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Study on Durability Characteristic Strength of Recycled Waste Concrete as Fine Aggregates in Self-Compacting Concrete

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Abstract: In developing nations, with the raising overpopulation, both economy and pollution free environment in construction industry are of principal importance in order to meet the undeniable human needs of multifarious forms. Thus, use of waste aggregates in the manufacturing is of new type of concrete, which plays a critical role in the construction industry, for fulfilling the demand of aggregates. Most of the waste materials are arising from industrial waste and demolishing waste. Hence, recycling, reuse and exchange of this waste appears to be an effective solution and most appropriate decision. In the current research work desirable characteristics of recycled aggregate concrete were considered. These experiments were conducted for different ages of concrete such as 7 and 28 days to assess the split tensile strength. The workability properties of mix are evaluated by workability tests are flow test. It addresses experiment on different mixes of self- compacting concrete. One with fresh coarse and fine aggregates, while the others with restoration of 15%, 30%, 45%, 60%, 75%, 90% and 100% recycled fine aggregates. The design mix proportion in M25 with the proportionate of 1:1:2 for self-compacting concrete is taken.
Keywords: Recycled waste concrete, spilt tensile strength, self-compacting concrete.

I. INTRODUCTION

Construction is the backbone of infrastructural development and it acquires its essential ingredients, which are sand and stone aggregate from nature. In the current scenario, the construction works is on boom, which leads to various environmental hazards. The construction industry has collapsed the ecological balance up to a great extent by taking away the natural stock of aggregates. The air pollution from quarrying caused by release of suspended particulate matter into the atmosphere leads to danger for the working staff and the adjoining population. The particulate matter from quarrying also runs off to the nearby rivers or water bodies, which pollute the water and destroy the aquatic life. To facilitate the non-use of natural aggregates from the nature, various steps to be taken by the construction industry for the infrastructure development. The use of recycled aggregates is the new step in developing the concrete for the construction practices.

The main objectives of this research work is to study the properties of recycled aggregates for their use in concrete

A. Self-Compacting Concrete

Self-compacting concrete (1) is a flowing concrete mixture that is able to build up under its own weight. The highly fluid nature of Self compacting concrete makes it applicable for placing in difficult circumstances and in sections with congested reinforcement. Use of SCC can also help to minimize hail-related damages on the worksite that are induced by change of concrete. Another advantage of Self compacting concrete is that the time required to place broad sections is considerably decreased. Self-Compacting Concrete (2) was first established in Japan around the year 1980. Professor H. Okamura from the University of Tokyo, Japan is primarily responsible for initiating the spread of such concrete. Self-compacting concrete can be considered as the greatest technical advancement and most revolutionary development in concrete technology over the years, at least from 1980 till today. This is the concrete of the future, as it will be substituting the normal concrete because of its many assets. Self-compacting concrete (3) is placed or poured in the same way as natural concrete but without fluctuation. It is very fluid and can pass over obstructions and fill all the nooks and corners without danger of either mortar or other ingredients of concrete separating out, at the same time there are no involved air or rock pockets. This type of concrete mixture does not desire any compaction and is saves time, labour and energy. The surface finish produced by self- compacting concrete (4) is especially good and patching will not be necessary. Strength properties of SCC predict the fresh and hardened values of its mixes. The compressive strength and the tensile strength are the most essential properties of every mixes, which gives the strength parameters of SCC.

II. LITERATURE REVIEW

A. Domone (2005)

Analyzed the fresh & hardened properties of SCC in Sixty-eight cases from 1993 to 2003. He founded that, in forty-eight cases, maximum size of aggregate is in the range of 16-20 mm. Six cases used larger size of aggregate from 22- 40 mm. All mixes included superplasticizers. In thirty cases, an air-entraining admixture was used and in thirty-four cases, a viscosity modifying agent was also used. The coarse aggregate contents varied from 28% to 38% by volume of the concrete, with 80% of these within the range 29.1-34.8%, equivalent to about 770-925 kg/m^3 for aggregate relative density of 2.65. The paste contents varied from 30% to 42% by volume of the concrete, with 80% of these within the range 32.3-39%. The powder contents ranged from 425 to 625 kg/m3, with 80% in the range 445-605 kg/m3. Water/powder ratios ranged from 0.26 to 0.48, with 80% falling in the range 0.28-0.42. The mortar composition in terms of volume percentage of the fine aggregate varies from 38% to 54%, with 80% in the range 41-52%. It is concluded that, nearly, 50% of the test result for the stump flow test are in the range of 650- 700mm and nearly 90% are in the range of 600-750mm.

B. Jacobs and Hunkeler

He found that at a given strength, the modulus of elasticity of SCC is lower than the normal concrete because of smaller maximum grain size of SCC and high amount of cement paste.

C. Grdic et al. (2010)

Explained the potential for usage of coarse recycled aggregate obtained from crushed concrete for making of self-compacting concrete, which may solve the issue of the waste disposal sites created by the demolition of old structures. On the other hand, the issue of the waste disposal sites created by the demolition of old structures is solved. In the experiment, three types of concrete mixtures were made, where the percentage of substitution of coarse aggregate by the recycled aggregated was 0%, 50% and 100%. In the process of mixing, equal consistence of all concrete mixtures was achieved. Control concrete was made only with the river aggregate, test concrete P50 with 50% of recycled coarse aggregate, which entirely substituted the fraction 8/16 mm and test concreteP100 with 100% of recycled coarse aggregate, where all of the coarse aggregate was substituted by the recycled aggregate. Slump-flow, L-box test and sieve aggregation test were performed to check the properties of self-compacting concrete. Slump-flow test for flow ability and viscosity, for testing passing ability and Sieve segregation test for testing the segregation resistance. It was concluded from the experiment that the compressive strength of control concrete is more than the concrete made from recycled aggregate aggregates. But the difference between them is very less and can be controlled by using some adhesive material. The reason for less compressive strength can be because of the use of recycled aggregates. In recycled aggregates, there is change of shape i.e. irregular and inconsistent shape, especially in the cases of the aggregate obtained by demolition of structural elements a building. As opposed to natural aggregate, recycled aggregate has two components: natural aggregate and cement paste which is bound to it and which reduces its quality to a certain extent. The old cement paste is the cause of lower density, higher absorption capacity, lower abrasion resistance and high content of sulphates in the composition of the recycled aggregate in comparison to natural. In the course of setting and hardening, the new cement paste first reacts with the old paste residue on the grains of recycled aggregate, which requires a part of the water that is a part of the concrete mixture composition, and reduces compressive strength.

III. MATERIALS USED FOR MAKING SCC

In this section brief description on physical properties of the materials used to prepare SSC mixes is discussed.

A. Cement

Ordinary Portland cement of Grade 53 has been used for making the Self Compacting Concrete [5]. Properties of Cement are tabulated below.

Table-1 Physical Properties Of Cement

Properties	Ordinary Portland Cement		
Specific Gravity	2.356		
Initial Setting Time	200 Minutes		
Final Setting Time	10 Hours		
Compressive Strength of mortar cubes (Conforming to IS:4031 part-6-1988)	3 day	7 day	28 day
	32.64MPa	40.3MPa	44.65MPa

B. Fine Aggregates

The natural fine aggregate is taken from local river. The recycled fine aggregates were obtained by crushing demolished concrete waste in a laboratory jaw crusher. The fine recycled aggregate was sieved through 4.75mm sieve to remove any particles greater than 4.75 mm. Properties of the natural fine aggregate and recycled fine aggregates used in the experimental work are tabulated in below tables. The aggregates were sieved through a set of sieves to obtain sieve analysis

Table-2 Physical Properties Of Fresh/Natural Aggregates

Sr. No	Characteristics	Value
1	Specific gravity	2.85
2	Bulk Density	1,987Kg/m^3
3	Water Absorption	0.88%

Table-3 Recycled Fine Aggregates

Sr. No	Characteristics	Value
1	Specific gravity	2.63
2	Bulk Density	1868Kg/m^3
3	Water absorption	6.86%

Table-4 Sieve Analisis Of Recycled Fine Aggregates

Sr. No	Sieve Size	Mass retained	Percentage retained	Cumulative percentage retained	Percent Passing
1	4.75mm	4.0g	0.4	0.4	99.6
2	2.36mm	75.0g	7.5	7.9	92.1
3	1.18	178.0g	17.8	25.7	74.3
4	600	220.0g	22	47.7	52.3
5	300	274.0g	27.4	75.1	24.9
6	150	246.5g	24.65	99.75	0.25
				∑=256.55	

Fineness modulus of sand = 2.56

C. Coarse Aggregate

Persecuted gravestone is generally used as a coarse aggregate. Locally available course aggregate having the maximum size of 10 to 20 mm was used in our work. The aggregates were tested as per IS: 383-1970. The results of various tests conducted on coarse aggregate [(6)] are given in Table 5 and Table 6 shows the sieve analysis results.

Table-5 Physical Properties Of Coarse Aggregate

Sr. No	Characteristics	Value
1	Type	Crushed
2	Specific Gravity	2.66
3	Total Water Absorption	0.56
4	Fineness Modulus	6.83

Table-6 Sieve Analysis Of Coarse Aggregate

Sr. No	Sieve Size	Mass retained	Percentage retained	Cumulative Percentage retained	Percent Passing
1	20mm	0	0	0	100
2	10mm	2516	83.89	83.87	16.13
3	4.75mm	474	15.8	99.67	0.33
4	PAN	10	0.33	∑=183.54	

Total Weight taken= 3kg

Fineness Modulus of 10mm coarse aggregate= (183.54+500)/100=6.83

D. Water

Potable water is used in making concrete.

E. Fly Ash

Class F Fly ash obtained from –KTPS, Paloncha, Bhadradri Kothagudem Dt, Telanagana, India-507115

F. Admixture

Admixture used in this work is Super plasticizer of CICO brand, which complies with IS: 9103:1979 and BS: 5075 Part 3 and ASTM-C-494 type 'F' as a high range water reducing admixture. Ultracon SP 430 is ready to use admixture that is added to the concrete at the time of batching. Ultracon SP430 is differentiated from conventional super plasticizers in that it is based on aqueous solution of lingo-sulphonates, organic polymer with long lateral chains. This greatly improves cement dispersion. Ultracon SP430 is supplied as brown liquid instantly dispersible in water and specially formulated to give high water reduction up to 25% without loss of workability. Specific gravity is 1.22 to 1.225 at 30-degree c.

IV. EXPERIMENTAL INVESTIGATION

A. Test For Fresh Properties Of Self Compacting Concrete

1) Slump Flow Test

It is the most commonly used test and is used to assess the horizontal free flow of the concrete in the circular diameter to measure the filling ability of the concrete. It gives no indication of the ability of the concrete to pass among reinforcement without blocking, but may give some explanation of resistance to segregation

Procedure:

Moisten the droop cone's interior and base plate. Set the base plate on a flat, stable surface. Center the slump cone on the base plate, and firmly press it down. Place the scoop inside the cone. Don't tamp; just use the trowel to strike off the concrete until it is level with the top of the cone. Remove any extra concrete from the area surrounding the cone's base. Allow the concrete to pour out freely by raising the cone vertically. Start the stopwatch and note how long it took the concrete to come within 500mm of the spread circle. (It is the T50 period) In two perpendicular directions, gauge the concrete's final diameter. Get the average of the two diameters that were measured. (It is the slump flow in mm.)

B. Tests For Strength Properties Of SCC

1) Splitting Tensile Strength

The specimens used for the splitting tensile test were fabricated in accordance with ASTM C 496-11, "Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete specimens." A minimum of three specimens were made for each concrete mix. The specimens used for the splitting tensile test were the same types of specimens used for the compressive strength test. The specimens were fabricated according to ASTM C 192. After 24 hours, the specimens were de-moulded and placed in a moist curing chamber for 28 days, at which time they were then tested. After the specimens were allowed to cure for 28 days, the samples were removed from the curing chamber for testing. The periphery and height of the samples were recorded. The periphery of the instance was marked on the top of the instance. Two lines were then drawn down the long side of the instance from the previously drawn line. This was done to help in lining up the instance in the testing outfit. The instance was then loaded into the testing outfit on the line drawn down its perpendicular axis. The instance was placed on a piece of plywood. Another plywood strip was placed on the top of the instance between it and the cargo platen. These strips were used so the cargo would be distributed along the axis of the instances.

V. RESULTS

A. Fresh Properties

The result of fresh properties of all self compacting concretes are included in below table 7. The table shows the properties such as slump flow test, SSC made with recycled fine aggregates and natural coarse aggregate[7] typically needs more water than conventional SSC in order to obtain the same workability.

Table-7 Fresh Concrete Properties

Mixture	SLUMP(MM)	SLUMP(MM)
	Experiment Result	EFNARC Limits
SCC-C	750	650-800
RFA25	733	650-800
RFA50	708	650-800
RFA75	697	650-800

All SCC exhibited satisfactory slump flow in the range of 650-800 mm .

B. Hardened Properties

1) Split Tensile Strength

The split tensile strength tests results of Self compaction concrete are given in table 8

Table-8 Split Tensile Strength Test Results

Mix	7Days		28 Days		7 Days	28 Days
	Load P(KN)	SP (N/mm^2)	Load P	SP (N/mm^2)	Average	Average sp
Conventional SCC	486.2	13.6	625.21	16.5	11.8	16.76
	452.2	11.6	722.1	18.9		
	335.9	10.2	702.3	14.9		
RFA 20	473.25	13.4	755.5	20.8	12.3	18.96
	372.36	11	612.5	16.5		
	449.56	12.5	646.7	19.6		
RFA 40	420.5	13.53	800.3	20.6	13.18	19.6
	526.28	15.42	743.9	19.8		
	536.29	10.6	696.6	18.6		
RFA 60	610.2	17.64	918.2	25.4	17.36	26.1
	588.3	16.54	996.3	29.42		
	633.48	17.91	1028.1	23.48		
RFA 80	643.22	17.43	1142.5	28.2	18.31	28.73
	655.2	18.4	1066	31.6		
	663.76	19.1	1099.3	26.4		
RFA 100	684.52	19.75	1026.8	31.5	21.18	32.51
	725.65	21.2	1351	35.2		
	765.4	22.6	1065.9	30.82		

The 7 days split tensile strength shows the decreases in strength from 20.6 N/mm2 to 12.4 N/mm2 as the percentage of recycled fine aggregates increases in the mixes of SCC. The 28 days split tensile strength shows the decreases in strength from 32.6 N/mm2 to 19.3 N/mm² as the percentage of recycled fine aggregates increases in the mixes of SCC. With the percentage replacement of 20% of recycled fine aggregates, the 28 days compressive strength decreases by a small percentage of 11.62 %, with replacement of 40% of recycled fine aggregates, the 28 days compressive strength decreases to 19.71 %, with replacement of 60% of recycled fine aggregates, the 28 days compressive strength decreases to 39.71% and with replacement of 80% & 100% of recycled fine aggregates, the 28 days compressive strength decreases to 41.67% & 48.44%.

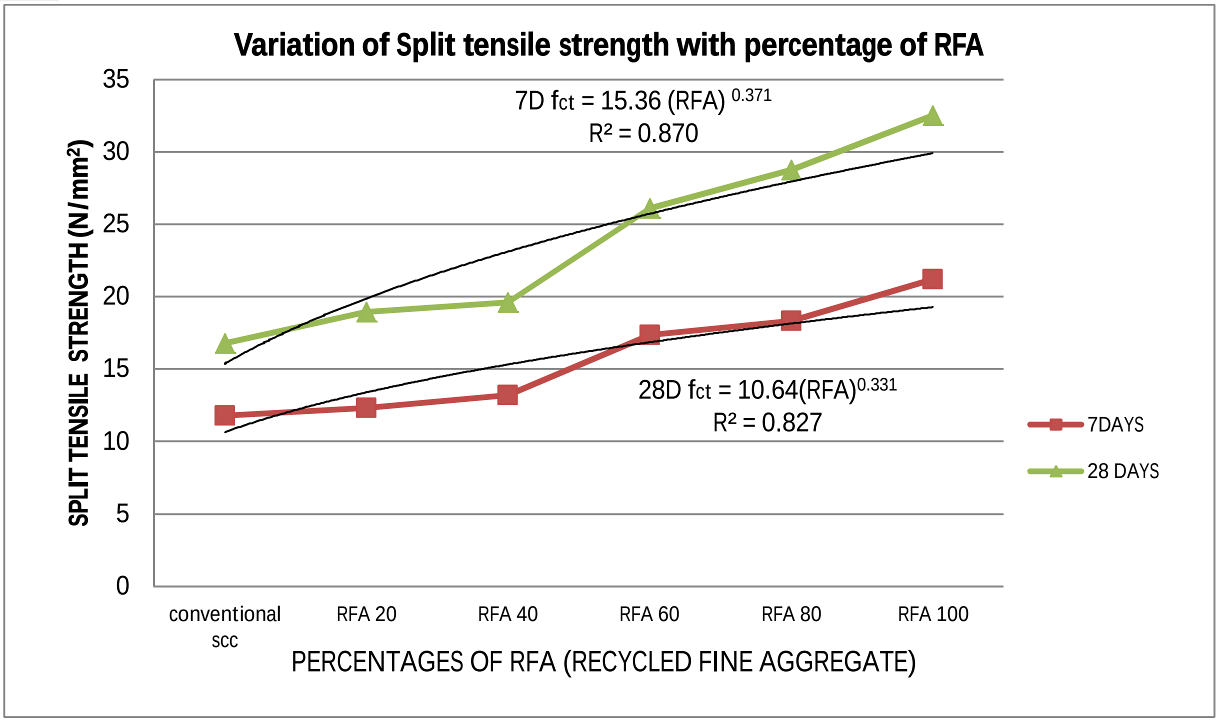

Fig1: Variation of Split tensile strength with percentage of RFA

VI. CONCLUSION

A. Fresh SCC Properties

The present investigations show that SCC made from recycled fine aggregates (RFA) gives satisfies workability requirements as per the desired acceptable limits. The slump flow test gives the value from 650 mm to 750 mm, Slump test value fall in the range of EFNARC limits. It justifies the restoration or use of RFA in SCC. Hence, recycled fine aggregates can be employed for making SCC.

B. Hardened Properties

Split Tensile Strength

With the percentage replacement of 20% of recycled fine aggregates, the 28 days compressive strength decreases by a small percentage of 11.62 %, with placement of 40% of recycled fine aggregates, the 28 days compressive strength decreases to 19.71 %, with replacement of 60% of recycled fine aggregates, the 28 days compressive strength decreases to 39.71 % and with placement of 80% & 100% of recycled fine aggregates, the 28 days compressive strength decreases to 41.67 % & 48.44%.

7days & 28 days Split tensile strength varies linearly as shown in the Fig.1 and are given by the following equations.

$7D\ fct = 15.36\ (RFA)^{0.371,}$ $R^2 = 0.870$ …..(1)

$28D\ fct = 10.64\ (RFA)^{0.331,}$ $R^2 = 0.827$ …..(2)

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