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Laboratory investigation on Pre-Coating technique on Recycled Concrete Aggregate

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Abstract - With rapid increase in construction, the demand for coarse has escalated lately. On the other hand construction and demolition waste (C&D waste) has become a major problem which is consuming numerous acres of land to dump this waste. Considering these two major issues experimental studies on Recycled concrete aggregate (RCA) is carried out. In present study Natural coarse aggregate (NCA) is replaced by RCA with 60,80 and 100 percentages. Basic tests have been conducted to characterise RCA for use in concrete applications. Different treatment techniques have been experimented by various researchers to modify the properties of RCA. In present study pre-coating of RCA using cement slurry with various percentages(0,2,4,6,8,10) have been used to improve the strength characteristics of Concrete made using RCA. It is concluded that precoating technique using cement slurry on RCA is effective in improving the mechanical properties of concrete.

***Key Words*: Construction and demolition waste, Recycled concrete aggregate, Natural coarse aggregate, Cement Slurry, Landfills**

1. INTRODUCTION

Construction materials are very significant in our lives because we spend 90% of our time in buildings or infrastructures(roads, highways, bridges, etc.). We are aware that concrete is the second most used material in the world after water. Materials used for concrete has become a great concern. As we are running out of materials we need to seek for other alternative materials or reuse the materials and also on other hand huge sets of land has been used just for disposal of waste materials. Aggregate is one of the most vitally important materials in use for concrete production as it profoundly influences concrete properties and performance. Regarding aggregate usage in concrete, a conservative estimate is that at least 4.5 billion tons of concrete aggregates per year are consumed worldwide. This figure is assumed to represent total aggregate production, including usage in concrete and road base. Aggregate usage in concrete constitutes perhaps between 25 and 35 per cent of the total aggregate production. The sheer bulk of global aggregate usage is staggering.

The above inevitably impacts on the environment due to the great huge quantity of general and construction waste materials or from building demolition sites generated in developed countries. The research conducted for the Industry Commission Report indicated that about 3 million tons of waste aggregate has been created in Australia alone. Construction and demolition (C&D) wastes account for a large portion of solid wastes and the generation of which has been increasing rapidly in China. Recycling/reusing C&D wastes is an important issue to foster sustainable development and has become a focus of research efforts in recent years.

2. OBJECTIVES

1. To study Physical and Mechanical characteristics of RCA & NCA.
2. To improve the strength characteristics of recycled concrete by pre-coating treatment with cement slurry of RCA.
3. To investigate strength and durability characteristics of recycled concrete

3. Literature Review

Namho Kim, Jeonghyun Kim, Sungchul Yang

This study used two types of Recycled Concrete Aggregates (RCAs) with the sameorigin virgin aggregate, but with different amounts of residual mortars. To verify that the mechanical properties of the concrete were affected by changing the unit volume of residual mortar, fresh mortar, and total mortar of the concrete, a series of paving concrete mixes were made using a modified equivalent mortar volume (EMV) mix design, along with a conventional American Concrete Institute (ACI) mix design. The test results showed that the RCA concrete with the conventional mix design, which led to a prominent decrease in compressive strength and elastic

modulus at each age, had 10% greater total mortar volume than that with the modified EMV mix design. As for the conventional ACI mix, it appears that the replacement ratio of RCA and the volume of the residual mortar in RCA directly affect the modulus of elasticity as well as the compressive strength of concrete. However, for the modified EMV mix, the modulus of elasticity of the concrete may be increased to be equivalent to the companion concrete with natural aggregate by controlling the new mortar volume so that the total mortar volume remains the same regardless of the RCA replacement ratio. It was observed that the smaller new volume requirement makes the RCA paving concrete more environmentally friendly and economically profitable.

Adel A.Al-Azzawi

This research presents an experimental investigation on the engineering properties of concrete prepared with crushed tiles as recycled coarse aggregates. Concrete mixes with a design compressive strength of 30MPa are made using recycled aggregates with percentages ranging from 0 to 100% of the total coarse aggregate. Their influence on concrete mechanical properties is investigated. As a result, it has been obtained that using recycled aggregate to replace part of the normal coarse aggregate effects the elastic modulus, tensile strength and compressive strength with a value depends on the coarse aggregate replacement percentage. For low percentages of recycled aggregate (25%) it can be obvious that this influence is practically negligible. It may be concluded that the use of recycled aggregates in concrete may help to solve a very important environmental issue and gives a solution to the problem of inadequate concrete aggregates. The comparison of test results with ACI 318 code spilt cylinder and modulus of elasticity equations show that these equations are not recommended to be used for recycled aggregate concrete with percentage exceeding 25%.

Togay Ozbakkaloglu, Aliakbar Gholampour and Tianyu Xie

The use of recycled concrete aggregates as an alternative aggregate material in concrete has been studied over the past two decades. It is now recognized that the recycled aggregate concrete (RAC), where natural aggregates are replaced with recycled concrete aggregates, is a promising technology for conserving natural resources and reducing the environmental impact of concrete. This paper presents a study on mechanical and durability properties of concretes manufactured with recycled aggregates of different sizes and contents. A total of 14 batches of RACs were manufactured. Tests were undertaken to establish the compressive strength, elastic modulus, flexural strength, splitting tensile strength, workability, drying shrinkage, and water absorption of each batch. Test parameters comprised the recycled aggregate replacement ratio, size of coarse aggregates, and mixing method used in the preparation of concrete. The results indicate that the compressive strength is not the only decisive factor on mechanical and durability- related properties of RACs. It is shown that the properties of different RACs mixes of the same compressive strength are affected by the size and content of the CA.

Khaldoun Rahal

This paper reports the results of an experimental study on some of the mechanical properties of recycled aggregate concrete (RAC) as compared to those of the conventional normal aggregate concrete (NAC). Ten mixes of concrete with target compressive cube strength ranging from 20 to 50 MPa were cast using normal or recycled coarse aggregates. The development of the cube compressive strength and the indirect shear strength at ages of 1, 3, 7, 14, 28 and 56 days, the compressive strength, the strains at maximum compressive stress and the modulus of elasticity tested by using concrete cylinders at 28 days are reported. The results show that the 28-day cube and cylinder compressive strength, and the indirect shear strength of recycled aggregate concrete were on the average 90% of those of natural aggregate concrete with the same mix proportions. For concrete with cylinder compressive strengths between 25 and 30 MPa, the modulus of elasticity of RAC was only 3% lower than that of NAC. The trends in the development of compressive and shear strength and the strain at peak stress in recycled aggregate concrete were similar to those in natural aggregate concrete.

4. MATERIALS & METHODOLOGY

4.1 MATERIALS

1. The cement used is of grade OPC 53, devoid of any lumps.
2. Manufactured sand is used as fine aggregate. The specific gravity and fineness modulus were found to be limited and confirmed to ZONE II. The properties are tested as per IS 2386: (1963).
3. NCA used in the present study was a mixture of two locally available crushed stones of 20mm and 10mm sizes. The aggregates were washed to remove dirt, dust and then dried to surface dry condition.
4. Recycled aggregate of 20mm maximum size conforming to IS 383: (1979) are used. The demolition material was first crushed with a jack hammer and then crushed into 20mm size with the help of a Jaw Crusher.

Various Lab Tests were conducted on aggregates. The results are shown in the Table below.

1.) CEMENT

Properties	Obtained Value	IS Code 2386:1963
Specific Gravity	2.625	2.6-2.85
Fineness Modulus	2.76	2.0-4.0
Water Absorption	8%	<3%

2.) FINE AGGREGATES

Properties	Obtained Values	IS CODE 8112:(1989)
Specific Gravity	3.15	3.1-3.25
Setting Time(min), Initial Set	35 min	Less than 30
Standard Consistency	36%	26%-35%

3.) NCA & RCA

Properties	NCA	RCA	Value	Reference
Specific Gravity	2.52	2.6	2-3	IS 2386:1963 (partIII)
Water Absorption	0.25%	1.16%	Less than 2%	IS 2386:1963 (partIII)
Crushing Test	29.97 %	28.86 %	20-45%	IS 2386:1963 (partIV)
Impact Value	29.62 %	27.95 %	15-30%	IS 2386:1963 (partIV)
Angularity Number	9	5	0-11	IS 2386:1963 (partI)
Flakiness Elongation Index	8.23, 38.94	15%, 20.48 %	30%	IS 2386:1963 (partIV)

4.2 METHODOLOGY

The materials from the demolished building are collected and then the production of required size of aggregates (20mm passing, 12.5mm retained) from demolished concrete has been done by crushing. Once the various physical and mechanical tests on the recycled concrete coarse aggregate, normal coarse aggregate, fine aggregate and cement are conducted ,the obtained test results of physical and mechanical properties of recycled coarse aggregates

are compared with natural aggregates. Recycled coarse aggregate is pre-coated with cement slurry for 100% replacement with various percentages (2,4,6,8 & 10) . Next the control mix according to IS 10262:2009 has been done for M40 grade concrete. The cubes and beams of sizes 150mmX150mmX150mm and 500mmX100mmX100mm respectively are casted using normal aggregates. Once they are casted then the casting of cubes and beams with normal aggregates as well as RCA by taking 60 ,80 and 100%(pre-coated) replacements are done. The prepared cubes are allowed for curing for 28 days in the curing tank. The compressive strength tests on cubes and flexure strength test on beams are conducted after 28 days of curing.

5. MIX DESIGN

Mix	Cement (Kg/m3)	FA (Kg/m3)	NCA (Kg/ m3)	RCA(Kg/ m3)	W/C Ratio
60%	343	673	472	663	0.45
80%	343	673	236	886	0.42
100%	411.42	689.27	0	1079.61	0.42

0.4% of admixture had been added in all the mixes. After calculation of mix design, proportions of 60%,80% and 100% replacements are 1:1.96:3.26, 1:1.96:3.26 and 1:2.07:3.28 respectively.

6. EXPERIMENT RESULTS

Compressive Strength Test Results of Pre-Coated RCA of 28 Days Strength

Sl No	Proportion	Compressive Strength(MPa)
1	RCA(Coated)	28 Days
2	100(0%)	20.10
3	100(2%)	27.72
4	100(4%)	29.83
5	100(6%)	33.62
6	100(8%)	35.71
7	100(10%)	37.13

Compressive Strength Test Results of Non-Coated RCA of 28 Days Strength

Sl No	Proportion	Compressive Strength(MPa)
1	80%	22.10
2	60%	24.00

Flexural Strength Test Results of Pre-Coated RCA of 28 Days Strength

Sl No	Proportion	Flexural Strength (N/mm2)
1	RCA(Coated)	28 Days
2	100(0%)	2.60
3	100(2%)	8.03
4	100(4%)	10.55
5	100(6%)	11.37
6	100(8%)	12.03
7	100(10%)	12.85

Flexural Strength Test Results of Non-Coated RCA of 28 Days Strength

Sl No	Proportion	Flexural Strength(MPa)
1	80%	3.00
2	60%	3.40

7. CONCLUSIONS

1. In this study, various properties of recycled aggregates have been found and they are compared with the natural aggregates.
2. From the test results of physical and mechanical properties, it has been determined that the impact value of recycled aggregates is higher than the corresponding values of natural aggregates.

3. The combined flakiness & elongation index values and the value of angularity number of recycled aggregates is more than that of natural aggregates. However, the specific gravity value of RCA is lower than that of natural aggregates.
4. 4. It has been analyzed that 100% replacement of fresh coarse aggregates with recycled coarse aggregates proves to be economical with sufficient strength, however 60% or 80% replacement can be used if the strength requirement is more. If the budget allows, the pre-coating technique is a proven efficient technique which can be used to further increase the strength.

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