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PARTIAL REPLACEMENT OF COARSE AGGREGATE BY DEMOLITION WASTE

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***ABSTRACT-** Day by day we are consuming our natural resources continuously for used in concrete production. Our country producing large amount of construction waste and this waste required large land for disposal and the waste also create environment pollution. Many researches were introduced for recycled this waste in replacement of cement, sand and aggregate in concrete production without sacrificing the strength. This paper is based on the reuse of demolition waste in concrete as partial replacement of coarse aggregate. The use of waste in concrete is useful for both environmental aspects and economical aspects.*

The waste collected near the vit campus and separated by mechanical procedures and used as a partial replacement of coarse aggregate and for increasing the binding property used silica fume. The taste were carried out for measuring and comparing the different properties of recycled aggregate and pure aggregate for replacement of 5%, 15% and 25%. Silica fume is taken as 10% of total weight of cement. These tastes were carried for 7 days and 28 days.

***Keywords-** NFA, NCA, RCA, Superplasticizer, Demolished Waste*

I. INTRODUCTION

Concrete is a composite material. It consists of aggregates (coarse aggregates and fine aggregates), binding materials (cement) and admixtures. The main constituent is coarse aggregate. It occupy approx 60-70% of total volume of concrete. In our country 125 crore population and this population requires basic infrastructure and structures for their development so we use the natural resources continuously. The old structures are unfit for use in modern technology so they are demolished and waste produced from them are deposed on land that require huge area of land. The large amount of constituents and demolition waste produced from construction site. Some quantity of this waste is reused in concrete.

Many old buildings, bridges, road pavements are unfit for use to due to their over life span and durability. So, these wastes are also reused.

The construction demolition waste collected from different places and crushed into a mechanical procedure. The suitable size of aggregate such as 20mm, 10mm are found from these crushers. The recycled aggregate surrounded by mortar layer. So, "this will increase the waste requirement". The porosity of aggregates increases which increase the water requirement of the concrete.

The workability of recycled aggregate concrete at same w/c ratio is less as natural aggregate concrete. The adhesive action of recycled aggregate and cement is less as compare to the natural aggregate and cement. So, we use "silica fumes" for increasing properties of the material.

II. EXPERIMENTAL MATERIALS

CEMENT

Pozallana portland cement(PPC) of 43 grade is used in the mix design. The properties of cement conforming IS code 8112.

SAND (FINE AGGREGATE)

The natural river sand used in the mix designed as a fine aggregate. The sand allowed to pass through 4.75 mm IS sieve is taken. The specific gravity and water absorption of sand is 2.450 and .62 %.

COARSE AGGREGATE

It is the main constituent of the concrete and the strength of concrete is mostly depends upon the strength of the coarse aggregate. Coarse aggregate which having particle size 10-20 mm is considered for the design. The specific gravity and absorption of the coarse aggregate is 2.552 and 1.90%.

DEMOLISHED WASTE

The demolished waste is used as the material replacement of coarse aggregates. Since the strength of concrete is mainly dependent upon the strength of coarse aggregates. So the different properties of the demolished aggregate take precisely.

The demolished waste was collected near VIT campus, Jaipur. The specific gravity and water absorption ratio of demolished waste is 2.230 and 6.50%.

The average size of particles of demolished waste is not more than 20 mm.

MINERAL ADMIXTURES

Silica fumes is used as a mineral admixtures as a micro filler. Silica fume is taken as 10% of total wt. of cement.

WATER

The portable and fresh water is used in the concrete mix design. The water is free from organic materials.

III. METHODOLOGY

There are three types of aggregates used here i.e. fine aggregates (sand), Coarse aggregates and Recycled aggregates (demolition waste). The demolition waste is collected from different places and crushed by mobile crusher into suitable grade i.e. Average size of particles is 20 mm.

The test was performed on the coarse aggregate and recycled aggregate for comparing the properties of aggregates.

The test performed are:-

i) Specific gravity.

ii) Water absorption.

iii) Aggregate impact value.

iv) Aggregate abrasion value.

Cement Used	OPC 43 grade	
1	Sp. Gravity of Cement	3.15
2	Sp. Gravity of Water	1
3	mecha Admixture	Not Used
4	Sp. Gravity of 20 mm Aggregate	2.552
5	Sp. Gravity of Sand	2.45
6	Water Absorption of 20 mm Aggregate	1.90%
7	Water Absorption of Sand	0.62%
A-1	**Target Strength for Mix Proportioning**	
1	Target Mean Strength (MORT&H 1700-5)	30N/mm^2
2	Characteristic Strength @ 28 days	20N/mm^2
A-2	**Selection of Water Cement Ratio**	
1	Maximum Water Cement Ratio (MORT&H 1700-3 A)	0.5
2	Adopted Water Cement Ratio	0.5
A-3	**Selection of Water Content**	
1	Maximum Water content (10262-table-2)	186 Lit.
2	Estimated Water content for 25 mm Slump	145 Lit.
3	Superplasticizer used	nil
A-4	**Calculation of Cement Content**	
1	Water Cement Ratio	0.5
2	Cement Content (145/0.5)	290 kg/m^3
		Which is greater then 250 kg/m^3
A-5	**Proportion of Volume of Coarse Aggregate & Fine Aggregate Content**	
1	Vol. of C.A. as per table 3 of IS 10262	62.00%
2	Adopted Vol. of Coarse Aggregate	65.00%
	Adopted Vol. of Fine Aggregate (1-0.65)	35.00%
A-6	**Mix Calculations**	
1	Volume of Concrete in m^3	1
2	Volume of Cement in m^3	0.09
	(Mass of Cement) / (Sp. Gravity of Cement)x1000	
3	Volume of Water in m^3	0.145
	(Mass of Water) / (Sp. Gravity of Water)x1000	
4	Volume of Admixture @ 0% in m^3	nil
	(Mass of Admixture)/(Sp. Gravity of Admixture)x1000	
5	Volume of All in Aggregate in m^3	0.763
	Sr. no. 1 – (Sr. no. 2+3+4)	
6	Volume of Coarse Aggregate in m^3	0.496
	Sr. no. 5 x 0.65	
7	Volume of Fine Aggregate in m^3	0.267
	Sr. no. 5 x 0.35	
A-7	**Mix Proportions for One Cum of Concrete (SSD Condition)**	
1	Mass of Cement in kg/m^3	**290**
2	Mass of Water in kg/m^3	**145**
3	Mass of Fine Aggregate in kg/m^3	**696**
4	Mass of Coarse Aggregate in kg/m^3	1429
5	Mass of Admixture in kg/m^3	**nil**
6	Water Cement Ratio	0.5

The test performed on fresh concrete are:-

1) Bulk density of hardened concrete
2) Compressive strength (7, 28 days)

IV. RESULTS AND DISCUSSION

Aggregate

Test results of NFA, NCA and RCA are shows that both NFA and NCA comply with the Indian Standard Specifications while some properties of RCA do not.

Particle size distribution of RCA

The results of sieve analysis carried out on the RCA for the fifteen samples are represented in and RCA are separated to various sizes during the process of crushing and sieving. The amount of coarse particles (>4.75 mm) after recycling was in the order of 60–80% depending on the original quality of demolished concrete.

Specific gravity and water absorption

The specific gravity of RCA was 2.230 which is lower as compared to NCA (2.552) since the RCA from demolished concrete consists of crushed stone aggregate with old mortar adhering to it. As per is code the water absorption limit is (2.5%), RCA water absorption was 6.50 % which is relatively higher than that of the NCA. Past researchers had concluded the same result this also attributed to the adherent mortar to the aggregates. As the water absorption characteristics of recycled aggregates are higher, it is advisable to maintain saturated surface dry conditions of aggregate before starting the mixing operations of concrete.

Sample	Physical and mechanical properties					
	Specific weight	Bulk density (t/m3)	Absorption (%) < 2.5%	Fines content (%) < 3 % by weight	Abrasion index (%) < 30 %	Impact value (%) < 30 %
NCA	**2.552**	**1.43**	**1.90**	**1.62**	**20.50**	**16.20**
RCA	**2.230**	**1.25**	**6.50**	**0.56**	**42.60**	**25.20**
NFA	**2.450**	**1.45**	**0.62**	**1.10**	**-**	**-**

Bulk density

The bulk density of RCA is lower than that of NCA. The lower value of loose bulk density of RCA may be attributed to its higher porosity than that of NCA.

Abrasion index and impact values

The RCA is relatively weaker than the natural aggregate against mechanical actions. As per IS 2386 part 4 - 1963, the abrasion and impact values for concrete wearing surfaces should not exceed both 30%. The test results of impact value of RCA 25.20 % which are lower than the IS 2386 part 3 limit. On the other hand, results of abrasion values of RCA did not satisfy the IS 2386 part 3 limits. However, ASTM C33 includes a requirement of an abrasion loss (by ASTM C535 to be less than 50% for aggregates used in concrete construction and less than 40% for crushed stone used in pavements.

Previously discussed aggregates' results show that some of the characteristics of RCA are systematically lower than those usually required compared to natural aggregate to be used in structural concrete. So, it is necessary to combine a limited proportion of recycled aggregate with good quality natural aggregate in order to improve the characteristics of the structural concrete coarse aggregates.

Workability of fresh concrete

Workability is a property of fresh concrete and it is measured by the slump test and is described as a measure consistency. Test results showed that it is required to increase water by 9–13% to achieve the same level of workability when using RCA. This can be referred to more angularity in shape and rough surface of recycled aggregates and the existence of adhering mortar to the aggregates in the case of RCA. Increasing replacement level of RCA in concrete decreases the workability of the concrete hence water demand increases to achieve the required workability. Full replacement of NCA with RCA requires about 10% increase in mixing free water to achieve the same workability without using superplasticizer.

Compressive strength (fc)
Compressive strength test results at 7 days (fc7) and 28 days (fc28) in MPa.

MIX	NCA	RCA5	RCA15	RCA25
$\mathbf{f_{c7}}$	18.24	16.71	15.58	14.32
$\mathbf{f_{c28}}$	24.42	22.16	20.82	19.23

Compressive strength of concrete is commonly considered its most valuable property in mechanical properties because it usually gives an overall picture of the quality of concrete and it is directly related with other properties. Past researchers reported a reduction in compressive strength of RAC as low as 40%.
The compressive strength at 28-day age of all the RAC mixes achieved a level of 20 MPa plus a suitable margin of safety and most structural concrete applications. The standard deviation of these mixes represents 15.78% of the average strength and this can be attributed to the difference in physical and mechanical properties of the used RCA as it were driven from different sources of original concrete. The characteristic compressive strength value is 20 and compressive strength test results should possess a value greater than this. Accordingly if the number of test results is less than 20, it is not allowed for any test result to be less than the characteristic compressive strength value. The results show that the concrete specimens with greater content of recycled aggregate have lower compressive strength. The reduction in compressive strength for 25% replacement of NCA aggregate was insignificant (4–8%). Increasing the replacement ratio to more than 25 % led to a non-linear drop in compressive strength ranging from 15–23% less than control concrete. From the obtained results, it is clear that there is a possibility to produce good quality structural concrete using 5–25% RCA level of replacement according to RA properties and mix proportions.

V. CONCLUSION

Based on test results, the following conclusions are drawn:
1.Concrete rubble could be transformed into useful recycled aggregate used in concrete production with properties suitable for most structural concrete applications in India.
2. Few properties of RCA such as absorption and abrasion resistance were lower than those required by Indian standard concrete code of practice although it complies with other international codes.
3. RAC with replacement ratio up to 25% of NA produced structural concrete with 20 MPa characteristic strength which is suitable for most structural concrete applications in India.
4. Full replacement of natural aggregates by RCA led to less workability and a decrease in concrete strength and to overcome that effect superplasticizers and higher cement content were used in order to have a more compact matrix which led to enhancing structural concrete performance.
5. Replacing proportions from 5% to 25% of NCA with RCA achieved a good performance of concrete mixes. Replacing 25% of NCA with RCA has no significant adverse effect on structural concrete performance.
6. Using Silica fume as mineral admixture enhanced the performance of RAC due to better interfacial zone between new and old mortar attached to RCA and working as a micro filler.

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