Effect of Recycled Aggregate on Compressive Strength of Concrete

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***Abstract*— Waste products are to be used as aggregate and it is called 'Green' concrete. Use of hazardous waste in concrete-making will lead to green environment and sustainability. In this study an attempt is to be made to investigate the different properties of recycled aggregate and compared with natural aggregate. Experiments were carried out to determine compressive strength at different percentage replacement of recycled aggregate for M20 and M30 mixes and compared with conventional concrete made of natural aggregate. Test results indicate that strength characteristics are comparable to the conventional concrete.**

***Index Terms*— recycled aggregate, natural aggregate, compressive strength.**

I. INTRODUCTION

The construction, characteristics, operation, and demolition of buildings are increasingly recognized as a major source of environmental impact; including direct effects on human. Buildings have a huge role to play in addressing environmental concerns. They contribute around 40% of global greenhouse gas emissions and the same proportion of waste.[1]

The recycling of construction and demolition wastes has long been accepted to have the possible to conserve natural resources and to decrease energy used in production. In some nations it is a stand as substitute for both construction and maintenance, particularly where there is a scarcity of construction aggregate. The use of recycled aggregate weakens the quality o f recycled aggregate concrete which limits its application. The results indicated that the compressive, flexure and split tensile strength of recycle aggregate is found to be less than the natural aggregate. [2]

II. BACKGROUND

The rapid development in research on the use of RCA for the production of new concrete has also led to the production of concrete of high strength performance. It should be noted that the use of coarse RCA (up to 30%) is normally recommended but the addition of super plasticizers is often considered necessary for achieving the required workability of new concrete.

Recycled concrete aggregate had lower relative density and high water absorption than natural aggregate. It was shown that there was no effect with the replacement of 30% coarse recycled concrete aggregate used on the ceiling strength of concrete. [3]

The main aim that testing the recycled aggregate is to find out the result of the strength characteristic on it and analysis whether recycled aggregate is suitable to apply in the construction area. The compressive strength of recycled aggregate concrete was relatively lower and variation was depended on the strength of parent concrete from the obtained aggregate. [4]

III. PRILIMINARY INVESTIGATION

The cement was an ordinary Portland cement shall confirm IS 12269. Physical properties of cement are described in Table 1. Locally available Fine aggregate and coarse aggregate was used. Particle size distribution of fine and coarse aggregates were conducted as per IS: 2386-1963 and IS: 383-1970. Particle size distribution of the coarse natural aggregates recycled aggregate and fine aggregate shown in Fig 1, and Fig 2. Water absorption value of natural, recycled and fine aggregates were shown in Table 2.

Table 1 Physical Properties of Cement

Sr No	Physical Property	Results Obtained
1	Fineness	-
2	Normal Consistency	34
3	Initial Setting Time	31.5min
4	Final Setting Time	457 min
5	Compressive Strength(7-day)	38.57
6	Compressive Strength(28-day)	57.62

Table 2 Physical Properties of Aggregates

Sr. No	Physical Tests	Coarse Aggregates		Fine Aggregates
		Natural Aggregates	*Recycled Aggregates*	
1	Specific Gravity	2.916	2.76	2.58
2	Fineness Modulus	9.91	8.83	2.63 (Zone II)
3	Bulk Density(Loose)-kg/m^3	1436	1405	2530
4	Bulk Density(Compacted)-kg/m^3	1634	1600	2630
5	Water Absorption (%)	2	4.25	1.62
6	Flakiness	16.84	19.56	----
7	Elongation	17.48	21.50	----
8	Impact value	14.46	20.28	----

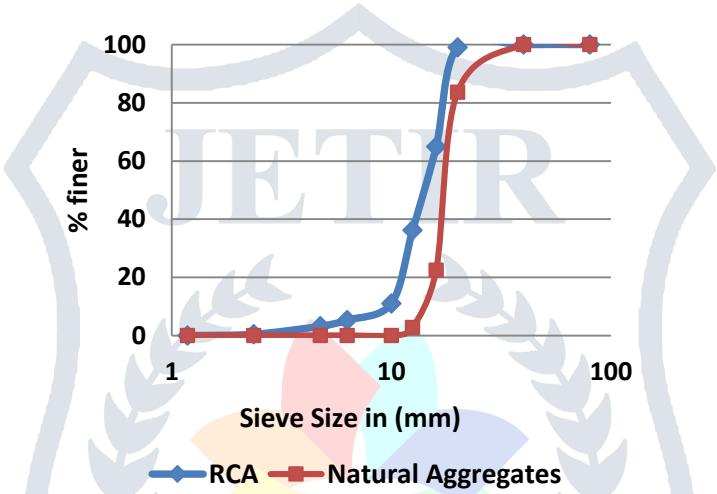

Fig 1: Particle Size Distribution of RCA and Natural Aggregates

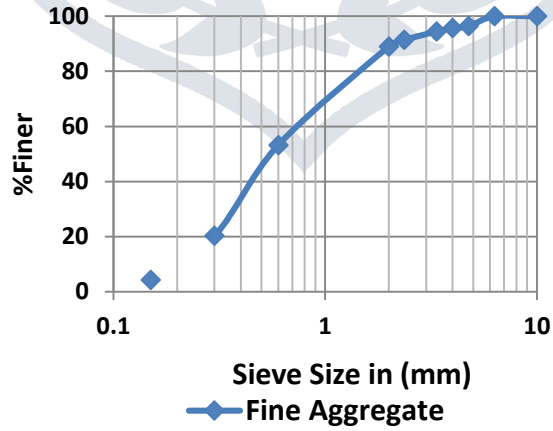

Fig 2: Particle Size Distribution of Fine Aggregate (Natural Sand)

IV. EXPERIMENTAL PROGRAM

Mix M-20 and M-35 grade were designed as per Indian Standard method and the same were used to prepare the test samples. The design mix proportions are shown in Table 3 and Table 4 respectively.

Table 3 Concrete Mix Proportion for M20

Cement	Coarse Aggregate		Fine Aggregate	Water	W/C
	20mm	*10mm*			
350 Kg/ m^3	779.18 Kg/ m^3	419.56 Kg/ m^3	684.68 Kg/ m^3	197 Kg/ m^3	0.56

Table 4 Concrete Mix Proportion for M30

Cement	Coarse Aggregate		Fine Aggregate	Water	W/C
	20mm	*10mm*			
438 Kg/ m^3	757 Kg/ m^3	407 Kg/ m^3	665 Kg/ m^3	197 Kg/ m^3	0.45

The evaluation of Recycled Aggregate for use as a replacement of coarse aggregate begins with the concrete testing. Concrete contains cement, water, fine aggregate, coarse aggregate (Kapachi and grit). Natural coarse aggregate is replaced in different percentage i.e., 10%, 20%, 30%, 40%, 50%, 60%,70%, 80%, 90% and 100% by recycled coarse aggregate and test result data is compared with data from test result of control mix i.e., concrete with no replacement of recycled coarse aggregate. To understand the workability of recycled coarse aggregate concrete and conventional concrete, slump test was conducted as per IS 7320-1974.

For each mix, nine cubes (three for 7 days, 14 days and 28days) of size 150mm were cast to determine compressive strength (IS: 516-1959), the specimens were de molded 24h after casting and were cured under fresh water at 27° with 2°tolerance until the test age.

V. RESULT & DISCUSSION

Slump Test

Slump test was conducted to compare the workability of recycled aggregate concrete and natural aggregate concrete. Results of the slump test of both the mix were shown in Fig 3. The result shows that slump value is decreases in both mix proportion (M-20 & M-30) as replacement level of recycled aggregate is increases. The reason behind this behavior is the water absorption of recycled aggregate is higher than natural aggregate.

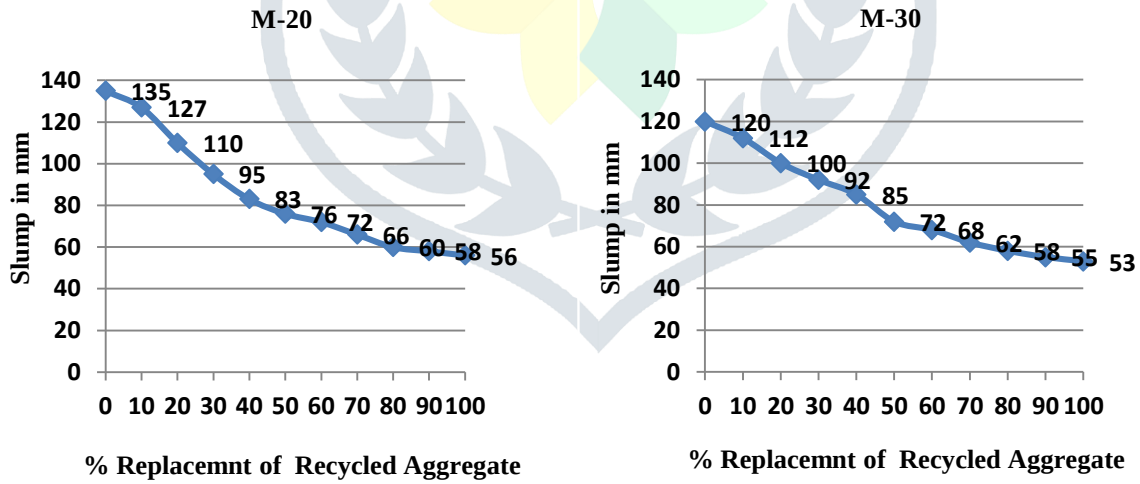

Fig. 3 Slump test result for Mix- M-20 & M-30

Compressive Strength Test

Compressive strength of recycled aggregate concrete was tested after 7-days, 14-days and 28-days after casting. Compressive strength of recycled aggregate concrete was compared with natural aggregate concrete. Result shows that compressive strength of recycled aggregate is decreased with increase in replacement of recycled aggregate. [5]

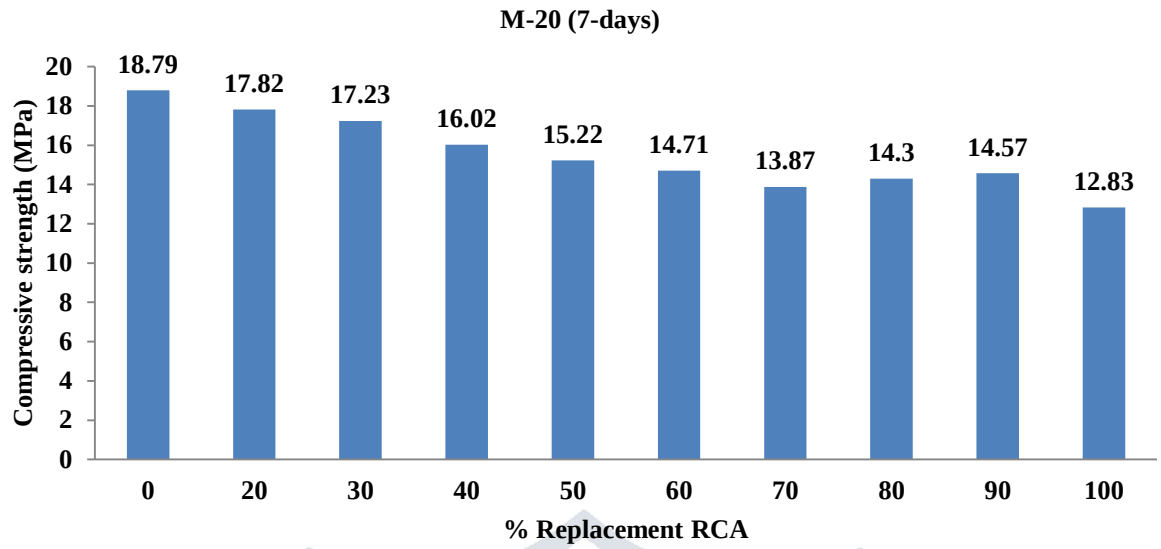

Fig 4: 7-days Compressive strength of M-20 mix concrete with different replacement level of recycled aggregate.

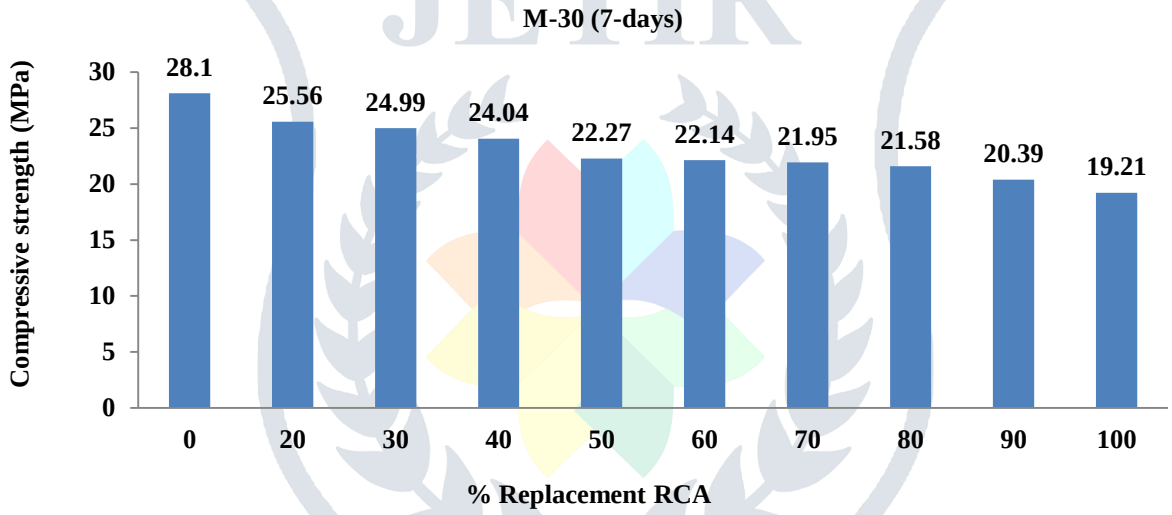

Fig 5: 7-days Compressive strength of M-30 mix concrete with different replacement level of recycled aggregate.

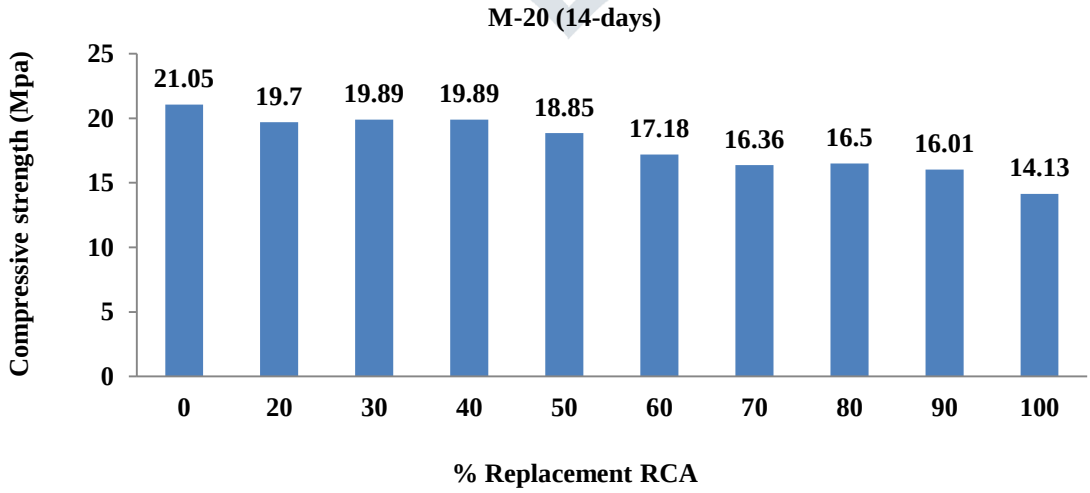

Fig 6: 14-days Compressive strength of M-20 mix concrete with different replacement level of recycled aggregate.

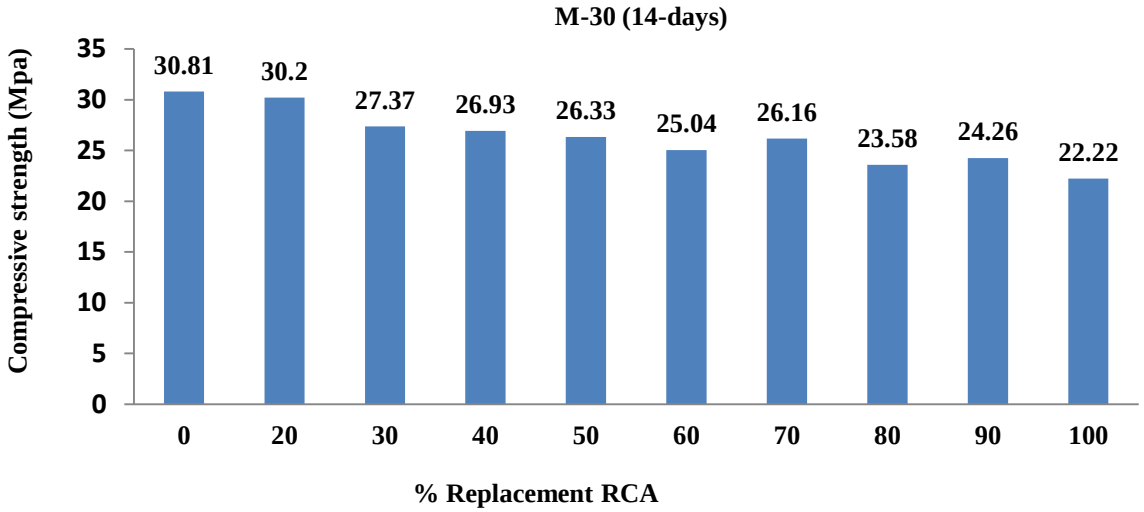

Fig 7: 14-days Compressive strength of M-30 mix concrete with different replacement level of recycled aggregate.

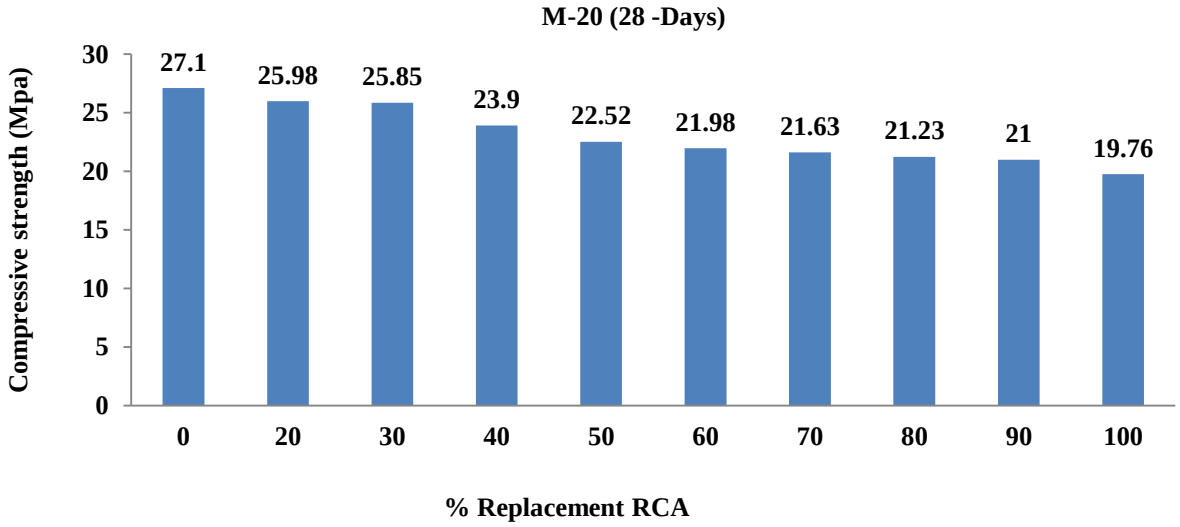

Fig 8: 28-days Compressive strength of M-20 mix concrete with different replacement level of recycled aggregate

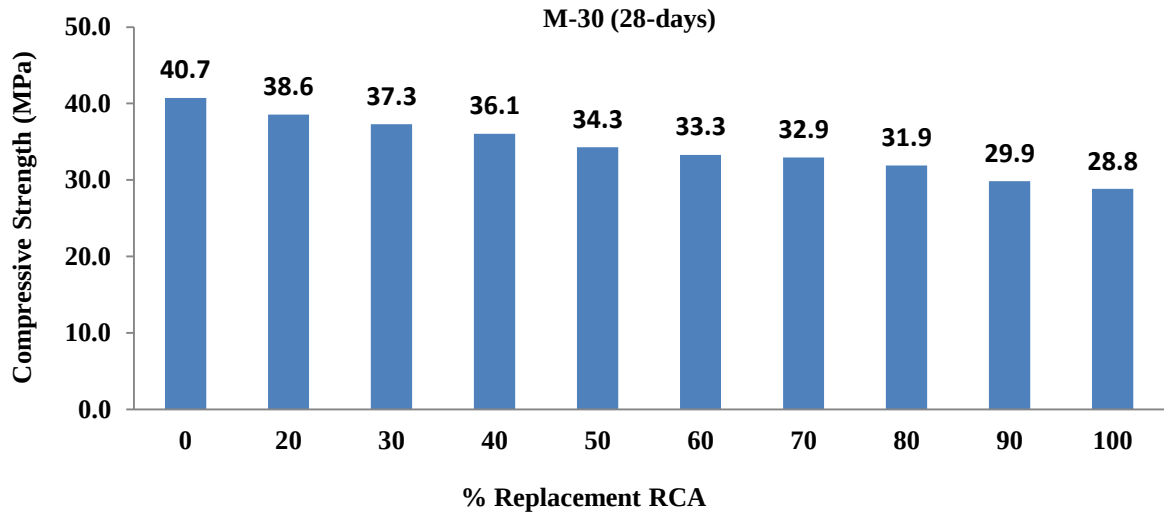

Fig 9: 28-days Compressive strength of M-30 mix concrete with different replacement level of recycled aggregate.

VI. CONCLUSION

Based on experimental work, the following observations/conclusions are drawn:

- Water absorption of RCA was 3 times higher and specific gravity of is 15% to 16% lower than the NA.
- Elongation and flakiness index were observed little higher for RCA.
- Crushing value of RCA is 29% higher than NA.
- Impact Resistance of RCA is decreased by 30% compared to NA.
- Abrasion value of RCA is 35% higher than NA.
- These aggregates are used without any type of treatment i.e without washing or any other treatment. Water absorption, specific gravity and density will further improve, if one can use these aggregates by proper treatment.
- The compressive strength of RAC at 100% replacement level is decreased by 27% and 29.23%, while at 50% replacement level it reduced by 16.9% and 15.72 % in M20 and M30 respectively compared to reference concrete.
- However 30% RA replacement in RAC shows only 4.13% and 8.35 % reduction in M20 and M30 respectively which is not significantly different from the conventional concrete.

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