An Experimental Investigation of Natural Aggregate replace by RCA for producing Eco-friendly concrete

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***Abstract*- The Rapid growth of the construction sector in India, Producing a huge quantity of Construction and Demolition waste every year, which occupies the larger space of land to dump. This creating a disposal problem in the country. To overcome this issue broadly possible use of recycled concrete aggregate can be done in concrete construction. It will further help to conserve natural resources. The present work is directed towards the evaluation of concrete using partial replacement of natural coarse aggregate (NCA) with RCA and particle size distribution of recycled concrete aggregate. The experimental results on RCA concrete are also evaluated and compared with NCA concrete. This experimental study aims to use recycled RCA as an alternative to NCA with a change in gradation of Aggregate in a concrete mixture**

***Index terms*- Recycled concrete aggregate, Concrete Mix Design, Flexural Strength, Split Tensile strength, Compression Test**

1. INTRODUCTION

India is one of the most populated countries in the world. The population of India is projected close to 1.37 billion or 1,369 million in 2019, compare to 1.354 billion in 2018. To fulfill the demand of a growing population, construction activities are also on a fast track. The construction mainly depends upon natural resources like sand, aggregate, water, silica, timber, iron, etc. And which tends to produce a large amount of debris also. According to the Indian Government estimates, India produces at present about 165-170 million tones (MT) of debris annually and as per estimates of the Union Ministry of Urban Development, India produced 12-14.7 MT of C & D waste per annum as reported by CPCB in March 2017[4]. We need to take action on it. Construction and Demolition waste can be managed by reusing and recycling it. While the landfilling is considered the least desirable option. This paper focused on maximizing the recycling of RCA in concrete.

Fig. No.1 C&D waste

2. OBJECTIVES

- To find out the % RCA for the production of concrete.
- To find out the financial feasibility of RCA.
- To minimize the impact of waste materials on the environment.
- The effect of particle size distribution in recycled concrete aggregate.
- To compare test results

2.1. EXPERIMENTAL ANAYSIS

2.1.1. MATERIALS

1. Cement- Cement 43 grade Ordinary Portland Cement used in the experimental investigation. Tests are carried out by procedures described in IS 4031:1968[6].
2. Fine Aggregate (Crushed sand)- The sand used throughout the experimental work is obtained from the locally available in the market. The specific gravity of fine aggregate is 2.6

3. Water- Potable water available in the laboratory is used for mixing and curing.
4. Coarse Aggregate- The coarse aggregate of nominal size 12.5mm,20mm,30mm obtained from the local quarry confirming to IS specification was used.
5. Recycled Concrete Aggregate- The recycled concrete aggregate used in the investigation is obtained by crushing the tested laboratory concrete cubes. The specific gravity of aggregates is 1.98
6. Superplasticizer- Polycarboxylate, as chemical admixtures in RCA mix design.

Fig.No.2. 40 mm size recycled aggregate

Fig.No.3. 20 mm size recycled aggregate

Fig.No.4. 10 mm size recycled aggregate

Fig.No.5. 5.6 mm size recycled aggregate

2.1.2. TEST ON RECYCLED CONCRETE AGGREGATE

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Water absorption gives an idea of the strength of aggregate. By referring IS: 2386 part III we performed specific gravity and water absorption on recycled concrete aggregate

Table No.1. Water Absorption of recycled coarse aggregate

Sr No.	DESCRIPTION	SAMPLE
1.	Weight of saturated aggregate and basket in water (w1) gm	2100
2.	Weight of basket in water (w2) gm	750
3.	Weight of saturated aggregate in the air (w3) gm	2600
4.	Weight of oven-dried aggregate in the air (w4) gm	2475
5.	Specific gravity of aggregate =w4/[w3-(w1-w2)]	1.98
6.	Apparent specific gravity of aggregate =w4/[w4-(w1-w2)]	2.01
7.	Water absorption of aggregate =(w3-w4)/w4 X 100	5.05

Table No.2. Percentage Variation of RCA

Sr.no	Sizes of RCA	Mix 1	Mix 2	Mix 3
1	40mm	30%	40%	50%
2	20mm	30%	25%	20%
3	10mm	25%	20%	15%
4	5.6mm	15%	15%	15%

Table No.3. The specific gravity of recycled coarse aggregate

Sr.no	DESCRIPTION	SAMPLE
1.	The empty weight of pycnometer (m_1)	610
2.	Weight of pycnometer +weight of aggregate (m_2)	1015
3.	Weight of pycnometer + weight of aggregate+ weight of water (m_3)	2000
4.	Weight of pycnometer + weight of water	1800
5.	Specific gravity of aggregate = m_2-m_1 /(m_2-m_1)-m_3-m_4	1.98

2.2.1 CONCRETE MIX DESIGN (NCA) BY IS METHOD (10262-2009)[7]

Grade – 15 MPA

Coarse Aggregates =2.65

Fine aggregates = 2.6

Specific gravity of cement= 3.15

Exposure condition = Moderate

Step 1 :- Target Mean Strength :

Fck =20.775 MPA

Step 2:- Selection of water cement ratio :

w/c ratio = 0.5

Step 3:- Selection of Water Content : 186 kg/m3

Step4:- Calculation of cement content :

Cement Content = 372 kg/m3

Step 5 :- Proportion of volume of coarse aggregates :

1. Volume of coarse aggregates = 0.62
2. Volume of fine aggregates = 0.38

Step 6 :- Mix calculations :

1. Volume of Concrete = 1 m3
2. Volume of Concrete = 1 m3
3. Volume of cement = 0.118 m3
4. Volume of water = 0.186 m3
5. Volume of all in aggregates = 0.696m3
6. Mass of coarse aggregates = 1143.58 kg
7. Mass of fine aggregates = 687.69 kg

Mix proportion : 1 : 1.8 : 3.074

2.2.2 CONCRETE MIX DESIGN (RCA) BY IS METHOD (IS 10262-2009)

Grade = 15 MPA

Coarse aggregate = recycled concrete aggregate

Fine aggregate =crushed sand

Specific gravity of recycled concrete aggregate =1.98

Specific gravity of fine aggregate = 2.6

Specific gravity of cement = 3.15

Exposure condition = moderate

Degree of supervision = good

Method of concrete placing = by hand mixing

Solution:

Step 1:- Target Mean Strength: (IS 10262-2009 Cl.4.2)

Fck = 1.65 + fck x S

= 1.65 + 15 X 3.5

= 54.15 N/mm2

Step 2:-Selection of w/c ratio (IS 10262-2009 C.l.4.2)

Adopt w/c ratio = 0.8

Step 3:-Calculation of cement content (IS 10262-2009 Cl.4.3)

water = 124.179 kg/m3

cement content =248.358 kg/m3

Step 4:- The proportion of volume of coarse aggregate

Volume of recycled coarse aggregate = 0.72

Volume of fine aggregate = 0.28

Step 5:- Mix Calculation

1. Volume of concrete = 1cu.m
2. Volume of cement = (mass of cement / specific gravity)*(1/1000)

= (248.358/3.15*1000)

= 0.0788m3

3. Volume of water = (124.179/1)*(1/1000)= 0.1241 m3
4. Volume of super plasticizer = 2% of mass of cement

= (2/100) *248.358

= 4.96 kg

5. Volume of all aggregate ={a-(b+c+d)}

= {1-(0.0788+0.124+0.00433)}

= 0.79287 m3

6. Mass of recycled coarse aggregate = 0.79287 *0.72*1.98*1000 = 1130.20kg
7. Mass of fine aggregate = 0.7928 x 0.28 x 2.6 x 1000 = 577.15kg

Mix proportion :- RCA = 1 : 2.3 : 4.55

Fig.No.6. Mix design

Table No.4 Material Requirement for Cube for Compressive Strength

Description	NCA	RCA		
		Mix 1	Mix 2	Mix 3
Grade of cement	53	53	53	53
Cement Content (kg)	3.16	2.175	2.175	2.175
Water Content (kg)	1.63	1.74	1.749	1.74
Super plasticizer (kg)	-	0.0435	0.0435	0.0435
W/C Ratio	0.5	0.8	0.8	0.8
CA & RCA (kg)	10.01	9.915	9.915	9.915
FA (kg)	6.03	5.06	5.06	5.06

Table No.5 Percentage Variation of RCA for cubes

Sr no	Sizes of RCA	RCA		
		Mix1	Mix2	Mix3
1	40mm	2.975(30 %)	3.965(40 %)	4.955(50 %)
2	20mm	2.975(30 %)	2.475(25 %)	1.98(20 %)
3	10mm	2.475(25 %)	1.98(20%)	1.485(15 %)
4	5.6mm	1.485(15 %)	1.485(15 %)	1.485(15 %)
Total		9.915	9.915	9.915

Table No.6 Material Requirement for Cylinder for Split Tensile Strength

Description	NCA	RCA		
		Mix 1	Mix 2	Mix 3
Grade of cement	53	53	53	53
Cement Content (kg)	2.54	1.74	1.74	1.74

Water Content (kg)	1.27	1.39	1.39	1.39
Super plasticizer	-	0.0348	0.0348	0.0348
W/C Ratio	0.5	0.8	0.8	0.8
CA & RCA	7.83	7.74	7.74	7.74
FA	4.71	3.95	3.95	3.95

Table No.7 Percentage variation of RCA for cylinder

Sr no	Sizes of RCA	RCA		
		Mix1	Mix2	Mix3
1	40mm	2.32(30%)	3.096(40%)	3.87(50%)
2	20mm	2.32(30%)	1.935(25%)	1.548(20%)
3	10mm	1.935(25%)	1.548(20%)	1.16(15%)
4	5.6mm	1.16(15%)	1.16(15%)	1.16(15%)
Total		7.74	7.74	7.74

Table No.8 Material Requirement for Beam for Flexural Test

Description	NCA	RCA		
		Mix 1	Mix 2	Mix 3
Grade of cement	53	53	53	53
Cement Content (kg)	7.615	5.08	5.08	5.08
Water Content (kg)	3.805	4.064	4.064	4.064
Super plasticizer	-	0.1016	0.1016	0.1016
W/C Ratio	0.5	0.8	0.8	0.8
CA & RCA	23.14	23.14	23.14	23.14
FA	14.05	11.81	11.81	11.81

Table No.9 Percentage Variation of RCA for beam

Sr no	Sizes of RCA	RCA		
		Mix1	Mix2	Mix3
1	40mm	6.94(30%)	9.256(40%)	11.57(50%)
2	20mm	6.94(30%)	5.78(25%)	4.628(20%)
3	10mm	5.78(25%)	4.628(20%)	3.471(15%)
4	5.6mm	3.471(15%)	3.471(15%)	3.471(15%)
Total		23.14	23.14	23.14

Table No.10 Density of materials

Density (kg/m3)			
Materials	Cube	Cylinder	Beam
NA	24.36	24.41	24.45
RCA	19.53	19.57	19.62

3. RESULT AND DISSCUSION

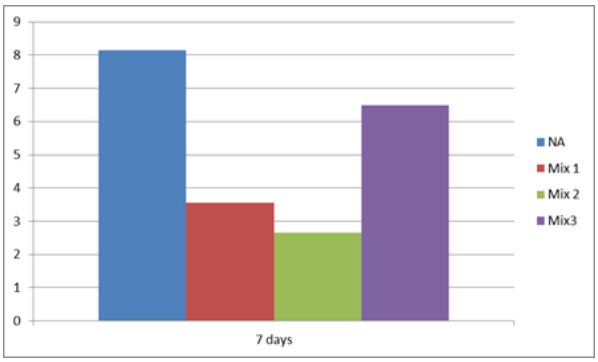
3.1 COMPRESSIVE TEST ON CUBE

Universal Testing Machine is used to perform the compressive Test. As per IS -516:1959 BIS[8], Standard size of cast iron molds are taken for preparing the concrete cubes. Finally, cubes are kept in a curing tank for Seven days.

Curing period (days)	Natural Aggregates (MPa)	Average (MPa)	Recycled Concrete Aggregate (MPa)			Average (MPa)
			Mix 1	Mix 2	Mix 3	
7 days	8.14	8.04	3.55	2.66	6.48	4.48
	7.95		4.66	3.77	5.77	

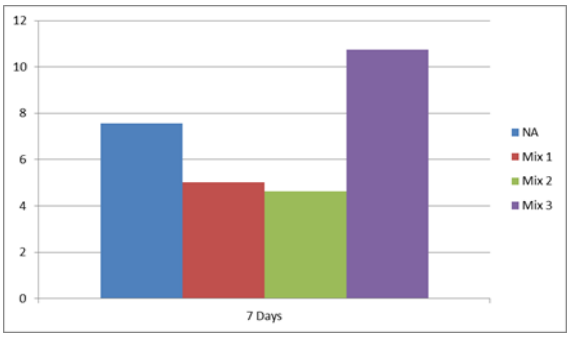
Table No.11 Result of Compressive test for cube

Fig no.7. Testing of a cube on UTM



Graph no 1. Comparison of compressive strength of cube

Fig no.8. Test on cylinder



Graph no 2. Comparison of the tensile strength of the cylinder

3.2 SPLIT TENSILR TEST ON CYLINDER

By IS-5816-1999,[9] Standard split Tensile test carried out on concrete specimens keeping horizontally in Universal Testing Machine after seven days of curing.

Table No.12 Result of the tensile strength of the cylinder

Curing period (days)	Natural Aggregates (MPa)	Average (MPa)	Recycled Concrete Aggregate (MPa)			Average (MPa)
			Mix 1	Mix 2	Mix 3	
7 days	7.56	7.58	5.03	4.62	10.75	6.85
	7.60		5.68	4.80	10.30	

3.3 FLEXURE TEST ON BEAM

As per IS-516:1959 BIS[8], the load was applied on the middle third span of a concrete beam in the Flexural Testing Machine. The curing period for concrete specimens was seven days.

Curing period (days)	Natural Aggregates (MPa)	Average (MPa)	Recycled Concrete Aggregate (MPa)			Average (MPa)
			Mix 1	Mix 2	Mix 3	
7 days	3.94	3.96	3.60	3.43	3.78	3.65
	3.98		3.81	3.25	3.82	

Table No.13 Result of flexural test for beam

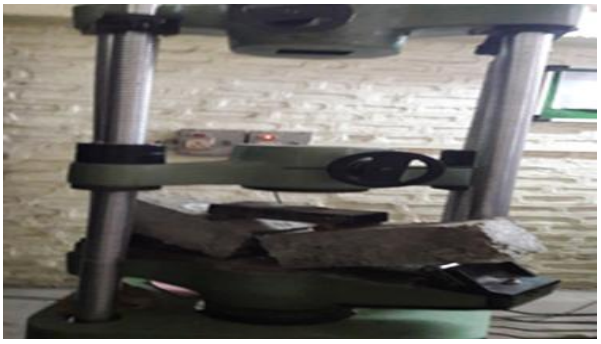
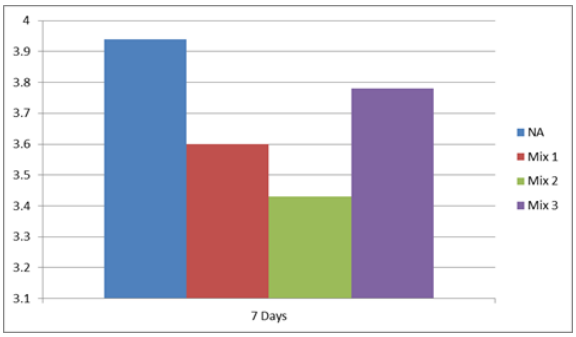


Fig no.9. Test on Beams



Graph No 3. Comparison of flexure strength of a beam

4. CONCLUSION

- It is observed that the Water absorption ratio is Higher in RCA concrete mix as compared to conventional concrete.
- The density of RCA concrete is Lower than Conventional concrete. Thus can be used as Lightweight concrete.
- In the above-performed tests, MIX 3 showing significantly higher values than MIX 1 and MIX 2 But lower than the conventional concrete.
- From the observation of split tensile test, 50% replacement of 40mm-size RCA in MIX 3, gives higher value than MIX 1 and MIX 2.
- RCA concrete can be used in the construction of Road dividers, Landscape seating.
- Recycling and reuse is an appropriate solution to the problem of dumping of debris accompanied by a shortage of Natural Aggregate.
- The use of recycled aggregate proves to be valuable, Ecofriendly building material in a technical environment and economical. There is a need for modifying codes, the specification for Recycled Concrete Aggregate.

REFERENCES

[1] Yasir Karim, Zuber khan, Mohammad S. Alsoufi, Mohammed Yunus- A review on recycled aggregate for the construction industry in American journal of civil engineering and architecture 2016 vol 4, no 32-38.

[2] Mr.Tushar Sonawane, Prof .Dr.Sunil S Pimplikar -Use of RCA in Journal of civil engineering (IOSR-JMCE) ISSN-2278,1684-2010

[3] Sakshi Gupta, Malik RK- The impact of C & D waste on Indian Environment: A critical Review-Juniper publisher-Vol 5-Issue 2- 2 May 2018
[4] Chetna Vyas, Darshana R Bhatt- A techno-economical study on Recycled aggregate concrete-IJAET Oct-Dec- 2012-Pg No 107-109
[5] Guidelines by CPCB 2017-18
[6] IS-8112-1989 Indian Standard of OPC 43 BIS, New Delhi
[7] IS-10262-2009 Indian Standard of Concrete Mix Design, BIS, New Delhi
[8] IS-516:1959 Indian Standard of Strength Test, BIS, New Delhi
[9] IS-5816-1999 Indian Standard Splitting Tensile Strength of concrete, BIS, New Delhi Circuits, Vol. 48, No. 2, pp 1 -15, February 2013