International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Volume 1 Issue 9 (October 2014) www.ijirae.com

STRUCTURAL APPLICABILITY OF RECYCLED CONCRETE WITH BOTH RECYCLED COARSE AND RECYCLED FINE AGGREGATE

Minna Roselin Cherian
PG student, Dept. of Civil Engg.
MA College of Engg, Kothamangalam
Ernakulam, Kerala, India

Praveen Mathew
Asst. Professor Dept. of Civil Engg.
MA College of Engg, Kothamangalam
Ernakulam, Kerala, India

Abstract - The subject of concrete recycling is regarded as very important in the general attempt for sustainable development in our times. In a parallel manner, it is directly connected with (a) increase of demolition structures (b) demand for new structures (c) reduce of landfill. This paper reports the results of an experimental study on some of the properties of recycled aggregate concrete (RAC) as compared to those of the conventional concrete. The comparison of results is done for the following.

1. ***Natural Aggregate concrete and Recycled Coarse aggregate concrete with cement content 380 kg***
2. ***Natural coarse plus Recycled fine aggregate concrete and Recycled coarse aggregate plus Recycled fine aggregate concrete for a cement content of 380 kg,***
3. ***Natural Aggregate concrete and Recycled Coarse aggregate concrete with cement content 370 kg. Recycled aggregate could be used extensively for various works as the test results indicated that the various test parameters are in acceptable range. The extensive use of recycled aggregate concrete thus presents a vital solution to the various problems faced by construction industry and also makes the environment greener.***

Keywords: Recycled coarse aggregate, Recycled fine aggregate, Compressive strength, Flexural strength, Split tensile strength, Elastic modulus, Ultrasonic Pulse velocity

I. INTRODUCTION

By the end of the 20th century, sustainable development and environmental protection became key goals of modern society. Important role in the sustainable development of the built environment, reduction of pollution, conservation of natural resources and energy savings certainly has the entire civil engineering, especially construction materials industry. In this context, main problems that industry of construction materials faces are:

- Natural aggregate depletion.
- High consumption of Portland cement and associated high emission of carbon dioxide.
- Large amount of generated construction and demolition (C&D)waste and land fill space depletion.

C&D waste, which occurs as a result of new construction and demolition of existing structures, is one of the biggest environmental problems in the European Union, as in many developed countries. For example, it is estimated that about 180 million tons per year or 480 kg/person/year of C&D waste is generated in the EU. The usual method of ‘‘management’’ of this waste in the recent past was to dispose it in landfills. In this way, huge landfills of C&D waste were made, occupying the land and presenting an environmental problem. Concrete is for decades the most used construction material in the world and the global production of concrete has reached a value of more than one ton of concrete per capita of planet. It is known that 1 m^3 of concrete contains almost 1 m^3 of aggregates. The trend of excessive aggregate consumption raises the question of the exhaustion of natural resources of aggregates and puts forward the need to find new options for obtaining aggregates. Recycling of waste concrete and producing recycled concrete aggregate (RCA), presents a sustainable solution to the problems of the depletion of natural aggregate deposits and land fill space.
Over last decade a significant volume of research in the area of recycled aggregate concrete (RAC) and its possible application in the construction industry was performed. Here, as recycled aggregate concrete is understood as a concrete in which a part or a total amount of natural aggregate (NA) is replaced by recycled aggregate concrete.

II. EXPERIMENTAL WORK

A. Need for study

The need for conducting detailed study on this topic includes:

1. Not enough studies are done in Recycled aggregate concrete using the concept of Residual mortar content.
2. To find the structural applicability of recycled concrete with both recycled coarse and fine aggregate.
3. To find an alternate way to reuse the Recycled coarse and fine aggregate thereby reducing construction and demolition waste.

International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Volume 1 Issue 9 (October 2014) www.ijirae.com

B. Objective and scope

The main objective is to study the structural applicability of recycled concrete with both recycled coarse and fine aggregate. Various tests and studies were conducted for various mix design in which both coarse and fine aggregates are replaced with Recycled aggregates. For one cement content two mix designs done, one for Natural fine aggregate and other for Recycled fine aggregate.

C. Material Properties

The materials used for study includes Natural coarse and fine aggregate, Recycled coarse and fine aggregate, Dalmia Superoof OPC 53 grade as cement, Master Glenium Sky 8233 as admixture and portable drinking water. Physical Properties of coarse aggregates and fine aggregates are given in Table 1 and Table 2 respectively. Physical properties of cement are given in Table 3. Residual Mortar content was obtained to be 35 %. Slump test results are given in Table 4. Compaction factor test results are given in Table 5.

TABLE I

Properties	Natural Coarse Aggregate	Recycled Coarse Aggregate
Fineness Modulus	7.024	7.814
Specific Gravity	2.69	2.34
Water Absorption	0.6	5

TABLE II

Properties	Natural Fine Aggregate	Recycled Fine Aggregate
Fineness Modulus	3.065	3.688
Specific Gravity	2.68	2.47
Water Absorption	13.89	23.45

TABLE III

Physical properties of cement	
Standard consistency	35%
Initial setting time (in mins)	128
Final setting time (in mins)	364
Specific gravity	3.15

TABLE IV

Mix	Slump Value
N1	165
R1	130
N2	160
R2	120
N3	150
R3	110

TABLE V

Mix	Compaction Factor
N1	0.93
R1	0.88
N2	0.96
R2	0.87
N3	0.95
R3	0.86

D. Mix design

Mix design is done in order to obtain concrete with ingredients in their suitable proportions to get concrete with sufficient strength and durability. Mix design is done as per IS 10262-2009 for N1, N2, N3 and correspondingly mix proportion for R1, R2 and R3 using residual mortar content was obtained. The results are given in Table VI, VII, VIII, IX, X and XI.

TABLE VI - MIX DESIGN FOR N1

Cement	Natural Fine Aggregate	Natural Coarse Aggregate	Water
380 kg	812.50 kg	1038.0 kg	190 lit

TABLE VII - MIX DESIGN FOR R1

Cement	Natural Fine Aggregate (NFA)	Recycled Coarse Aggregate (RCA)	Natural Coarse Aggregate (NCA)	Water
274 kg	585.6 kg	901.35 kg	485.34 kg	137 lit

TABLE VIII - MIX DESIGN FOR N2

Cement	Recycled Fine Aggregate	Natural Coarse Aggregate	Water
380 kg	783.5 kg	1001.0 kg	190 lit

TABLE IX - MIX DESIGN FOR R2

Cement	Fine Aggregate (RFA)	Recycled Coarse Aggregate (RCA)	Natural Coarse Aggregate (NCA)	Water
280 kg	578 kg	873.821 kg	470.519 kg	140 lit

TABLE X - MIX DESIGN FOR N3

Cement	Fine Aggregate	Coarse Aggregate	Water
370 kg	829 kg	1072.2 kg	174 lit

TABLE XI - MIX DESIGN FOR R3

Cement	Fine Aggregate (NFA)	Recycled Coarse Aggregate (RCA)	Natural Coarse Aggregate (NCA)	Water
266 kg	596.9 kg	918.63 kg	494.64 kg	125 lit

E. Experimental Results

The results were obtained for the various tests like compression test, flexural test, split tensile test, UPV and modulus of elasticity. Test results are given in Table XII.

TABLE XII

Mix	Compressive Strength in 28 Days (N/mm^2)	Average Flexural Strength in 28 Days (N/mm^2)	Average Split Tensile Strength in 28 Days (N/mm^2)
N1	21.67	3.24	3.19
R1	17.32	3.12	2.26
N2	18.24	3.28	2.41
R2	18.12	2.88	1.76
N3	24.6	2.08	3.03
R3	17.37	1.92	2.74

Modulus of elasticity

The modulus of elasticity was determined by subjecting cylinders to uniaxial compression and measuring the deformation by dial gauges which is fixed between gauge length. The stress-strain graph of the respective mixes are shown in Fig 6.1, Fig 6.2, Fig 6.3

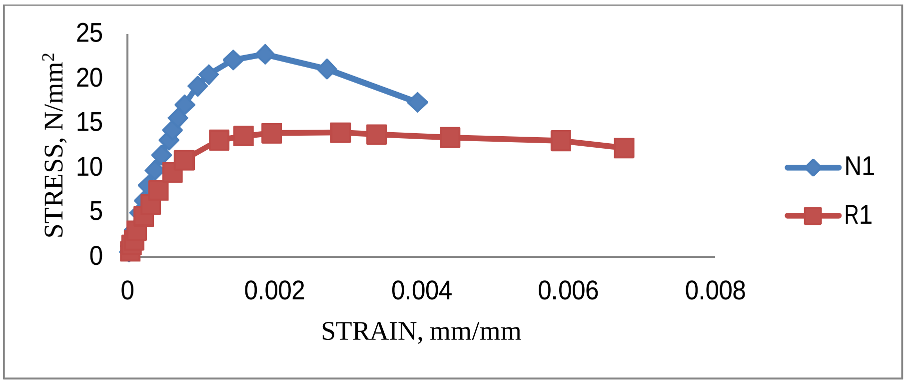

Fig1 Stress-Strain curve for N1 & R1

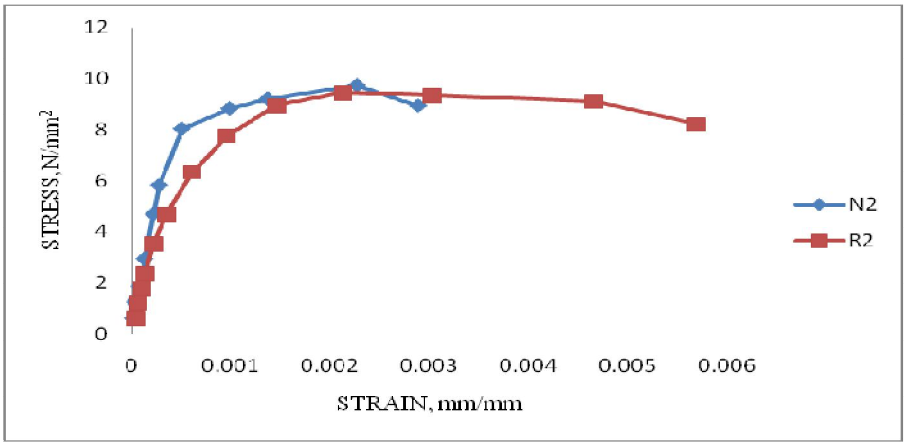

Fig 2 Stress-Strain curve for N2 & R2

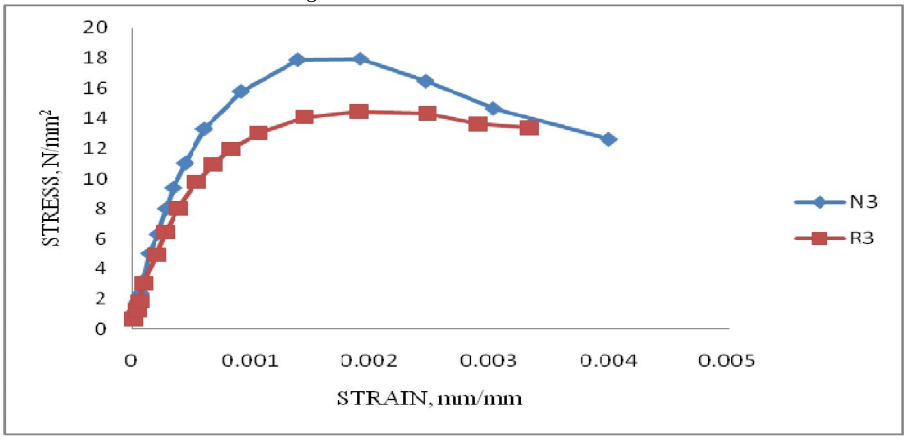

Fig 3 Stress-Strain curve for N3 & R3

Ultra sonic pulse velocity test

The technique has been successfully used for detecting the presence of voids, honeycombing or other discontinuities. Table 6.5 gives the pulse velocity rating for each specimen. The quality is determined based on a rating suggested by CBRI.

TABLE XIII - ULTRA SONIC PULSE VELOCITY RESULTS

Mix	Average Ultrasonic Pulse Velocity Results (km/s)	General Condition	Quality Classification
N1	6.410	Excellent	Very Good
R1	5.474	Excellent	Very Good
N2	5.906	Excellent	Very Good
R2	5.576	Excellent	Very Good
N3	6.024	Excellent	Very Good
R3	5.576	Excellent	Very Good

III CONCLUSION

The following conclusions are obtained from the study on Recycled aggregate concrete.

1. The compressive strength of R1 is about 80 % of concrete made with mix N1. For R2 it was obtained to be 99 % of that of N2 and for R3 it was obtained to be 70 % of that with N3.
2. Flexural strength of R1 was found to be 96 % of that with mix N1. Flexural strength of R2 was obtained to be 88% of that with mix N2 and for R3 it was obtained to be 92 % of that with N3.
3. Split tensile strength for N1 was found to be 71 % of that with mix N1. For R2 it was obtained to be 74 % of that with N2 and the split tensile strength of R3 was found to be 91 % of that of N3.
4. From UPV test it was found that the quality of concrete with RAC is as good as that with NAC.
5. Elastic Modulus of RAC is found to be lower than NAC.
6. Workability of recycled aggregate was found to be less when compared with NAC
7.

REFERENCES

1. Gonzalez Andreu , *Journal on Construction and building materials "Experimental analysis on properties of high performance recycled aggregate concrete"* volume 31, 2014.
2. Vlastimir Radonjanin , *Journal on Construction and building materials "Green recycled aggregate concrete"* volume 47, 2013.
3. Mohammed S. Imbabi, *Journal on Construction and building materials "Trends and developments in green cement and concrete technology"* volume 1, 2012.
4. P K Bal, *Journal on Procedia engineering "Properties of self compacting concrete using recycled coarse aggregates"* volume 51, 2012.
5. Wai Hoe Kwan, *Journal on Construction and building materials "Influence of the amount of recycled coarse aggregate in concrete design and durability properties"* volume 26, 2012.
6. Yong P.C, *UNIMAS Journal of Civil Engineering "Utilization of Recycled Aggregate as Coarse Aggregates in Concrete*" Volume 1, 2009.
7. V.W.Y Tam, Waste and Resource Management *"Ways to facilitate the use of Recycled aggregate concrete"* volume 10,2009
8. R. Kumutha, *APRN Journal of Engineering and Applied Science "Strength of Concrete incorporating Aggregates Recycled from Demolition waste"* Volume 5, 2010.
9. G. Murali, "*International journal of Engineering Research and Applications*" Experimental study on recycled aggregate concrete" volume 2, 2010.
10. Khaldoun Rahal, *Journal on Building and environment "Mechanical properties of concrete with recycled coarse aggregate"* volume 42, 2007.
11. H J Chen, *Journal on cement and concrete research "Use of building rubbles as recycled aggregates"* volume 33, 2003.
12. S.R Yadav, Paper on *"Use of Recycled Concrete Aggregates In making Concrete- An Overview*".
13. IS: 2386 (Part III) – 1963 Indian standard – " *Methods of test for aggregates for concrete - Part III Specific grtavity, density,voids, absorption and bulking*", Bureau of Indian standard, 1997, New Delhi
14. IS: 2386 (Part I) – 1963 Indian standard – " *Methods of test for aggregates for concrete - Part I Particle size and shape*", Bureau of Indian standard, 1997, New Delhi
15. IS: 2386 (Part IV) – 1963 Indian standard – " *Methods of test for aggregates for concrete - Part IV Mechanical Properties*", Bureau of Indian standard, 1997, New Delhi.
16. IS: 10262:2009 Indian standard – " *Concrete mix proportioning - guidelines*", Bureau of Indian standard, 1997, New Delhi.
17. IS: 383 – 1970 Indian standard – " *Specification for coarse and fine aggregates from natural source for concrete*", Bureau of Indian standard, New Delhi, India,1970.
18. IS: 456 – 2000 " *Plain and Reinforced concrete – Code of practice", aggregates from natural source for concrete*", Bureau of Indian standards, New Delhi, India,1970
19. M S Shetty " Concrete Technology Theory and Practice", S Chand & Company Ltd New Delhi 2003