flexural strength and split tensile strength of Self-compacting concrete with recycled aggregate is less than the self-compacting concrete.
- The compressive strength, flexural strength and split tensile strength of Self-compacting concrete increases with the increase in the amount of recycled aggregate.
- The test result indicates that in 28 days test Self-compacting concrete marginally achieves required compressive strength up to 35% replacement Recycled coarse aggregate.
- The test result indicates that in 28 days test Self-compacting concrete marginally achieves required Flexural strength up to 30% replacement Recycled coarse aggregate.
- The test result indicates that in 28 days test Self-compacting concrete marginally achieves required split tensile strength up to 30% replacement Recycled coarse aggregate.

SCOPE OF FUTURE WORK

- Self-compacting concrete produces large benefits and advantages over normal or regular concrete like, labor reduction, accelerates over normal or work, superior strength and durability and produces good surface finish etc.…
- To achieve the above properties of self-compacting concrete it requires a proper mix proportion. This can be resulted by making many trail mixes. This trail mixes are produced by proper mix design.
- It is used for the smaller construction like individual house, small buildings, kerb etc.…
- The adequate compaction and homogeneity of the cast concrete and to facilitate its placement especially in structures with congested reinforcement and restricted areas, self-compacting concrete has been introduced.

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