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IMPACT TEST ON RECYCLED COARSE AGGREGATE BASED SELF-COMPACTING CONCRETE

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Abstract- Self-compacting concrete (SCC) is a highly flowable type of concrete that spreads into the form without the need for vibration. SCC is a non-segregating concrete that is placed by means of its own weight. SCC requires considerably more quantity of fine particle as compared to traditional concrete to achieve self-compactibility. Reused Aggregate is called as Recycled Coarse Aggregate (RCA) which is mainly obtained by crushing concrete of demolished concrete structures. In this study, Nan-Su method of mix design is employed to obtain mix-proportions for SCC and two grades of concrete mixes were used. This study aims to evaluate the impact resistance of SCC by replacing NCA with different percentages of RCA (25%, 50%, 75%, 100%) in unprocessed and various processed states(500R, 1000R, 1500R, 2000R). For mix-A at 75% replacement of RCA and 1000 revolutions, for mix-B at 75% replacement of RCA and 500 revolutions maximum impact resistance was found.

Keywords: SCC, NCA, RCA, Impact resistance.

I. INTRODUCTION

Self-compacting concrete, also known as self-consolidating concrete, is the concrete that is able to flow under its own weight without vibration. It is able to fill the form work while maintaining homogeneity even in the presence of congested reinforcement. SCC contains mineral admixture such as flyash as a partial replacement of cement which helps in maintaining the flowability and adequate yield value of fresh mix. SCC contains more finer particles than coarse, which increases the slump flow of the mix, though required dosage of superplasticizer is used to maintain the slump flow.

Reused aggregate is called as recycled coarse aggregate which is obtained by crushing concrete of demolished concrete structures. Recycled coarse aggregate which is in unprocessed state contains cement paste adhered to its surface can be removed using deval’s abrasion test and the obtained aggregate is called processed aggregate. It also depends on the no. of revolutions of abrasion test like 500R, 1000R, 1500R & 2000R.

Many concrete structures are often subjected to short duration dynamic loads. These loads originate from sources such as impact from missile projectiles, wind gusts, earthquakes and machine vibrations. Impact resistance of concrete is known as an important property in construction damage caused due to impact forces adversely affects the life span of any concrete structure which leads to early replacement. The impact is a complex phenomenon that involves crushing shear failure and tensile fracturing. Drop weight test is the simplest and popular method to find the impact resistance of the concrete specimen according to the ACI committee-544. Impact resistance has been characterized by measuring the number of blows in a “repeated impact” test to achieve a prescribed level of distress in the test specimen. The objective of the present work is to study the behavior of SCC under impact loading with varied % of RCA. Impact energy was determined by using the simple and economical drop weight impact testing machine.

II. EXPERIMENTAL PROGRAM

A. MATERIAL PROPERTIES

Ordinary Portland cement of grade 53 confirming to IS 12269 was used for concrete mixtures. The specific gravity of cement 3.15 was used for preparing the concrete mix of different grades. Two different grades of concrete as M35 and M45 were used with inclusion of different percentages of RCA as a replacement of NCA. The specific gravity of the fine and recycled coarse aggregates were 2.6 and 2.84 respectively. According to Nan-Su method of mix design maximum and minimum size of CA used is 16mm and 12mm. This method of mix design considers mineral admixture like flyash having specific gravity 2.25 and chemical admixture like super plasticizer at required dosage to achieve self-compactability of concrete.

TABLE I : Properties of Materials

TESTS	FINE AGGREGATE	NCA	RCA
Grading zone	II	-	-
Bulk density	1500 Kg/m^3	1402Kg/m^3	1404Kg/m^3
Void ratio	0.52	0.8	0.82
% voids	35%	48.6%	44.6%
Fineness modulus	2.6	-	-

B. MIX DESIGN

Mix design for M35 and M45 grades of concrete were done based on Nan-Su method which is most suitable method for SCC. The mix proportions are shown below:

TABLE II : Mix Design of M35 Grade Concrete

Grade: M35	**Cementitious**	**Fine aggregate**	**Coarse aggregate**	**Water & (W/C)**
Quantity (kg/m^3)	523.61	924	680	195.20
Proportions	1	1.76	1.30	0.38

TABLE III : Mix Design of M45 Grade Concrete

Grade: M45	**Cementitious**	**Fine aggregate**	**Coarse aggregate**	**Water & (W/C)**
Quantity (kg/m^3)	554.98	924	680	189.58
Proportions	1	1.66	1.22	0.35

C. SPECIMEN MOLDING

Each series of freshly mixed concrete was placed in the cylindrical mould of 150mm diameter and 60mm height for casting 84 number of specimens of same dimension with 42 number of mixes varying in different percentages of RCA. These specimens of different concrete mixes were tested in a laboratory after 28 days of curing period at standard room temperature under drop weight impact test machine.

D. IMPACT TEST

The drop weight impact test was carried out on these specimens according to the guidelines of ACI committee 544.2R-89. The impact load was applied with a hammer of 43.6N dropped repeatedly from a height of 500 mm onto a steel ball of 63.5mm diameter placed at the center of the top surface of specimen.
84 specimens were casted to obtain the average number of blows required to cause first crack and ultimate failure after 28 days of curing. Number of blows required for first visible crack and ultimate failure were noted as N1 and N2 respectively. The schematic diagram of drop weight test machine is shown in Figure-1 and Figure-2.

Fig.1: Drop weight impact testing machine

Fig.2: Steel ball placing at center of specimen

The impact energy delivered to the specimen produced by each blow is calculated using the following expression:

$I = ½ x m x (V_h)^2 x N$

Where, I– Impact energy(N-m)

m – drop hammer mass

V_h – impact speed(m/s)

N – number of blows at Ultimate failure

m=(W/g)

III. RESULTS

The number of blows required to cause the first visible crack(N1) and Ultimate failure (N2) of the concrete specimens are shown in the Table-IV and Table-V including the impact energy of specimens corresponding to the number of blows taken by specimen at ultimate failure of the specimen and is calculated based on the following expression:

Substituting the corresponding values in the equations below, we get

$H=(gt^2/2)$

$500 = (9810 x t^2) / 2$

t = 0.3192 sec ;

$V_h=gt$

$V_h = 9810 x 0.3192 = 3131.52$ mm/s

The Impact energy delivered by hammer per blow can be obtained by using equation as below

$I = ½ x m x (V_h)^2 x N$

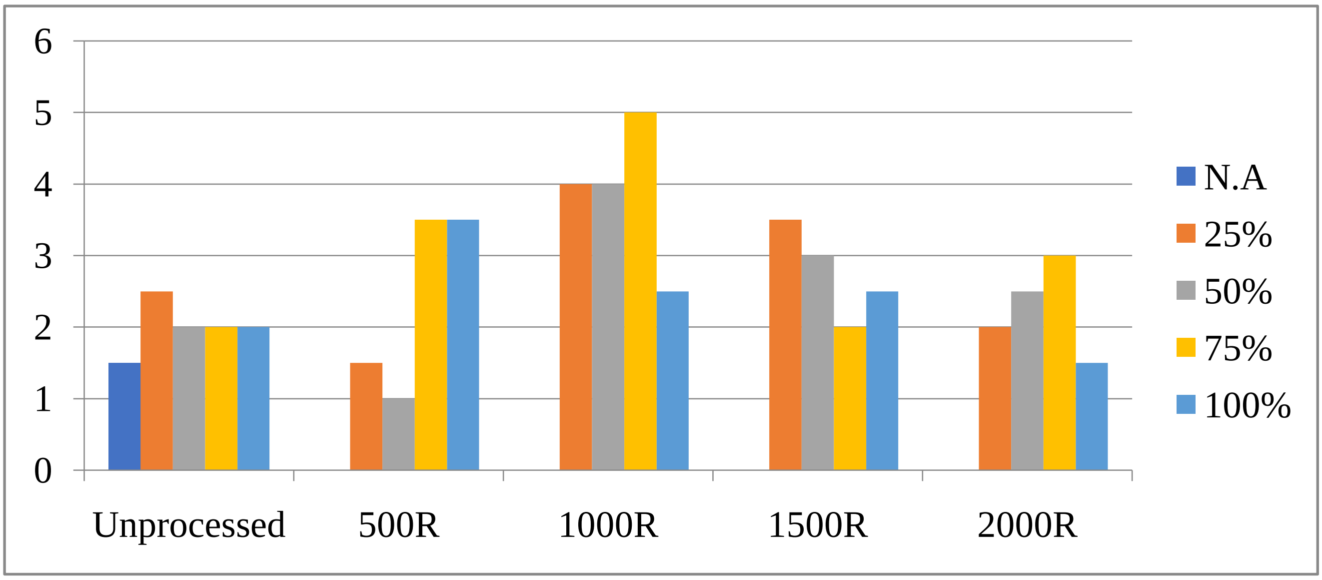
$= (43.6) x (3131.52)^2 x1/ (2 x 9810)$

= 21.79 kN-mm

TABLE IV : Average number of blows at first crack(N1) and Ultimate failure(N2) for M35 grade

M35	UNP			500R			1000R			1500R			2000R		
	N1	N2	I	N1	N2	I	N1	N2	I	N1	N2	I	N1	N2	I
N.A	1.5	2	43.58	0	0	0	0	0	0	0	0	0	0	0	0
25%	2.5	3	65.38	1.5	1.5	32.69	4	4.5	98.06	3.5	4.5	98.06	2	3	65.38
50%	2	3	65.38	1	2	43.58	4	5.5	119.86	3	4.5	98.06	2.5	4	87.17
75%	2	3	65.38	3.5	4.5	98.06	5	5	108.96	2	3.5	76.27	3	4	87.17
100%	2	3	65.38	3.5	4.5	98.06	2.5	3	65.38	2.5	3.5	76.27	1.5	2.5	54.48

Fig 3: Failure of specimen (M35)

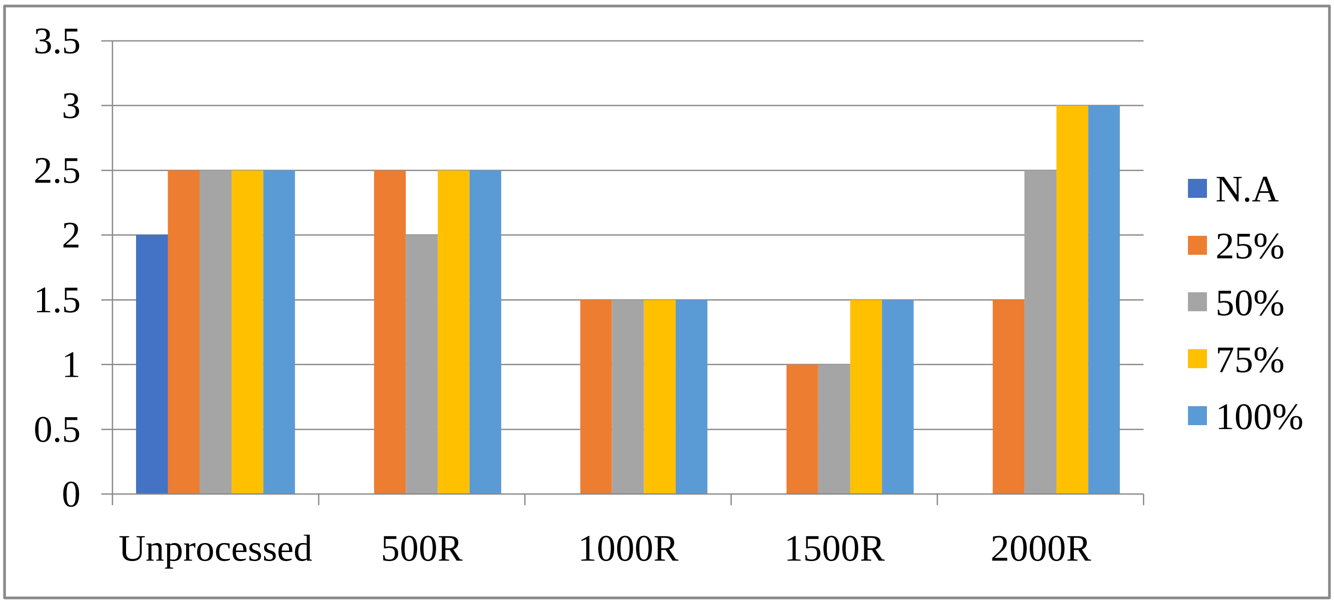


Graph 2: ULTIMATE FAILURE FOR M35 GRADE CONCRETE

TABLE V : Average number of blows at first crack(N1) and Ultimate failure(N2) for M45 grade

M45	UNP			500R			1000R			1500R			2000R		
	N1	N2	I	N1	N2	I	N1	N2	I	N1	N2	I	N1	N2	I
N.A	2	3	65.38	0	0	0	0	0	0	0	0	0	0	0	0
25%	2.5	3.5	76.27	2.5	3.5	76.27	1.5	2.5	54.48	1.5	2	43.58	1.5	2.5	54.48
50%	2.5	3.5	76.27	2	2	43.58	1.5	2.5	54.48	1	2	43.58	2.5	2.5	54.48
75%	2.5	2.5	54.48	2.5	4	87.17	1.5	3	65.38	1.5	2.5	54.48	3	3.5	76.27
100%	2	2	65.38	2.5	3.5	76.27	1.5	2.5	54.48	1.5	2.5	54.48	3	3.5	76.27

Fig 4: Failure of specimen (M45)



Graph 2: ULTIMATE FAILURE FOR M45 GRADE CONCRETE

From the results projected in Table-IV and Table-V, it was experimentally observed that the impact resistance of the specimens has increased with increase in the percentage replacement of NCA by RCA and also with the increase in processing revolutions of RCA.

It is also observed that the impact resistance of the specimens was decreased with increase in processing revolutions of RCA in both M35 and M45 grades of concrete because of the smoothening of RCA while increasing the processing revolutions and due to less strength possessed by RCA compared to NCA.

IV. CONCLUSIONS

Based on the experimental results, the following conclusions are drawn:

- It was found that the increase in the percentage replacement of NCA by RCA upto 75%, increased the impact resistance for both M35 and M45 grades of concrete specimens.
- The impact resistance also increased with the increase in processing of the RCA upto 1000R and it gradually decreased beyond 1000R for M35 grade of concrete mix.
- The impact resistance gradually increased with the increase in processing of the RCA for M45 grade of concrete mix.
- The maximum impact energy was observed at 1000R with 50% replacement of RCA for M35 grade of concrete mix and at 500R with 75% of RCA for M45 grade of concrete mix.

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