DEVELOPMENT AND STUDY OF BEHAVIOR OF SELF-COMPACTING CONCRETE USING RECYCLED AGGREGATES

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ABSTRACT

The present investigation covers a review of literature on recycling and reuse of waste concrete aggregate. Dumping of raw material has become a problem for many countries. Construction industry in india generate around 10-20 million tones of waste annually. In this paper the literature related to the recycling and reuse of waste concrete aggregate to the self compacting concrete is presented. The experimental procedure consists of fixing the optimum mix for SCC taking into account the criteria for SCC and design mix calculated as per Nan Su method. The mix ratio obtained from Nan Su method is made to satisfy the EFNARC Guidelines by trial mix method. Then the coarse aggregate is replaced by 25-60% with an interval of 5% by RCA for the optimum mix and studied the fresh and hardened properties. Results obtained reports that as much of 40% of aggregates can be replaced without any significant consequences on the concrete produced.

Keywords - Compressive Strength, Natural Aggregate, Recycled Coarse Aggregate, Split Tensile Strength

I. INTRODUCTION

The self compacting concrete consist of cement, sand, coarse aggregate and superplastisers. Their proportion in the concrete is based on grade of concrete. Cement has two main functions, to fill voids between aggregate particles and water tightness and to give Strength to hardened concrete. The aggregate which comprises of 70 to 80 % of volume of concrete has three main functions are to provide a cheap filler, to provide a mass of particles for resisting the action of applied loads and to reduce the volume changes resulting from the settling and hardening process. Recycling is the act of processing the used material for use in creating new product. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement material. Recycled aggregate comprised of crushed, graded inorganic particle processed from the materials that have been used in the construction and demolition wastes. These materials are from building, roads, bridges etc.

Many researchers have come across many benefits and barriers. Barriers like in some countries it is considered that low economic cost of natural aggregate than that of recycled aggregate, non-regular supply of waste. Benefits are like reduction in transportation cost, wastes generally present near the construction site, and it increased the demand of eco-friendly products and reuse of materials. The objective of the research is to recycle and reuse the large amount of waste generated from the construction and demolition due to increase in population and urbanization or natural disaster.

These wastes constitute a major portion of total solid waste production in the world, and most of it is used in the landfills. Due to the shortage of dumping sites and increase in cost of transport, majority of developed/developing countries are facing problems in handling and disposal of such wastes. By considering all the aspect, it is beneficial to reuse the generated waste for effective utilization and to save environment.

II. LITERATURE REVIEW

A.N.Dabhade et al (1): There investigation was carried out using workability test, compressive test, split tensile test and bulk density, water absorption, impact value test, crushing value test, Fineness modulus. There were total of sixth batches of concrete mixes, consists of every 20% increment of recycled aggregate replacement from 0% to 100%. The results showed that a gradually increasing in the compressive strength up to 20% of recycled aggregate and as well as for the tensile strength as the percentage of recycled aggregate.

C. Sumanth Reddy et al [2]: They studied the mechanical and durability properties of the concrete. Three concrete grades M20, M40 and M60 are prepared with recycled aggregate substitutions of 0%, 25%, 50% and 100% to test for compressive strength, acid resistance and water adsorption. Results suggest that as much of 25% of aggregates can be replaced without any significant consequences on the concrete produced. They concluded that RCA concrete performance deteriorated with increase in grade of concrete suggesting that caution is to be exercised when using RCA for higher grade concretes.

Md. Safiuddin et al [4]: have investigated on the effects of RCA on the key fresh properties such as filling ability, passing ability, and segregation resistance of SCC. In the present study, RCA was used as partial and full re-placements of NCA to produce self-consolidating concrete (SCC). Different SCC mixes were produced with RCA substituting 0%, 30%, 50%, 70%, and 100% NCA by weight. The overall test results suggest that RCA can be used to produce SCC substituting up to 50% NCA without affecting the key fresh properties of concrete.

Mirjana Malesev et al [5]: have investigated on the properties of fresh and hardened concrete with three types of concrete mixtures were tested: concrete made entirely with natural aggregate (NAC) as a control concrete and two types of concrete made with natural fine and recycled coarse aggregate (50% and 100% replacement of coarse recycled aggregate). They concluded the concrete with more than 50% of recycled coarse aggregate has significantly more shrinkage compared to concrete with natural aggregate.

Prashant O. Modani et al (6): In this study coarse recycled aggregate (RCA) were 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%. They have concluded that all the mixes having recycled aggregates have higher permeability values, which is a consequence of high initial water absorption of RCA. Concrete mixes up to 40% RCA have shown good resistance to acid attack and chloride penetration.

Srinivas Vasam et al (7): They were discussed about the potential for usage of coarse recycled aggregate obtained from crushed concrete for making self-compacting concrete, emphasizing its ecological value. They have concluded that the use of RCA in SCC provides dual advantage by deriving the benefits of both the materials as these materials reduce the impact of CO2 emissions apart from improving properties.

Sudhir P.Patil et al [8]: they aimed to evaluate physical properties of concrete using recycled coarse aggregate. In this research concrete waste is from demolished structure (Near Kamla Nehru Park, Bhandarkar Rd, Pune) has been collected and coarse aggregate of different %
is used for preparing fresh concrete. The compressive strength of recycled coarse aggregate (RCA) is found to be higher than the compressive strength of normal concrete when used upto a certain %. At the end it can be said that the RCA up to 50 % can be used for obtaining good quality concrete.

III. MATERIALS AND METHODS

Materials

Cement: Portland cement is one of the most widely used additives for all types of construction activity. The cement used for the investigation was Ordinary Portland cement (PPC-43grade). It confirmed to the requirement of Indian Standard Specification IS: 8112-1989.
Sand: Good river bank sand in absence of any earthy matter and organic matter. Particles are angular in shape passing 4.75mm and retaining on 150 micron standard sieve.
Coarse aggregates: The maximum size of aggregate is generally limited to 20mm. Coarse aggregate which passed through 12mm sieve but retained on 6mm sieve are used for the SCC mix.

Mixing water: Ordinary potable water of normal pH 7 is used for mixing and curing the concrete specimen.

Superplasticizer: Conplast SP430 is used because it is essential component of SCC to provide necessary workability.
Recycled coarse aggregates: Demolition of old and deteriorated buildings and traffic infrastructure, and their substitution with new ones, is a frequent phenomenon today in a large part of the world. The main reasons for this situation are changes of purpose, structural deterioration, rearrangement of a city, expansion of traffic directions and increasing traffic load, natural disasters. A possible solution to these problems is to recycle demolished concrete and produce an alternative aggregate for structural concrete in this way shown in FIG 1.

FIG 1:Coarse aggregate segregated from concrete waste

Basic Properties of Concrete with Recycled Concrete Aggregate

Increased water absorption, Decreased bulk density, Decreased specific gravity,Increased abrasion loss, Increased crushability and quantity of dust particles are high.

Treatment process for RCA:

To improve the quality of RCA some treatment process is required which is given in detail.

Washing:

The aggregates collected by sieve analysis are washed by pressure washing. This is done so as to remove the mortar adhered to the aggregates. The pressure at which water is applied is 500 psi for about 15 to 20 mins. Washing process cleanes the aggregates to a considerable extent as shown in FIG 1. The RCA were then kept for sun drying for about 30 mins as shown in FIG 2.

Heating:

The RCA were then heated in an oven at temperature of around 150 ° C for about an hour. The RCA were kept in trays and heated .The end result turned out to be great with more clean RCA than before. The figure below shows the RCA in trays before the start of the heating process.

FIG 2: Washing of RCA

FIG 3: Drying of RCA

IV. EXPERIMENTAL PROGRAMME

Cement: Ordinary Portland cement of 43 grade conforming to IS-1489(part I)-1991.All the test are conducted as per IS 8112-1989 and result as shown in Table 1.

Table 1: Properties of cement

SL No.	Properties	Results	As per IS : 8112-1989
1.	Consistency of Cement	32.0%	_
2.	Specific gravity	3.1	3.15
3.	Initial setting time	57 mins	>30 mins
4.	Final setting time	363 mins	<600 mins
5.	Fineness of cement	6%	< 10 %

Fine aggregate: River sand locally available nearby area.

Coarse aggregate: Machine crushed granite obtained from quarry was used as a coarse aggregate.

Recycled aggregate: It is obtained from demolition of concrete

Table 2: Properties of aggregates

Properties	Fine Aggregate	Natural aggregate	Recycled aggregate
Specific gravity	2.65	2.7	2.3
Bulk Density Kg/m3	1297	1327	1228
Fineness modulus	2.30	4.24	3.55
Water absorption	1.2%	0%	0.3%

V. RESULTS AND DISCUSSIONS

FRESH PROPERTIES

The rheological properties are assessed by using rheology tests such as Filling, Passing and Segregation resistance. When coarse aggregate is replaced with RCA, a lower dosage of Superplasticizer is required to maintain the same filling ability. T_{50} times indicates the viscosity of highly flowable concrete mixes. Lower time indicates greater flowability. The T_{50} was influenced by the dosage of water and superplasticizer. V funnel test was performed to assess the flowabilty and stability of the SCC. The rheological properties are shown in Table 3.

Table 3: Fresh Properties of SCC

Specifications	Slump flow (mm)	T_{50cm} Slump flow (Sec)	V-funnel (Sec)	V-funnel T5 minutes (Sec)	J-ring (mm)	U-box (mm)
SCC	705	4.76	8	1.62	8.50	8
S- RCA 25%	702	4.52	9	1.75	8.65	11
S- RCA 30%	696	4.36	9	1.89	8.90	15
S- RCA 35%	691	4.24	10	1.99	9.10	17
S- RCA 40%	682	4.10	10	2.08	9.25	18
S- RCA 45%	675	4.00	10	2.19	9.45	21
S- RCA 50%	666	3.78	11	2.33	9.82	23
S- RCA 55%	659	3.53	11	2.65	9.95	25
S- RCA 60%	654	3.36	12	2.99	10.60	26

Hardened properties of SCC

From the test result it is found that 40% of recycled aggregate can be effectively used in coarse aggregate for making the M_{30} grade concrete. It is observed that in all the tests, strength of concrete is gradually decreased as percentage of recycled aggregate increased. The comparison of 7 and 28 days compressive as well as split tensile strength for various water cement ratio is shown in Table 4 & 5.

Table 4: Compressive strength at 7 and 28-days for various replacement levels of RCA (%).

Specifications	7-days compressive strength (Mpa)	28-days compressive strength (Mpa)
SCC	22.80	39.80
SCC_25% RCA	20.90	38.70
SCC_30% RCA	20.60	38.30
SCC_35% RCA	21.10	39.00
SCC_40% RCA	21.60	39.20
SCC_45% RCA	21.10	38.80
SCC_50% RCA	19.90	37.60
SCC_55% RCA	19.20	37.00
SCC_60% RCA	18.80	36.80

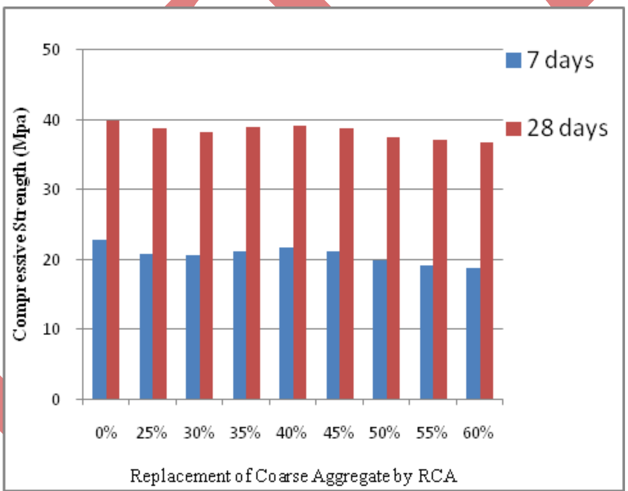

Fig 4: Compressive strength of SCC containing RCA for 7 and 28-days.

Observation

From the Fig.4, The optimum strength gained after 7 and 28 days curing period is at 40% replacement and the lowest strength at 60% replacement of RCA with coarse aggregate.

Table 5: Splitting tensile strength at 7 and 28-days for various replacement levels of RCA (%).

Specifications	7-days Split tensile strength (Mpa)	28-days Split tensile strength (Mpa)
SCC	**2.30**	**3.10**
SCC_25% RCA	2.30	3.00

SCC_30% RCA	2.20	3.00
SCC_35% RCA	2.20	2.90
SCC_40% RCA	2.20	2.70
SCC_45% RCA	2.10	2.70
SCC_50% RCA	2.10	2.60
SCC_55% RCA	2.00	2.40
SCC_60% RCA	1.80	2.30

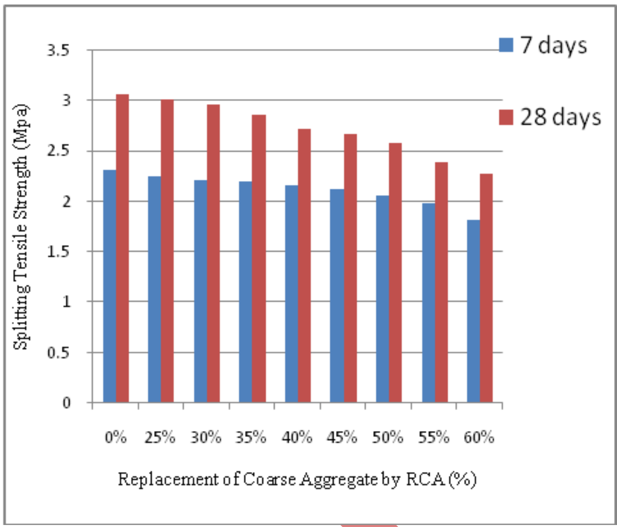

Fig 5: Split tensile strength of SCC containing RCA for 7 and 28-days.

Observation:

From the Fig 5, After 7 and 28 days curing the optimum strength gained is at 25% replacement and lowest at 60% replacement of RCA with coarse aggregate.

VI. CONCLUSIONS

In the present investigation, the replacement of coarse aggregate was carried out in the range of (25-60%) at an increment of 5%. From the various experiment results, the following conclusions are drawn.

- The water content used in all mixes is 0.45. The proportion of cement: sand: gravel is 1:1.38:1.33.
- It is found that as the natural aggregate replaced by RCA the strength of the concrete decreases.
- Use of the waste aggregate in the new concrete as the recycled concrete aggregate reduces the environmental pollution as well as providing an economic value for the waste material and water absorption of RCA is higher than natural aggregate.
- There is an increase in the strength of SCC when the coarse aggregate was replaced by RCA at 35-45% than other mixes. This also reduces the coarse aggregate content by increasing the RCA thus reducing the further cost of SCC mixes developed.
- It is seen that density is directly proportional to strength, as the density increases, strength increases where as the density decreases, strength also decreases.

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