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"Experimental Study on the Properties of M25-Grade Recycled Aggregate Concrete"

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Abstract
RAC is made by replacing some or all natural aggregates in concrete with crushed concrete waste. While it offers environmental benefits, its strength generally falls short of normal concrete. The strength reduction is linked to factors like the absorption capacity of old mortar on the recycled aggregate and micro-cracks in the old interfacial transition zone (ITZ).
However, studies have shown that certain measures can improve RAC strength. These include using lower water-cement ratios, adding silica fume, and limiting the percentage of recycled coarse aggregate. The use of RAC in construction projects requires careful consideration of these factors to ensure adequate structural performance.
Keywords: *RCA, compressive strength, workability, durability.*

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I. INTRODUCTION

Environmental control is an increasingly pressing concern in the construction industry. Natural resources are consumed in its day-to-da operations and waste is generated. Construction activities thereby impose significant environmental impacts over the entire construction life cycle. Waste management in the construction industry has not been successfully controlled, and it is challenging to initiate improvement. It has been thought that the reuse and recycling of materials will provide effective means to reduce the impact on limited landfill spaces and also improve waste management. Concrete is an essential, mass-produced material in the construction industry, as are steel and soil. However, much effort has been made to recycle and conserve precious natural resources, and repeated recycling can be suitable for concrete, as is the case for steel and aluminum. An effective method would be the use of recycled aggregate (RA) in the production of recycled aggregate concrete (RAC). RA is a particle of stones attached with old cement mortar generated by crushing demolished concrete waste.

RAC is created by mixing RA along with other natural ingredients, including cement, water, fine aggregate and other materials. As concrete is composed only of cementitious materials, and the powders generated during the production of RA can be reprocessed as cement resources, repeated recycling is possible. This also enables concrete to be recycled in a fully closed system, thus improving the environment by reducing landfill and concrete waste. Concrete recycling can be accomplished by reusing concrete products, processing into secondary raw materials for applications such as fill, road bases and sub-bases, or aggregate to produce new concrete for non-structural applications.

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 projects are significantly reduced.

In addition to the resource management aspect, recycled concrete aggregates absorb a large amount of carbon dioxide from the surrounding environment. The natural process of carbonation occurs in all concrete from the surface inward. In the process of crushing concrete to create recycled concrete aggregates, areas of the concrete that have not carbonated are exposed to atmospheric carbon dioxide.

1.2 LITERATURE REVIEW

1.2.1 Macro Breccolotti et al., (2010), did theoretical research on the structural use of concrete manufactured with recycled aggregates. The results of both the experimental and theoretical works suggested the adoption of appropriate adjustments to the design procedure when dealing with RAC for structural use.

1.2.2 Li et al. (2009) suggested a new technique i.e. recycled aggregate surface coated with pozzolanic powder. The authors also concluded that the compressive and flexural strength of RAC were improved with this new technique compared to normal mixing. In addition, the combination of silica fume and fly-ash further enhances the strength of RAC which is primarily attributing to the higher packing density.

1.2.3 M Etxeberria et al., (2006), specified recycled coarse aggregates obtained by crushed concrete were used for concrete production. Four different recycled aggregate concretes were produced; made with 0%, 25%, 50% and 100% of recycled coarse aggregates, respectively.

1.3 PHYSICAL PROPERTIES OF RECYCLED AGGREGATES

1.3.1 Grading, shape and surface texture:- (2010) studied the influence of different size of the coarse aggregate and w/c ratio on properties of recycled aggregate. The author reported that the w/c ratio of the concrete from which the recycled aggregate derived and the shape and texture of parent concrete aggregate does not affect the grading of recycled aggregate

1.3.2 Density and specific gravity:- ((2013), it was found that porous and rough nature of the surface, generated due to the presence of adhered mortar on recycled coarse aggregate, help in developing better bond

1.3.3 Mechanical properties of recycled aggregates:- Generally, it is seen that the RCA was weaker than the natural coarse aggregates such as aggregate crushing value, impact value and Los Angeles abrasion loss value

1.3.4 Los Angles abrasion resistance value:- The Los Angeles abrasion loss depends on the strength of concrete from which the RA was obtained, size of aggregate and the amount of adhered mortar

Table 1.1 Los Angles abrasion loss of recycled aggregate obtained from 16 MPa and 40MPa strengths concrete

Authors	Los Angles abrasion loss percentage							
	16 MPa strength concrete				40 MPa strength concrete			
	4-8 mm	8-16 mm	16-32 mm	5-25 mm	4-8 mm	8-16 mm	16-32 mm	5-25 mm
	41.40	37.00	31.50		30.10	26.70	22.40	
Hasaba et al. (1981)				24.50				23.00
BCSJ (1978)[#]	25.10 to 35.10							
Yoshikane (2000)				28.70				20.10

(#) Recycled coarse aggregates obtained from 15 different concrete of different strengths

1.4 Experimental Work

1.4.1 GENERAL :- *In this present work, a comprehensive experimental schedule is being formulated to achieve the objective and scopes of the present investigation. The whole experimental work is classified into four steps.*

1.4.2 Production of recycled coarse aggregate :- The demolished waste concrete material from laboratory wastes of CIT Tatisilwai Campus near civil engineering department, the demolished waste concrete materials are various mix grade. The details of old concrete are unknown.

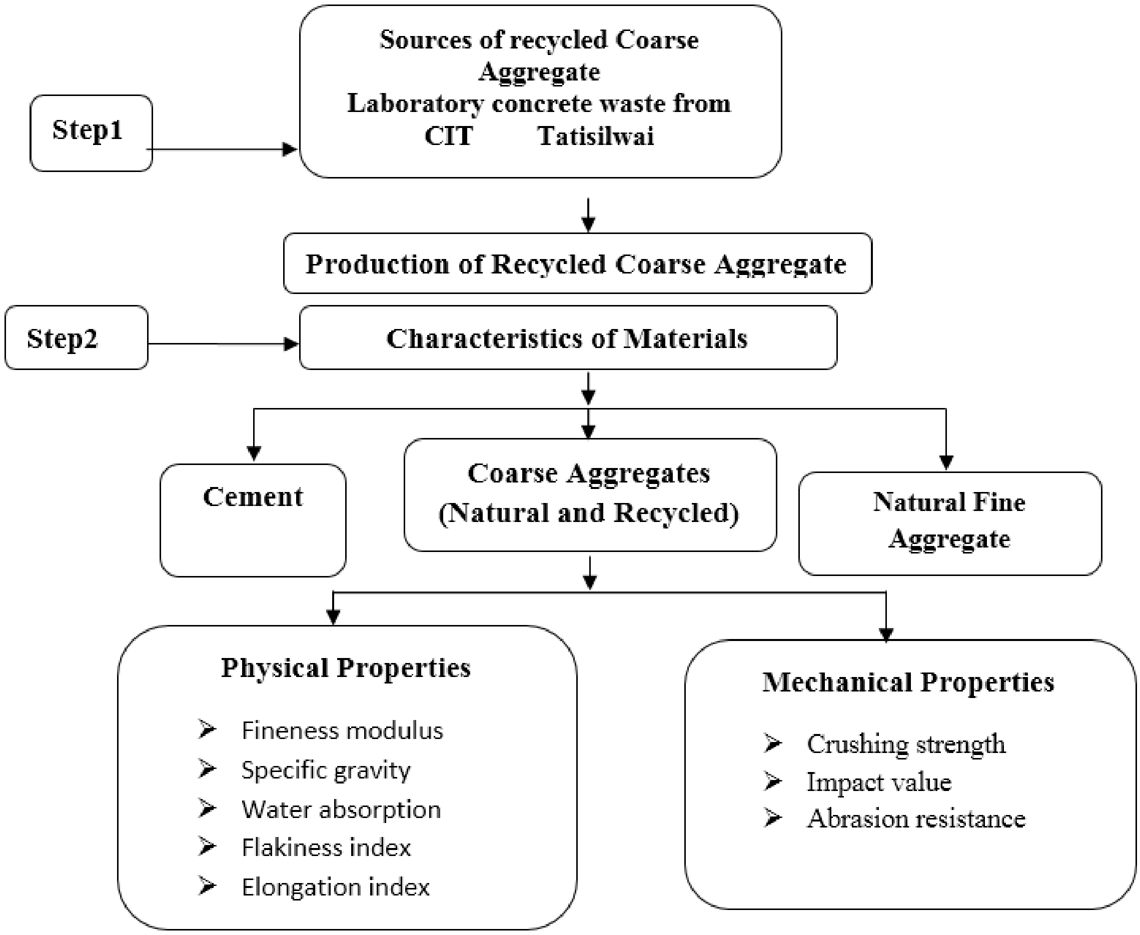
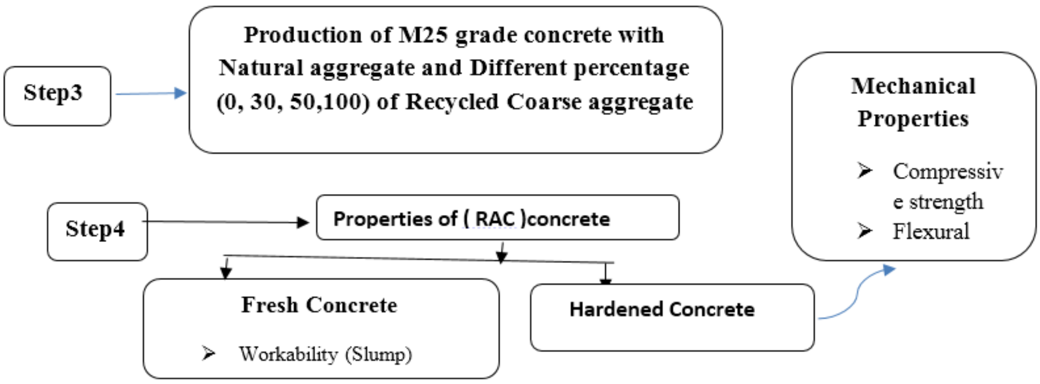


Fig. 4.1 Experimental work overview



1.4.3 Cement:- Portland Slag Cement conforming to IS: 455 were used in the entire experimental study. To avoid the long storage times and to avoid the loss of strength, cement was procured according to the phase wise requirement.

Table 1.2 Physical and Mechanical Properties of cement

Properties	Results	**Standard Limits (IS: 455)**
Consistency	32%	_
Soundness	Expansion 3.5mm	**<10mm**
Initial setting time (min)	75 minutes	**>30 min**
Final setting time	235 minutes	**<600 min**
Specific gravity	3.12	_

Fineness	2.5% Retain on 90 micron sieve	**<10mm**
Compressive strength 1. 3days 2. 7days 3. 28 days	N/mm^2 27.12 34.55 46.57	**N/mm^2** **>16** **>22** **>33**

1.4.4 Production of normal and recycled aggregate concrete

This step explains the suitability of recycled coarse aggregate in the production of concrete. As there is no standard mix design procedure available in the literature for recycled aggregate concrete, normal concrete mix design procedure given in IS: 10262-2009 is adopted for the design of recycled aggregate concrete mixes. Three concrete mixes were prepared with 30%, 50% and 100% recycled coarse aggregate in place of natural coarse aggregate. The mix prepared with recycled coarse aggregate is designated as "MN-RAC30, MN-RAC50, MN-RAC100", the mixes prepared with RCA obtained from concrete laboratory waste of CIT Tatisilwai.

Table 1.3 Details of mix proportions for RCA (kg/m^3)

Amount of RCA in %	Cement (kg)	Natural FA (kg)	Natural CA (kg)	RCA (kg)	w/c ratio	Slump (mm)
0	410	557	1135	0	0.45	67
30	410	557	795	307	0.45	62
50	410	557	567.5	523	0.45	54
100	410	557	0	1020	0.45	51

II. RESULT AND DISCUSSION

2.1 PROPERTIES OF AGGREGATES:- As mentioned in Section 4.2, the recycled coarse aggregates are obtained from laboratory waste CIT Tatisilwai, Ranchi. The characteristics of recycled coarse aggregates are dependent on several factors and the quality of the original concrete, from which recycled coarse aggregates has been derived, is one of them, as there is no data available on the original concrete from which recycled coarse aggregates are derived, the characteristics of recycled coarse aggregates are to be studied in detail before preparing the concrete. The physical and mechanical properties of recycled coarse aggregate obtained from Source along with the natural coarse aggregates have been presented in this section.

2.2 Particle gradation:- The particle size distribution of NCA, RCA and natural fine aggregate are presented through Fig. 5.1 and 5.2 using IS: 383-1970. Fig 5.1 show the grading curve of NCA and RCA and it is observed that the RCA are relatively finer than NCA. Hence, the fineness modulus of recycled coarse aggregate is 6.48 which is less than that of fineness modulus of NCA of 6.69. It was also observes that the particle of size less than 4.75 mm in a mix with maximum size of RCA of 20 mm is approximately 4.6 %.

Table 2.1 Sieve Analysis of Natural course Aggregate and Recycled coarse aggregate

IS Sieve (mm)	**% of Passing**			
	NCA	**RCA**	**70% NCA + 30% RCA**	**50% RCA + 50% NCA**
40 mm	**100**	**100**	**100**	**100**
20 mm	**95.50**	**96.30**	**97.50**	**96.43**
10 mm	**26.80**	**51.40**	**35.70**	**40.50**
4.5 mm	**9.00**	**3.30**	**2.30**	**4.43**

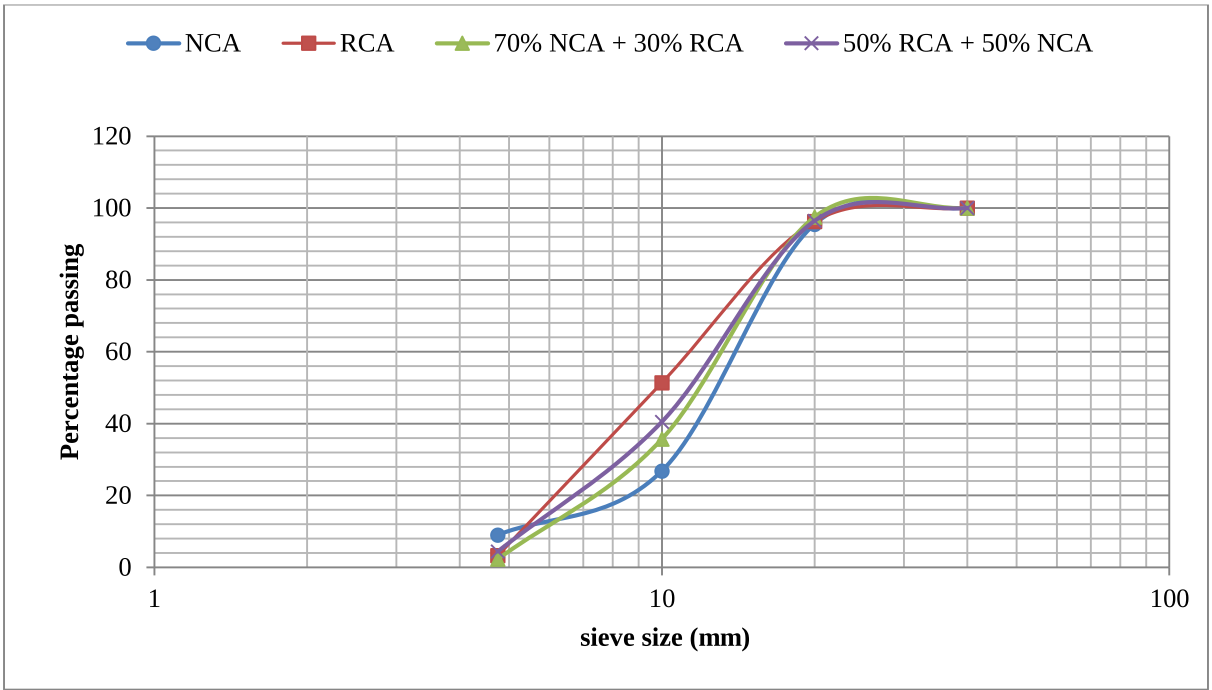


Fig. 2.1 Particle size distribution of NCA and RCA

Table 2.2 Sieve Analysis of Fine Aggregate
Weight of sample = 1000gms

IS Sieve (mm)	Wt. Retained(gms)	% Retained	% Cum Wt. (gms)	% Passing	Remarks
4.75 mm	5	1.50	1.50	98.50	Sand Zone II as per IS: 383-1970 CLAUSE 4.3 TABLE 4
2.36 mm	23	2.30	3.80	96.20	
1.18 mm	141	14.40	17.90	82.10	
600 micron	245	24.50	42.40	57.60	
300 micron	380	38.00	80.40	19.60	
150 micron	185	18.50	98.90	1.10	

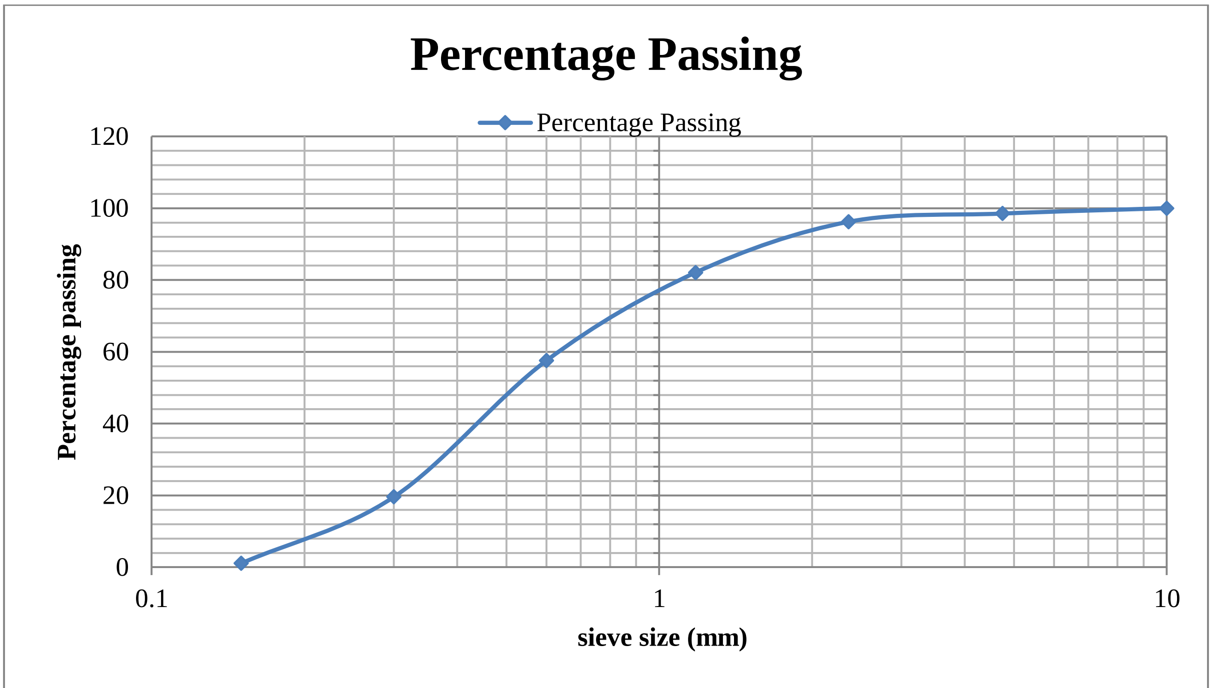


Fig. 2.2 Particle size distribution of natural fine aggregate

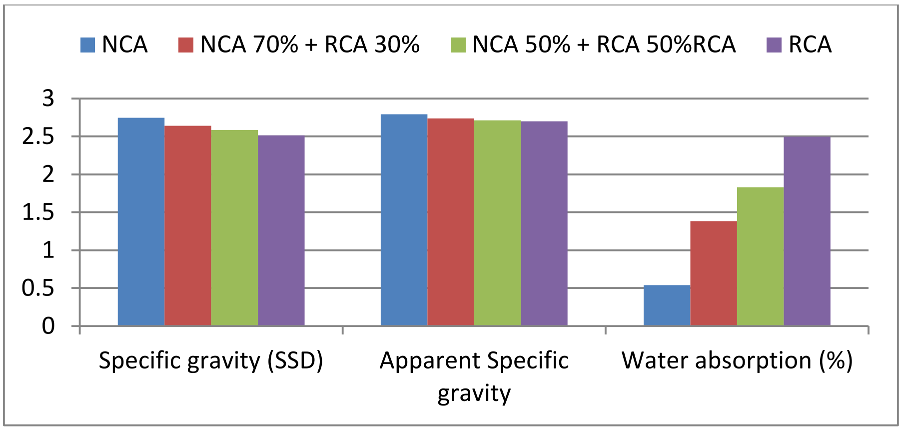


Fig. 2.3 Specific gravity and Water absorption of NCA and RCA

III. CONCLUSION

The present study comprises of experimental work on different properties of recycled coarse aggregates obtained from laboratory concrete waste of CIT Tatisilwai, Ranchi. The affect of different percentages of these recycled coarse aggregate on the properties of fresh and hardened concrete prepared by NMA was studied. The work presented in this thesis is therefore concluded as follows:

1. The specific gravity and bulk density of recycled coarse aggregate is less than that of natural coarse aggregate as a result in the mix design lesser weight of recycled coarse aggregate is required than natural coarse aggregate.
2. The presence of adhered mortar on recycled coarse aggregate produces porous and rough nature of surfaces, which help in developing better bond. But for achieving required workability, the water absorption for recycled coarse aggregate is more than that of natural aggregate.
3. Larger quantity of RCA (more than 30%) in RAC reduces the compressive strength and split tensile strength of concrete. However, replacement of natural aggregates with lower (< 30%) RCA has no significant influence on compressive strength and split tensile strength of concrete.
4. The reduction in flexural strength of RAC is around 6% by NMA using 50% RCA in RAC when compared with normal aggregate concrete.

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