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Stresses in Structural Concrete Block with Mixing of RCA

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Abstract: An examination of mechanical behavior and versatile properties of reused total concrete (RCA) is displayed. RCAs were arranged by employing a coarse total division made of reused concrete coming from a reusing plant in which rubble from concrete structure devastation is collected and reasonably treated. A few concrete blends were arranged by utilizing either the as it was virgin totals (as reference) or 30% coarse reused total supplanting rock and by utilizing two diverse sorts of cement. Distinctive water-to-cement proportions were received extending from 0.40 to 0.60. Concrete workability was continuously within the run 190–200 mm. Concrete compressive quality, flexible modulus, and drying shrinkage was assessed. Comes about gotten appeared that auxiliary concrete up to C32/40 quality course can be made with RAC. Besides, comes about gotten from experimentation were examined in arrange to get valuable data for RAC structure plan, especially in terms of flexible modulus and dry.

Keywords - Recycled Aggregate; Recycled Concrete Aggregate (RCA); Load Test; Structural Concrete; 3-R Principal; Waste Management.

1. INTRODUCTION

Crushing concrete to produce coarse aggregate for the production of new concrete is one common means for achieving a more environmentally friendly concrete. Recycling concrete wastes will lead to reduction in valuable landfill space and savings in natural resources. In fact, the use of recycled aggregate concrete (RAC) is acquiring particular interest in civil construction as regards to sustainable development.

Many studies demonstrate the feasibility of the use of crushed concrete as coarse aggregates, its use being already accounted for in the regulations of many countries. In Italy, the use of 30% recycled concrete instead of natural aggregate is definitively allowed for producing structural concretes (up to C 30/37 strength class) since July 2009. The study of the elastic behavior of concretes made of 30% recycled-concrete aggregates, discussed here, just had the aim to provide useful information. The key objective is to determine the sustainability, strength and other important properties of concrete made with recycled aggregate, so that recycled aggregate can be used as a substitute for natural aggregate.

Waste management strategies adopted in different countries. Comparative analysis was used to identify the main aspects that government considered in improving construction waste management. The fundamental of waste management is 3R principal Reuse, Recycle and Reduce to attain sustainability. As per report of Central Pollution Control Board (CPCB) Delhi, India , 48 millions tones of solid wastes is produced out of which 14.5 million tone waste is produced from the construction sector out of which 3% waste is only use for the purpose of embankment.

World construction Aggregate Demand (million metric tons) (The Freedonia Group, 2012)

Table I - Problems with C&D Waste

	2005	2010	2015	% Annual Growth	
				2005-2010	2010-2015
Construction Aggregate Demand	27300	37400	48300	6.5	5.2
North America	3280	3010	3710	-1.7	4.3
Western	2920	2630	3050	-2.1	3.0

Europe					
Asia Pacific	16000	24750	32600	9.1	5.7
Other	5100	7010	8940	6.6	5.0

2. Ingredients of structural concrete block

The major ingredients required to produce a concrete bock are Recycle concrete Aggregate (R.C.A.), cement, fine aggregate and water. Conventional Portland cement is utilized in this extend. Quartz sand (0–5 mm), fine rock (6–12 mm), and rock (11–22 mm) were used. Water used in this project is free from chlorine and other contaminated in simple term the water which has the satisfactory property for dinking that water is best or water quality must be accruing to IS 3025-2007. Table 2 shows the Physical properties of the R.C.A.

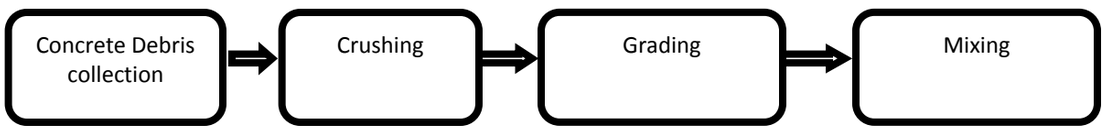
Recycle concrete Aggregate (R.C.A.) – Recycled concrete aggregate; grain sizes 10mm,12mm and 25/20mm**.** Recycled aggregate fraction (11–22 mm) was used, coming from a recycling plant in which rubble from concrete structure demolition is suitably treated. The substance in reused concrete division of chlorides, sulfates, and natural materials were assessed agreeing to the strategies suggested by UNI EN 1744-1 and the nearness of alkali-silica responsive materials agreeing to the strategy prescribed by UNI EN 8520-22.

Table II - Physical properties of the R.C.A.

Physical properties	**Value**
Specific Gravity	2.54
Aggregate crushing value	28.91%
Aggregate impact value	24.17%
Water absorption value	2.44%
Nominal Max size (mm)	20
Fineness Modulus	6.79
Bulk Density (kg-m^{-3})	1250
Porosity (vol.%)	5.03
Absorption (wt.%)	2.03
Moisture content (wt%)	1.57
Angular number	12.7

3. Experiment Result

Recycled concrete aggregate was produced by crushing of old concrete cubes used for compressive strength testing and one precast reinforce concrete column, which had in appropriate dimensions. The strength class of old concrete cubes was C30/37 and the corresponding value of compressive strength for precast column was C40/50. The primary crushing was done with a pneumatic hammer and secondary crushing was performed in a rotating crusher. The blain fineness of cements were 0.42m2/g. respectively and there specify gravity were 3.05kg/m3. As per IS 269-1989. Quartz sent (0-5mm), fine gravel (6-12mm), and gravel (11-22mm) were used suitably combined for preparing the reference mixtures. There main physical properties were evaluated according to {IS 383-1970} and physical properties as per IS 2386 per 2-8.The contain is recycle concrete fraction of chlorides, sulphates and organic materials were evaluated according to the methods recommended by IS code and also presence of alkali silica reactive materials according to the methods recommended by IS code. The second concrete mix had 50% of natural river coarse aggregate and 50% of recycled coarse aggregate (R50). The third concrete had 100% of recycled coarse aggregate (R100). As all the other variables were kept constant, this research enabled us to determine the influence of the coarse recycled aggregate amount (0%,50% & 100%) on tested concrete properties.



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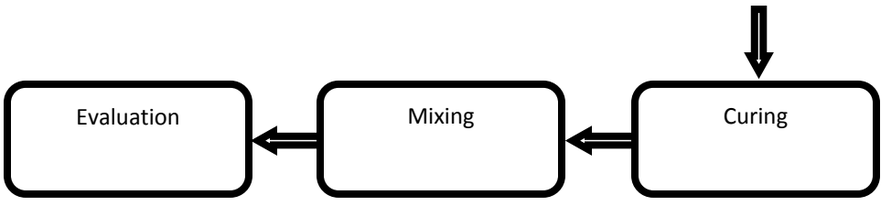

Fig. 1: Flow Chart of the Process

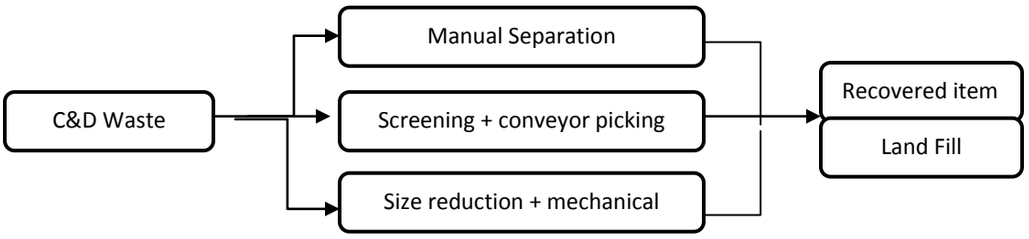

Fig. 2: Method of Concrete Debris Waste Treatment

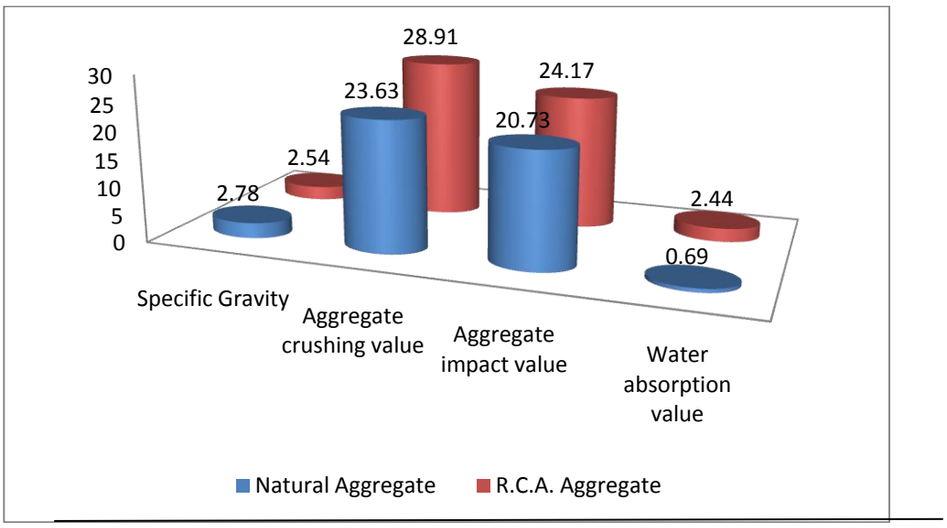

Fig. 3: Variation in Physical Properties of the Aggregates

3.1 Mix Proportion Design

Concrete mix proportions were calculated according to above listed conditions and are shown in Table below . Dried recycled aggregate, basic water content and additional water quantity were used to achieve the required workability of RAC.

Table III – Design Quantity of Component Material

Material Concrete mixture	Cement (kg/m^3)	Effective water kg/m^3	Agg. Kg/m^3	Additional water kg/m^3	Effective W/C	Total W/C	Bulk Density kg/m^3
RO	350	180	1857	1857	0.514	0.514	2.387
R50	350	180	1816	1816	0.514	0.569	2.365
R100	350	180	1776	1776	0.514	0.620	2.343

Composition:

Ratio = CEMENT: SAND: R.C.A (1:2:4), R.C.A= Recycled concrete aggregate

Water = 0.5% of volume manufacturing cubes (by using recycling concrete)

Cube Size = 150X 150 X 150 mm, Modify Size=250 X 200 X 125mm

Weight of concrete per unit volume of cube = 23 KN/m^3.

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3.2 Tests for RCA

a) Specific Gravity Test
Specific Gravity [G] = density of soil solid / density of water.
=Mass of soil solid / mass of equal volume of water

Table IV – Result of Specific Gravity Test

Sl. No.	M_1	M_2	M_3	M_4	$M_2 - M_1$	$G=(M_2-M_1)/\{(M_4-M_1)-(M_3-M_4)\}$
1.	600gm	1000gm	1850gm	1610gm	400gm	2.5
2.	600gm	830gm	1760gm	1610gm	230gm	2.875

Mean G_s: 2.65%

b) Water Absorption Test

Table V – Result of Water Absorption Test

Description	Sample
Wt.of saturated surface dry sample (W1)	978(gm)
Wt. of oven dry sample(W2)	959(gm)
Water Absorption {(W1-W2)/W2}*100	1.98%

c) Sieve Analysis

Table VI – Result of Sieve Analysis

IS Sieve	Mass retained(g) (x_1)	% retained= (x_1/x)*100	Cumulative % retained	% passing
20mm	50gm	2.5	2.5	97.5
16mm	110gm	5.5	8	92
12.5mm	210gm	10.5	18.5	81.5
10mm	220gm	11	29.5	70.5
6.3mm	730gm	36.5	66	34
4.75mm	149.92gm	7.496	73.496	26.504
2.8mm	180.06gm	9.003	82.5	17.5
2mm	262.84gm	13.142	95.641	4.359
1.4mm	48.44gm	2.422	98.063	1.937
1.18mm	5.78gm	0.289	98.35	1.65
1mm	0.96gm	0.048	98.4	1.6
0.600mm	3.82gm	0.191	98.591	1.409
0.075mm	9.94gm	0.497	99.088	0.912
pan	3.04gm	0.152	99.24	0.76
sum	1984.8gm	99.24	-	-

Mass of dry R.C.A. sample(x) =2000g

d) Impact Test

Table VII- Result of Impact Test

Specimen	Trial	Sample quantity (A_1)	After Impact test I.S sieve 2.36 passing (A_2)	Impact result (A_2/A_1)*100
R.C.A.	1	300gm	60gm	20%

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3.3 Tests for Workability of concrete by using RCA

a) Slump Test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete and therefore the ease with which concrete flows it can also be used as an indicator of an improperly mixed batch.

Table VIII – Result of Slump Test

No	Type of Concrete	Slump (mm)
1	Concrete for canal lining	70-80
2	Normal RCC work	80-150
3	Mass concrete	20-50
4	Concrete to be vibrated	10-25

Slump value of recycle concrete= 30mm. Hence it is mass concrete.
Proportion of recycle concrete= 1:2:4 Water cement ratio= 0.5 by volume

b) Compacting Factor Test

Compaction factor test of concrete is performed to find out the workability of fresh concrete. Slump test does not give accurate result for the low workability of concrete when the slump is < 50mm. Here to deal with compaction factor test used for concrete mix of very low workability.

Compaction Factor= $(W_2-W_1) / (W_3-W_1)$.

Where w_1= weight of cylinder, w_2= weight of partially compacted concrete, w_3= weight of fully compacted concrete.

The Result Compaction Factor of Recycle Concrete = 0.85.

Table IX - Result of Slump and Compacting Test

Degree of workability	Slump(Mm)	Compacting Factor
Very Low	-	0.78
Low	25-75	0.85
Medium	50-100	0.92
High	100150	0.95

c) Vee Bee Consistometer Test

Vee bee test is to determine the workability of the freshly concrete. the vee bee test gives an indication about the mobility and the compatibility aspect of the freshly mixed concrete..

The Result of Vee Bee test = 13 second.

Table X – Result of Vee Bee Consistometer Test

Workability	Vee Bee Time (Seconds)
Extremely Dry	32-18
Very Stiff	18-10
Stiff	10-5
Stiff Plastic	5-3

Plastic	3-0

Hence recycle concrete is very stiff category that is preferable for making cube.

3.4 Tests for Strength of concrete with RCA

a) Characteristic compressive strength of concrete

Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension size elongates.

Compressive strength=load /cross sectional area

Size of the cube= 150x150x150 mm.

Table XI - Result of compressive Test

Trial No.	Cement %	Fine Aggregate %	RCA %	Compressive Strength (N/mm^2)		
				3 days	7 days	14 days
1.	20	0	80	10	12.5	16.5
2.	10	10	80	4	8.5	13.5
3.	10	20	70	8.5	11.5	15.5
4.	20	10	70	6.88	10.5	13.5
5.	20	20	60	11.11	14.5	16.5

Note: 28 days Characteristic Compressive Strength of Concrete 10 N/mm^2 equivalent to M10 grade of concrete

b) Elastic Modulus of Concrete

It is the resistance of material to elastic of deformation under load. According to IS 456: 1978 the value of elastic modulus of concrete varies from $14X\ 10^3$ N/mm^2 to $40\ X\ 10^3$ N/mm^2 and increases with density and to some extent with age. It can be calculated by $E_c = 5700\sqrt{f_{ck}}$ N/mm^2. For this experiment we take f_{ck} = 10 N/mm^2 the value of elastic modulus is $18\ X\ 10^3$ N/mm^2

c) Flexural Strength of concrete

Tensile strength of concrete in flexure is called flexural strength of concrete It is used to determine the onset cracking starts in specimen. Since concrete don't take any tensile strength, it is taken as zero. But IS code recommends the tensile strength to be calculated using $f_{cr}= 0.7\ \sqrt{f_{ck}}$ N/mm^2. By calculation we get the Flexural Strength of concrete 2.21N/mm^2 equivalent to M10 grade of concrete.

Splitting tensile strength is calculated by $f_{ct}= 0.66\ f_{cr}$ where f_{ct} is Splitting tensile strength, f_{cr} Flexural Strength of concrete. The value of splitting tensile strength is 1.4586 N/mm^2 equivalent to M10 grade of concrete.

d) Tensile Strength of concrete

The tensile strength of concrete is tendency to bear or resist tension or pull. Tensile strength is one of the basic and important property of concrete it is important to find the value of tensile strength for the design of concrete structure. A good concrete have tensile strength $^1/_{10}$ (compressive strength). According to IS 456 2000. $F_t= 0.7\sqrt{f_{CK.}}$ Where $\sqrt{f_{CK}}$ is characteristic cube

strength of concrete @ 28 days. Tensile strength of concrete is 2.22 N/mm^2 equivalents to M10 grade of concrete.

4. Cost Effective for Modern Environment

Making cost of 1 unit of R. C. A. Block = Rs 15-17.

Selling Price of 1 unit of R. C. A. Block = Rs20-22.

Volume of material required in 1 unit block = 0.00375meter cubic for 150X150X150mm Block.

0.0075 meter cubic for 250X200X150mm Block.

Cement required = 0.0015 meter cubic. Fine aggregates = 0.0015 meter cubic.

R. C. A. = 0.0045 meter cubic.

Making cost of 1 unit of hollow block = Rs. 10-12.

Selling Price of 1 unit of hollow block = Rs.15-17.

Volume of material required in 1 unit block = 0.003334 mater cubic for 150X150X150mm Block.

Cement required 0.00007 meter cubic.

Fine aggregates = 0.0007 meter cubic. R. C. A. = 0.0021 meter cubic.

Fig. 4: RCA concrete block

5. Conclusion

Results obtained show that structural concrete up to C32/40 strength class can be manufactured by replacing 30% virgin aggregate with coarse recycled-concrete aggregate. Moreover, a correlation between elastic modulus and compressive strength of recycled-aggregate concrete was found showing that, in general, 16% lower elastic modulus is achieved by using 30% coarse recycled aggregates, whatever the recycled aggregate grain size distribution.

RCA aggregates, both coarse and fine, tend to be very angular and rough due to the crushing of the virgin aggregate particles and the presence of cement paste that continues to cling to the surfaces of the aggregate. Absorption Capacity: The amount of water that an aggregate can absorb is called absorption capacity. Limiting the use of recycled fine aggregate will also reduce the absorption capacity of the aggregate. The following properties of concrete were selected for testing: workability (slump test), Bulk density, Water absorption, Compressive strength, Splitting tensile strength, Flexural strength. Several specimens were made for testing. Utilizing reused materials as rock diminishes the require for rock mining. From financial point of see reused concrete could be a construction materials that the community does not got to pay for: those who created the concrete squander pay for charge to have it recycled. The quality of reused total concrete is almost 10 to 15% less as compared to concrete with new total.

Finally, on the basis of the results obtained by free drying shrinkage measurements, similar shrinkage behaviors are detected for equal-strength concretes, not depending on the kind of aggregate used. This last aspect, when considered together with a lower elastic modulus, predicts a lower tendency to crack appearance in RACs rather than in conventional concretes.

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References:

1. Paulo Monteiro “Structural Concrete Prepared with Coarse Recycled Concrete Aggregate: From Investigation to Design”, Use of Recyclable Materials in Sustainable Civil Engineering Applications Volume 2011 |Article ID 283984 , 2011.
2. S. W. Tabsh and A. S. Abdelfatah, “Influence of recycled concrete aggregates on strength properties of concrete,” Construction and Building Materials, vol. 23, no. 2, pp. 1163–1167, 2009.
3. .Jaswant singh Shekhawat, Ashish Simatli, Amardeep Meena, Chiranjia Kumari Devi “A Review-use of Recycled Aggregate in Making Concrete in India".
4. Rajendra Kumar Goyal, Abhishek Tiwari "Use of Banana Leaves Ash in Concrete" volume 4,2016.
5. V.Corinaldesi and G.Moriconi, “Recycling of rubble from building demolition for low-shrinkage concretes,” Waste Management, vol. 30, no. 4, pp. 655–659, 2010.