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Effect of Modification of Recycled Concrete Aggregates on Concrete Properties

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***Abstract*— Rapid increase in construction and demolition (C&D) waste generation and consumption of natural aggregate for concrete production became one of the biggest environmental problems for the construction industry. New fields of recycled concrete aggregate (RCA) application and new ways of its utilization in concrete manufacturing should be looked for. Recycled aggregates have different and non-uniform properties and therefore cannot be used safely for all kinds of applications. However, they can be safely used in a variety of applications, when necessary restrictions are in place. In the present paper, laboratory trials were conducted to investigate the possibility of 100 % recycled concrete aggregates as a replacement of coarse aggregates in pavement quality concrete (PQC) design mix (M40). Initially characterisation of recycled concrete aggregate is done to meet the requirements of its use as an aggregate in PQC. The experiment aims to test the specific way of producing concrete with RCA. To reduce its negative impact on the concrete properties, treatment of the RCA with cement slurry were applied. Cement slurry of 2, 4, 6, 8 and 10 percentages is prepared to coat the aggregates. As control samples, a mixture is prepared by natural aggregate only and another mixture with RCA by standard mixing without coating process were also tested. Fresh concrete properties of the mixes are analysed. Compressive and flexural strength of all the mixes are determined. Improvement of compressive and flexural strength is significant in cement slurry coated aggregate Mix.**

Keywords – Recycled concrete aggregate; construction and Demolition waste; pavement

I. INTRODUCTION

Conservation of any sort of resource has always been the need of the hour as over exploitation has not stopped since the starting of civilization and eventually resulted in the scarcity of resources. We also have known the fact that we need to conserve the resources and should be used efficiently and wisely. Same as other resources, construction materials are increasingly judged by their ecological characteristics and that's why concrete recycling gains importance because it protects natural resources and eliminates the need for disposal by using the readily available concrete as an aggregate source for new concrete or other applications. A huge amount of debris is generated by construction industries that should be recycled and reused as recycled aggregates (RCA) for partial or total substitution of natural aggregates. Recycling reduces waste and reduces energy consumption and hence contributes to a more sustainable construction industry.

Recycling of concrete is a simple process that involves breaking, removing, and crushing of existing concrete into a material with a specified size and quality. The quality of concrete with RCA is very dependent on the quality of the recycled material used. Reinforcing steel and other embedded items, if any, is removed, and care is taken to prevent contamination by other materials that can be troublesome, such as asphalt, soil and clay balls, chlorides, glass, gypsum board, sealants, paper, plaster, wood, and roofing materials. The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled concrete aggregates contain not only the original aggregates, but also hydrated cement paste. This paste reduces the specific gravity and increases the porosity compared to similar virgin aggregates. Higher porosity of RCA leads to a higher absorption. But this situation is taken care of by making the use of superplasticizers.

Recycling concrete provides sustainability several different ways. The simple act of recycling the concrete reduces the amount of material that must be land filled. The

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concrete itself becomes aggregate and any embedded metals can be removed and recycled as well. As space for landfills becomes premium, this not only helps reduce the need for landfills, but also reduces the economic impact of the project. Moreover, using recycled concrete aggregates reduces the need for virgin aggregates. This in turn reduces the environmental impact of the aggregate extraction process. By removing both the waste disposal and new material production needs, transportation requirements for the project are significantly reduced.

A. Indian Status

There is severe shortage of infrastructural facilities like houses, hospitals, roads etc. in India and large quantities of construction materials for creating these facilities are needed. The planning Commission allocated approximately 50% of capital outlay for infrastructure development in successive 10th & 11th five year plans. Rapid infrastructural development such highways, airports etc. and growing demand for housing has led to scarcity & rise in cost of construction materials.

Nonetheless India is constructing its foundation at a very fast rate. In this process of construction and reconstruction it has become the second largest producer of cement in the world only after China. Though it is not even in top ten when it comes to production of recycled aggregate concrete. One of the main reasons for it is the lack of proper source concrete in India. But if willed, the demand can be fulfilled with the help of Gulf Cooperation Council (GCC) countries like UAE, Saudi Arabia, etc. Now as the govt. is gearing up for development of new cities, buildings, roads etc., the gates are wide open for production of more RAC.

II. LITERATURE REVIEW

A brief review of the literature on different techniques adopted to improve the properties of RCA is presented here. Shrinath.H et al studied different techniques such as Acid soaking method, heating & scrubbing, coating with cement slurry and Coating with cement slurry & fly ash for M20 grade of concrete and concluded that acid soaking method is effective in improving mechanical properties. Yu-chang et al adopted cement slurry coating to improve the surface properties of concrete made using 100 % recycled coarse aggregates. The experimental results showed that proper surface pretreatments and mixing approaches can improve the quality of RAC significantly .V. Spaeth et al studied the use of polymer based treatments on RCA to lower the water absorption and to improve fragmentation resistance. W.Y. Tam et al(2005) proposed a new approach in mixing concrete, two-stage mixing approach (TSMA), to improve the compressive strength for RCA and hence lower its strength variability. Based upon experimental works, improvements in strength to recycled aggregate concrete were achieved.

III. EXPERIMENTAL DETAILS

Materials used in the present investigation include cement, fine aggregates, coarse aggregates and recycled coarse aggregates. OPC of 53 Grade confirming to IS – 383: 2016 was used. Manufactured sand having bulk density 1754 kg/m3 is used for the present study. Normal coarse aggregates (NCA) and RCA are procured from a recycled Plant in Bangalore. In this study MasterGlenium SKY 8233 is used as the super plasticizer which is based on polycarboxilicether The physical and mechanical properties are conducted to compare natural and recycled coarse aggregates, and test results are presented in Table 1. It is observed that, water absorption is little high compared to NCA due to the presence of mortar on the aggregate surface. Other mechanical properties of aggregates are within limits.

TABLE I
CHARACTERIZATION OF NATURAL AND RECYCLED COARSE AGGREGATES

PROPERTIES	NCA	RCA
IS2386:1963- Part III Specific gravity	2.6	2.45
IS2386:1963-Part III Water absorption	0.28%	1.36%
IS2386:1963-Part IV Crushing test value	21.3%	21.66%
IS2386:1963-Part IV Impact value	21.2%	31.04%
IS2386:1963-Part IV Abrasion resistance	26 %	28.3%
IS2386:1963-Part I Angularity number	9	10
IS2386:1963-Part I Flakiness Index	14%	11.18%
IS2386:1963-Part I Combined Index	34%	24%

IV. MIX DESIGN AND PRE COATING TECHNIQUE

Mix design of concrete is done in accordance with Indian Standard Code (IS: 10262- 2009) and Guidelines for Cement Concrete Mix Design for Pavements (IRC 44:2008). The grade of the concrete selected for the present study is M40 to use it as Pavement quality concrete. Pre coating of aggregates helps to have better bonding between aggregates in concrete mix by improving surface properties of recycled concrete aggregates. In this approach initially cement slurry prepared to coat the aggregates prior to mixing. Proper mixing is done with slurry so as to get proper coating on every particle of aggregate then excess slurry is drained out. The coated aggregates are then dries in air for 3 days to use it as fresh aggregates for preparing concrete. Pre coated aggregates are shown in Fig1.

V. FRESH CONCRETE PROPERTIES

Fresh concrete properties are tested to achieve required workability by slump, compaction factor and vee bee consistometer tests by varying water-cement ratio. Based on the trial and error the various proportions for design mixes were prepared. Slump values are within the limits. The results are given in Table II.

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Table II: Fresh concrete properties

Sl No	Particulars	W/C Ratio	Slump (mm)	Compaction factor	Vee bee consistometer (seconds)
1	100% RCA + 0% CS	0.45	45	0.862	13
2	100% RCA + 2% CS.	0.45	45	0.872	13
3	100% RCA + 4% CS.	0.45	44	0.876	11
4	100% RCA + 6% CS.	0.43	40	0.875	11
5	100% RCA + 8% CS.	0.43	42	0.867	12
6	100% RCA + 10% CS.	0.43	40	0.858	12

VI. HARDENED CONCRETE PROPERTIES

Concrete cubes of 150mm size are used to determine compressive strength of prepared concrete. 100*100*500 mm size beams are used to determine the Flexural strength of concrete. All the specimens are prepared by completely replacing the natural aggregates by pre coated recycled aggregates. 28 days of compressive and flexural strength details are given in Table III and Table IV.

Table III: Compressive strength of concrete after 28 days

Sl. No.	Description	Compressive Strength N/mm2
1	100% RCA + 0% CS	36.52
2	100% RCA + 2% CS.	37.72
3	100% RCA + 4% CS.	37.83
4	100% RCA + 6% CS.	38.62
5	100% RCA + 8% CS.	39.71
6	100% RCA + 10% CS.	40.13

Table IV: Flexural strength of concrete after 28 days

Sl No	Description	Flexural Strength N/mm2
1	100% RCA + 0% CS	4.26
2	100% RCA + 2% CS.	4.47
3	100% RCA + 4% CS.	4.59
4	100% RCA + 6% CS.	4.94
5	100% RCA + 8% CS.	5.08
6	100% RCA + 10% CS.	5.81

VII. RESULTS AND DISCUSSION

1. Except the value of water absorption which is slightly higher for RCA compared to NCA, other properties are within the limits as per IS code recommendations. Presence of Adhered mortar could be the reason. This can be improved by cleaning the aggregates /complete removal of mortar or surface treatments.

2. In the case of concrete made of coated aggregates there is an increasing trend of compressive strength compared to the concrete without coating. Complete replacement of RCA reduces the compressive strength. After treating RCA with 10% cement slurry, concrete could achieve the required strength.

3. Similar trend is observed in the case of Flexural strength. A flexural strength of 4.5 MPa is the minimum requirement as per IRC 44 for normal concrete of M40 mix. By the addition of 4% cement slurry itself, concrete could achieve the requirements.

VIII. CONCLUSION

1. It is concluded that pre coating using 10 % cement slurry is effective in improving strength characteristics of M40 concrete for 100 % replacement of natural aggregates with recycled concrete aggregates

2. New techniques for removal of surface mortar to reduce water absorption and pre wetting of RCA to saturate aggregates could be a solution for preventing more water absorption

2. Demolition waste should be regarded as an additional substitutable source of construction material available for replacement to that of conventional aggregate

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