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Methods of Enhancing the Performance of Recycled Aggregate Concrete through the use of Supplementary Cementations Materials

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ABSTRACT: Recycled aggregates are derived from crushing demolished concrete. They comprise of crushed, graded inorganic particles processed from the materials that have been used in the construction and demolition debris. The aim for this project is to determine the strength characteristic of recycled aggregates and the effect of natural admixtures on recycled aggregate concrete, which will give a better understanding on the properties of concrete with recycled aggregates, as an alternative material to coarse aggregate in structural concrete. The scope of this project is to determine and compare the strength of concrete by using different percentage of recycled aggregates with different types of admixtures for different purposes.

The use of recycled aggregates in concrete opens a whole new range of possibilities in the reuse of materials in the building industry. This could be an important breakthrough for our society in our endeavors towards sustainable development. Waste concrete can be produced from a number of different sources. The most common are demolition projects. Many concrete structures like buildings, bridges, sidewalks and roads are razed after a period of time into their service life for purpose of replacement or landscape changes. Other sources of waste include natural disasters like earthquakes, avalanches, and tornadoes; human causes like war and bombing; and structural failures. All these contribute to vast quantities of waste concrete that must be managed in some way.

The main aim of the present experimentation is enhancing the performance of recycled aggregate concrete through the use of supplementary cementitious materials. Produced by replacing natural aggregates by recycled aggregates in various percentages. Three different supplementary cementitious materials are used for investigation. The objective of the investigation is to improve the properties of concrete produced with recycled aggregate.

Keywords: Recycled aggregates, super plasticizers, cement, compressive test, tensile test.

I. INTRODUCTION

The building industry has the ability to act in a bilateral manner. On the one hand it has to be considered as a clear generator of a great quantity of residues and on the other, its long tradition defines its capability of re-using not only its own waste but also the waste from other branches of industry, this capacity of recovery is precisely what is needed to promote in our current society.

The use of recycled aggregates in concrete opens a whole new range of possibilities in the reuse of materials in the building industry. This could be an important breakthrough for our society in our endeavors towards sustainable development. Now a day, recycling is gaining wider attention as a viable option for the handling of waste concrete. The concrete industry places a heavy demand on primary resources. It is estimated that 165 million tones of aggregate are used for concrete each year. This is considered unsustainable due to environmental impact and resource depletion. Thus, it has become necessary towards the turn of the century to establish technology for a self recycling system for concrete whereby materials for concrete are regrouped from demolished concrete. Waste concrete can be produced from a number of different sources.

The most common are demolition projects. Many concrete structures like buildings, bridges, sidewalks and roads are razed after a period of time into their service life for purpose of replacement or landscape changes. Other sources of waste include natural disasters like earthquakes, avalanches, and tornadoes; human causes like war and bombing; and structural failures.

All these contribute to vast quantities of waste concrete that must be managed in some way. Recycled concrete is simply old concrete that has been crushed to produce aggregate. It has been satisfactorily used in road construction as an aggregate in granular sub bases, lean concrete sub bases, and concrete pavements. Also, it is used as an aggregate in soil cement and in new concrete as the only source of aggregate or as a partial replacement of new aggregate.

The concrete made from recycled aggregate concrete generally has the same properties as stone or gravel aggregate. The recycled concrete aggregate is lighter and more porous than natural aggregates. Recycled aggregate will have higher drying shrinkage than the conventional aggregates.

(a) Concrete containing RA

(b) RA particles with variable grain sizes

Fig. 1. Recycled aggregate concrete and distribution of variable grain sizes of RA particle.

The concrete made from recycled concrete aggregate generally has good durability and resistance to freeze-thaw action. It is necessary to utilize recycled aggregate as concrete aggregates for the effective utilization of concrete waste.

II. MATERIALS AND METHODOLOGY

A. Materials used

For the proposed experimental work, the basic ingredients of concrete were from locally available sources. The details regarding source and properties of each of the materials used in the experimental work is given below:

Cement. In this experiment 43 grade ordinary Portland cement (OPC) with brand name "ACC 43 grade" was used for all concrete mixes. The cement used was fresh and without any lumps. The testing of cement was done as per IS 8112:1989. The specific gravity of cement was found to be 3.15. The physical properties of cement used are as given in table 1.

Table 1: Physical properties of cement.

Particulars	**Experimental result**	**As per standard**
1.Fineness	268 m^2/kg	225 m^2/kg
2.Soundness		
a) By Le Chatelier mould		10 mm
b) By Autoclave		0.8 maximum
3.Setting time (minutes)		
a) Initial set	200 minutes	30 minutes minimum
b) Final set	270 minutes	600 minutes maximum
4.Comp strength (M Pa)		
a) 3 days	34	23 MPa
b) 7 days	44	33 MPa
c) 28 days	58	43 MPa
Temperature during testing	28^0 C	27° C ± 2%

Fine aggregate. The sand used for the experimental program was locally procured and was confirming to zone-II.

Table 2: Physical properties of fine aggregate.

Description of properties	Values for Fine aggregates
Specific gravity	2.62
Fineness modulus	2.525
Bulk density (rodded)	1.6325 kg/lt
Zone	II

Natural Coarse aggregate. The coarse aggregate from basalt origin were used in experimentation. C.A. of size 20mm and down was used obtained from local stone quarries.

Recycled Coarse aggregate. The source for recycled aggregate was field demolished concrete. Waste concrete from locally demolished buildings were collected and taken to a stone crushing unit for recycling. The concrete crushed in jaw crushers and of size 20mm down were used for the experimental work.

Table 3: Physical properties of natural and recycled coarse aggregate.

Description of properties	Values for Natural aggregates	Values for Recycled aggregates
Specific gravity	2.91	2.5
Fineness modulus	1.083	7.482
Bulk density (rodded)	1.764 kg/lit	1.642 kg/lit
Los Angles abrasion value	8.36%	25.79%
Crushing value	21.42%	27.2%

Super plasticizer admixture. The super plasticizer used is a sulphonated naphthalene based polymer liquid admixture. The trade name of the super plasticizer is “Conplast SP 430”, manufactured by Fosroc. It was added at the rate of 0.7% by weight of cement.

B. Specimen Casting and Test Procedure

Specimens were cast as per BIS methods to evaluate the strength and durability properties of the three supplementary cementations material recycled aggregate concretes. The specimen casting and test procedure is detailed below:

C. Strength properties

-Compressive strength Test:
-Tensile strength Test
-Flexural strength Test
-Impact strength Test:

D. Experimental Results

The following tables give the results of the entire experimental work.

Test results using Silica Fume on recycled aggregate-concrete for 28-days normal curing. The following tables give the test results of silica fume when natural aggregates are replaced by recycled aggregates in different percentages that are 0, 10, 20, 30, 40, 50, 60, 80 and 100.

Workability test results. From the result gives the workability values in terms of slump, compaction factor for concrete when natural aggregates are replaced by recycled aggregates in different percentages.

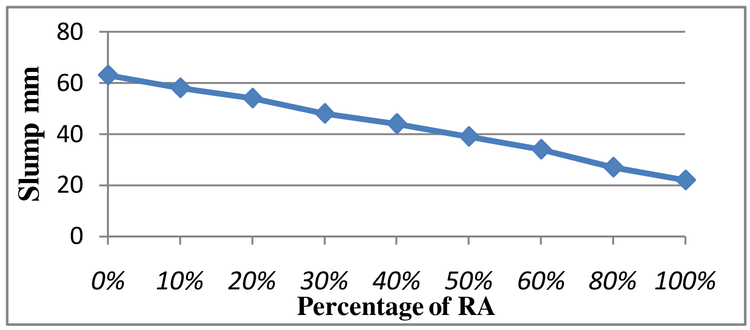

Fig 2: Variation in Slump for various percentages of SFRAC.

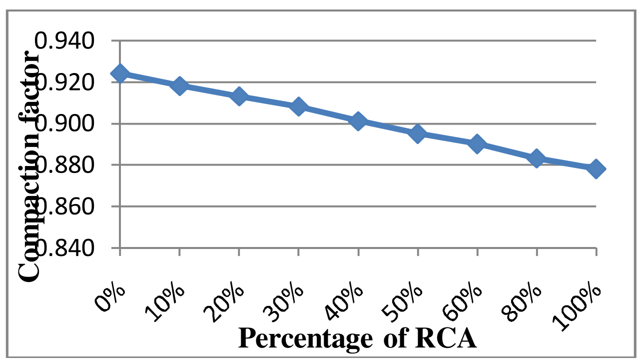

Fig. 3. Variation in Compaction factor for various percentages of RA.

Tensile Strength Test Results of Silica Fume. The following tables give the Tensile strength test results when natural aggregates are replaced by recycled aggregates in different percentages and normally cured for 28 days.

Overall Results of Tensile Strength: The following table 5 gives the overall results of Tensile strength of SFRAC when natural aggregates are replaced by recycled aggregates in different percentages like 0, 10, 20, 30, 40, 50, 60, 80 and 100.It also gives the percentage variation of tensile strength.

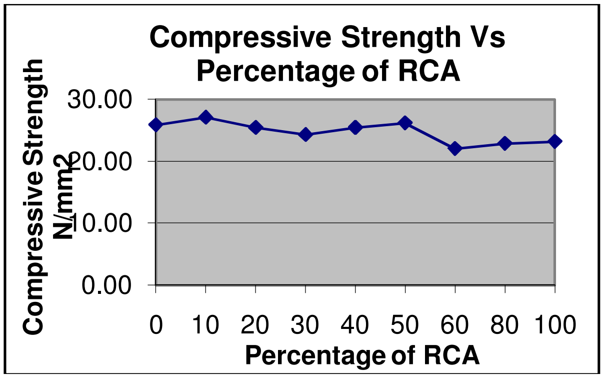

Fig. 4. Variation in compressive strength of SFRAC for various percentages of RA.

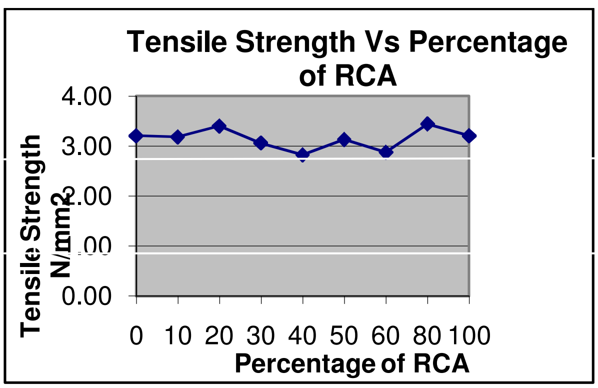

Fig. 5. Variation in tensile strength of SFRAC for various percentages of RA.

Flexural Strength Test Results of Silica Fume. The following tables give the Flexural strength test results **of** SFRAC when natural aggregates are replaced by recycled aggregates in different percentages and normally cured for 28 days.

Impact Strength Test Results for Silica Fume. The following tables give the Impact strength results when natural aggregates are replaced by recycled aggregates in different percentages and normally cured for 28 days.

Overall Results of Impact Strength: The following table gives the overall results of Impact strength of SFRAC when natural aggregates are replaced by recycled aggregates in different percentages like 0, 10, 20, 30, 40, 50, 60, 80 and 100.It also gives the percentage variation of Impact strength.

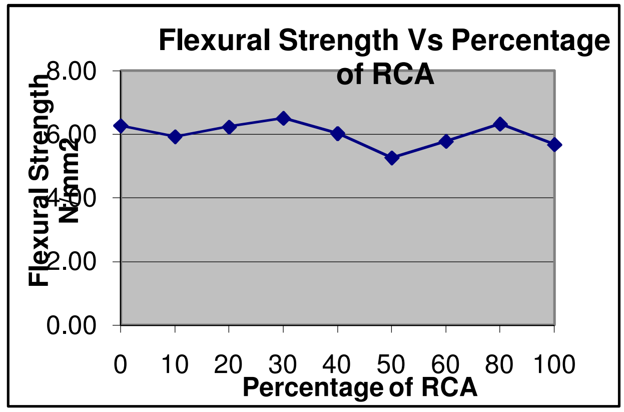

Fig. 6. Variation in flexural strength of SFRAC for various percentages of RA.

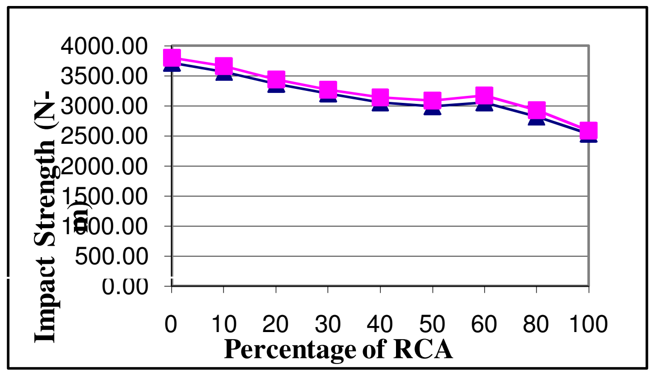

Fig. 7. Variation in impact strength of SFRAC for various percentages of RA.

Water Absorption Test Results for Silica Fume. The following tables give the water absorption results when natural aggregates are replaced by recycled aggregates in different percentages and normally cured for 28 days.

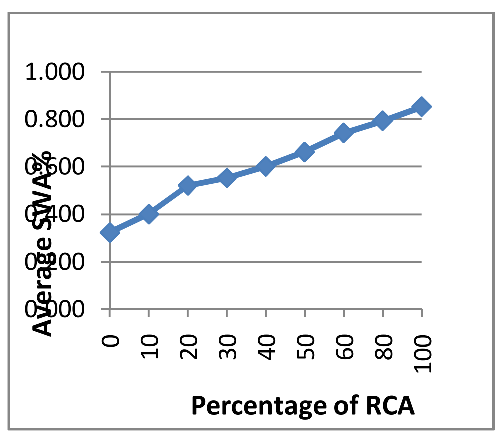

Fig. 8. Water absorption of SFRAC for various percentages of RA.

Overall Results of Water Absorption: The following table gives the overall results of water absorption of Silica Fume when natural aggregates are replaced by recycled aggregates in different percentages like 0, 10, 20, 30, 40, 50, 60, 80 and 100.

IV. OBSERVATION DISCUSSION AND CONCLUSIONS

The following conclusions are applicable to the materials used, test method adopted and the range of parameters studied.

-From the Workability test results it is observed that the slump and compaction factor of SFRAC, goes on decreasing, as the percentage replacement of natural aggregates by recycled aggregates goes on increasing. This may be due to fact that recycled aggregate may absorb more water because of more porous structure of recycled aggregate. Conclusion may be made that the workability of recycled aggregate concrete goes decreases as the percentage replacement of natural aggregates by recycled aggregates goes on increasing. Comparing the results it is observed that the workability of in more.

-From the Compressive strength test results it is observed that the compressive strength for all the three supplementary cementitious concretes, SFRAC increases, between 10% to 30% replacement of natural aggregate by recycled aggregate but the strength decreases for further increase in recycled aggregate percentage.

-The increase in strength may be due to fact that recycled aggregate have rough surfaces resulting in better bond between the constituents. The reduction in concrete compressive strength at higher percentages of recycled aggregate is obvious due to the poor strength of recycled aggregate. Conclusion may be made that 10% replacement for SFRAC and 30% replacement for yields maximum compressive strength.

-From the Tensile strength test results it is observed that the tensile strength for SFRAC and for replacement between 10% to 50% is same as reference mix strength with slight increase at 50% replacement, but the strength decreases for further increase in recycled aggregate percentage. This may be due to fact that recycled aggregate have rough surfaces resulting in better bond between the constituents. As explained above the reduction in concrete tensile strength at higher percentages of recycled aggregate is obvious due to the poor strength of recycled aggregate.

From the Flexural strength test results it is observed that the flexural strength for all the three supplementary cementitious concretes, SFRAC, increases, between 10% to 30% replacement of natural aggregate by recycled aggregate but the strength decreases for further increase in recycled aggregate percentage.

-The increase in strength may be due to fact that recycled aggregate have rough surfaces resulting in better bond between the constituents. The reduction in concrete compressive strength at higher percentages of recycled aggregate is obvious due to the poor strength of recycled aggregate.

-From the Impact test results it is observed that the impact strength for all the three supplementary cementitious concretes, SFRAC, goes on decreasing, as the percentage replacement of natural aggregates by recycled aggregates goes on increasing.

-This may be due to fact that the mortar attached to the surface of recycled aggregate results in poor strength against impact. Conclusion may be made that the impact strength of recycled aggregate concrete goes decreases as the percentage replacement of natural aggregates by recycled aggregates goes on increasing. Comparing the results it is observed that the impact strength.

-From the Water absorption test results it is observed that the water absorption for all the three supplementary cementitious concretes, SFRAC, goes on increasing, as the percentage replacement of natural aggregates by recycled aggregates goes on increasing. This may be due to fact that recycled aggregate may absorb more water because of more porous structure of recycled aggregate. Conclusion may be made that the value of water absorption goes on increasing, as the percentage replacement of natural aggregates by recycled aggregates goes on increasing. And also by comparing the results it is observed that the value of water absorption in SFRAC.

-From the soroptivity test results it is observed that the soroptivity for all the three supplementary cementitious concretes, SFRAC, goes on increasing, as the percentage replacement of natural aggregates by recycled aggregates goes on increasing. This may be due to fact that recycled aggregate may absorb more water because of more porous structure of recycled aggregate. Conclusion may be made that the value of soroptivity goes on increasing, as the percentage replacement of natural aggregates by recycled aggregates goes on increasing. And also by comparing the results it is observed that the value of soroptivity is less than the value of soroptivity for SFRAC.

-Based on the above results and discussion it is justified the efforts to use supplementary cementitious admixtures, Silica Fume recycled aggregate-concrete (SFRAC), Blast Furnace Slag recycled aggregate-concrete recycled aggregate concrete which can contribute to the preservation of the environment and can achieve the same final performance with probably less cost than ordinary concretes.

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