

A Study Using Recycled Coarse Aggregates in High Strength Concrete

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ABSTRACT: Concrete plays a vital role in the development of infrastructure viz., buildings industrial structures, bridges highways etc. Leading to utilization of large quantity of concrete. On the other side, cost of concrete is attributed to the cost of its ingredients which is scarce and expensive. The increased quest for sustainable and eco-friendly materials in the construction industry has led to reach on partial replacement of conventional constituents of concrete by selected waste materials. The present technical report concentrates on investigation of high strength concrete with recycled coarse aggregate as partial replacement for conventional coarse aggregate. The tests conducted are Split Tensile Strength and Flexural Strength of concrete by replacing coarse aggregate at different percentages by 0%, 10%, 20%, 30% 40%, 50% by weight and the mixes are tested for a period of 7 and 28 days.

KEYWORDS: recycle, construction material, coarse aggregate, demolished structure, compressive strength, split tensile strength.

I.INTRODUCTION

High strength concrete is a premier construction material used throughout the world for the construction of high rise buildings dams as well as to achieve required strength maintaining the architectural beauty. Concrete is a manufactured product essentially consisting of cement, water, aggregates and admixtures. Among these aggregates i.e inert granular material such as sand crushed stone or gravel form the major part. Which were readily available in the market at an economical price but now a days the extraction and usage of these natural aggregates are questioned due to the rise in environmental concerns at the 1992 Earth Summit in Rio de Janeiro, Hence governments throughout the world have now introduced various measures aimed at reducing the use of natural aggregates and increasing reuse and recycling of aggregates, where it is technically, economically, or environmentally acceptable. For example, the UK government has introduced a number of policies to encourage wider use of secondary and recycled coarse aggregate (RCA- defined as minimum of 95% crushed concrete) as an alternative to naturally occurring primary aggregates. These include landfill and future extraction taxes to improve economic viability, support to relevant research and development work.

Need to use RCA: Waste arising from Construction and Demolition constitutes one of the largest waste streams within the EU, Asian and many other countries. It is estimated that core waste (described as those types of materials which are obtained from demolished building or civil engineering infrastructure) amounts to around 180 million tons per year or 480kg/person/yr in the EU. This ranges from over 700 kg/person/yr in Germany and the Netherlands to under 200 in Sweden, Greece and Ireland. The estimates for the UK are 30million tones/yr and just over 500 kg/person/yr respectively. At the same time, the results of a recent study undertaken by the CSIR Building and Construction Technology have revealed that nearly a million tone of construction and demolition waste ends up in landfills in South Africa. This is in addition to large quantities that are dumped illegally. Thus, construction demolition waste has become a global concern that requires sustainable solution.

Central Pollution Control Board has estimated current quantum of solid waste generation in India to 48 million Tons per annum of which waste from Construction Industry accounts for 25%. Construction waste is bulky, heavy and

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is mostly unsuitable for disposal by incineration or composting. The growing population in the country and requirement of land for other uses has reduced the availability of land for waste disposal. Re-utilization or recycling is an important strategy for management of such waste. Above all, the fast depleting reserves of conventional natural aggregate has necessitated the use of recycling/ re-use technology in order to be able to conserve the conventional natural aggregate for other important works. Apart from mounting problems of waste management, other reasons which support adoption of reuse/ recycling strategy are reduced extraction of raw materials, reduced transportation cost, reduced capital investment on raw materials, improved profits and reduced environmental impact.

As a direct result of this, recycling industries in many part of the world, including South Africa, at present converts low-value waste into secondary construction materials such as a variety of aggregate grades, road materials and aggregate fines. Often these materials are used in as road construction, backfill for retaining walls, low-grade concrete production, drainage and brickwork and block work for low-cost housing. While accepting the need to promote the use of RCA in wider applications, it must be remembered that the aggregate for concrete applications must meet the requirements set in relevant specifications for its particular use. The gap between these interests has to be reduced in steps that are manageable and the use of RCA in structural concrete has to be promoted gradually. Similarly considerable attention is required to the control of waste processing and subsequent sorting, crushing, separating and grading the aggregate for use of the concrete construction industry. In some developed countries C & D waste is now regularly recycled and reused, albeit mainly as fill, drainage and sub-base materials, and there is considerable scope for increasing this market and the use of these materials. In addition, there is an urgent need for legislative or regulatory measures to implement sustainable C & D waste management strategy and encourage recycling for use in value added applications.

II. MATERIAL PROPERTIES

2.1 Introductory Remark:

The main aim of this research project is to utilize recycled concrete as coarse aggregate for the production of high strength concrete. It is essential to know whether the replacement of RCA in high strength concrete is inappropriate or acceptable. Three types of aggregates are used in this project which includes natural coarse aggregate, natural fine aggregate and RCA. Natural coarse aggregate used is microtonalite with maximum size of 25 mm. Natural fine aggregate used is m-sand and RCA used from demolished concrete waste from which physical test such as specific gravity, absorption and sieve analysis are carried out. Then concrete cube and cylinders prepared for 0%, 10%, 20%, 30%, 40%, and 50% with 0.4w/c ratio, 50% with 0.34 w/c ratio and the same has been tested for 7 and 28 days for determination of compressive strength, tensile splitting test, modulus of elasticity test and durability test. The results at each testing age are reported as an average. The engineering properties of the RCA were also compared to those of the reference concrete specimens. The main problem encountered is maintaining the workability as well as the water

2.2 Collection of Materials

(Fine aggregate and Coarse aggregate): The natural fine aggregate used for producing concrete is m-sand. The natural coarse aggregate used is microtonalite. The maximum size of this gravel is 25 mm. The cement used is OPC 43 grade Ultra Tech. Recycled aggregate used in this research is crushed concrete, i.e. RCA obtained from a site near St. Augustines Church, Aroor, Alappuzha.



2.3.1 Physical properties of NA and RCA:

To compare the physical properties of RCA with natural aggregates various test has been done on and following table shows the comparison between natural coarse aggregate and RCA.

Table 1 Physical properties of Natural and Recycled coarse aggregate

Sr.No	Physical property	NA	RCA
1	Water Absorbtion(%)	1.60	6.5
2	Specific Gravity	2.78	2.73
3	Bulk Density(kg/m ³)	1470	1335.25

2.4 Treatment process for RCA :

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

2.4.1 Washing :

The aggregates collected by sieve analysis are washed by applying pressure washing of 500 psi. The pressure at which water is applied is 500 psi for about 15 to 20 mins. This is done to remove mortar adhered to the aggregates. Washing process cleans the aggregates to a considerable extent. The RCA were then kept for sun drying for about 30 mins.

2.4.2 Heating :

The RCA is 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.

2.5 Casting process for cube and cylinder:

2.5.1 Batching :

After cleaning the aggregates, batching process was started for 7 and 28 days cube, 28 days cylinder. The different percentage of mixtures used as 0%, 10%, 20%, 30%, 40%, and 50% with 0.4w/c ratio, 50% with 0.34 w/c ratio. replacement of RCA. For each proportion three specimen is made for compressive strength, tensile splitting strength, cement ratio.

III. MIX DESIGN

The mix design is done according to the IS design method and numerous trial mixes were conducted to obtain the optimum mix. Once the optimum mix is determined, it is used to produce concrete with as 0%, 10%, 20%, 30%,

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40%, and 50% with 0.4w/c ratio, 50% with 0.34 w/c ratio replacement of RCA. The concrete is prepared to find out the compressive strength and the tensile splitting strength. The constituents of this optimum mix proportion are shown in the Table below.

Table 2 Mix design for High strength concrete

Cement	Water	Sand	Aggregate
367	147	726	1230
1	0.4	1.97	3.35

3.1 Slump test:

The slump is taken for each mixing of concrete with 0%, 10%, 20%, 30%, 40%, and 50% with 0.4w/c ratio, 50% with 0.34 w/c ratio replacement of RCA. The results show that slump of concrete made with natural aggregates is higher while the concrete with 100% replacement of RCA has less slump. The low slump in RCA is caused by the high absorption of RCA which absorbs water during the mixing process.

Table 3 Results of slump test

Percentage of recycled aggregate	Slump(mm)
0	87
10	86
20	82
30	81
40	79
50% with 0.4 w/c ratio	77
50% with 0.34w/c ratio	64

VI. EXPERIMENTAL PROGRAM

4.1 Compressive strength test:

The compression test is carried out according to determine the characteristic strength of the concrete. In this test, 150 mm standard cube mould is used for concrete mix. The apparatus should be clean and free from hardened concrete and superfluous water before testing. The test is carried out for each cube. The reported compressive strength is the average of 3 measurements tested at the age of 7 and 28 days. Figure no 11 and 12 shows specimen of cube tested in compression testing machine

Result : Table below shows the results of the 7 days and 28-days compressive strength of concrete. From the results, the compressive strength seems to increase slightly with the addition of RCA. This could be due to the higher absorption capacity of the recycled aggregate. When the water is absorbed by aggregate, more space left by the water being absorbed can be occupied by aggregates in a unit volume. Hence the density of recycled concrete is lower.

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Sl.no	% of RCA replaced	Average compressive strength in MPa (7-days)	Average compressive strength in MPa (28 days)
1	0	29	42.1
2	10	27	38.2
3	20	24.5	35.3
4	30	22.6	32.5
5	40	21.5	30
6	50% with 0.4 w/c ratio	19	26.6
7	50% with 0.34 w/c ratio	26	37



4.2 Tensile splitting test:

Split cylinder test is carried out on each concrete sample to find split tensile strength of concrete cylinder.

Result: The results of the split tensile strength for the tested concrete samples are shown in the table below. The figure and the table show the results of the tensile strength tests for the concrete mixtures at 28 days only, which is an average of three specimens.

Sl.No	%of replacement RCA	Average Split Tensile (7 days)	Average Split Tensile (28 days)
1	0	2.3	3.05
2	10	2.2	2.9
3	20	2.05	2.78
4	30	1.92	2.65
5	40	1.85	2.5
6	50% with 0.4 w/c ratio	1.62	2.32
7	50% with 0.34 w/c ratio	2.15	2.85



4.3 Modulus of Elasticity result and analysis:

The modulus of elasticity test indicates a decreasing tend of modulus of elasticity value, when the percentage of the recycled aggregate increased

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Sl. No	% of RCA replaced	Modulus of Elasticity (MPa)
1	0	31000
2	10	29326
3	20	27783
4	30	26122
5	40	24361
6	50	23740

4.5 Acid Resistance Test Analysis and Result:

The results are tabulated in the table from the result it was observed that the percentage loss in weight of concrete cubes after 45 days immersion in 3% sulphuric acid increases as the percentage of RCA replacement increases.



V. RESULTS AND DISCUSSIONS

5.1 SUMMARY

The experimental results show the recycled aggregate will influence the fresh and hardened concrete. As the percentage of the recycled aggregate is increased, the workability and strength of the concrete will be decreased. But it was observed that the concrete could reach the target strength by reducing the water cement ratio by using appropriate superplasticizer

VI. CONCLUSION

1. when the percentage of RCA is increased the compressive as well as split tensile strength got reduced. However when water- cement ratio of mix was decreased, the compressive strength increases.
2. the target strength (40 MPa) can be achieved for 30 to 40% of RCA replacement by decreasing the water cement ratio and adjusting the admixture concrete mix.
3. another result found in the research is that when reducing the water cement ratio used in recycled aggregate mixes, tensile strength and modulus of elasticity are also improved.
4. the percentage loss in weight of concrete cubes after the conduct of acid resistance test is negligible for 30 to 40% RCA replacements.

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