An Experimental investigation on Recycled Concrete Coarse Aggregates

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Abstract - Concrete has occupied an important place in construction industry in the past few decades and it is used widely in all types of constructions ranging from small buildings to large infrastructural dams or reservoirs. Cement is major ingredient of concrete. The cost of cement is increasing day by day due to its limited availability and large demand. At the same time the global warming is increasing day by day. Manufacturing of cement also releases carbon dioxide. In the present study an attempt been made on concrete and also an experimental investigation on the concrete using by replacing cement with FLYASH and GGBS to decrease the usage of cement as well as emission of concrete. Experimental studies were performed on plain cement concrete and replacement of cement with Fly ash is done. In this study the concrete mix were prepared by using flyash, sodium silicate, sodium hydroxide. A comparative analysis has been carried out for concrete to the Geopolymer concrete in relation to their compressive strength, split tension strength, acid resistance and water absorption. The concrete made with fly ash performed well in terms of compressive strength, split tension strength acid resistance and water absorption showed higher performance at the age of 7,14,28 days than conventional concrete. And also two different types of acid attack is done to determine the and compressive strength both on conventional concrete and geo polymeric concrete.

Index Terms- Fly Ash, Ground Granulated Blast Slag, Geopolymer concrete, Sodium Hydroxide, Sodium Silicate.

I. INTRODUCTION

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 the India alone. The disposal of all this waste has become a harsh social and environmental problem. This is a large burden on the world's natural resources and an increasingly expensive problem for solid waste management.

Understanding the application of Recycled Aggregates

The recycled concrete aggregate shown in Figure can be defined as crushed concrete composed of aggregate fragments coated with cement paste or cement mortar from the demolition of the old structures or pavements that has been processed to produce aggregates suitable for use in new concrete. The processing, as with many natural aggregates, generally involves crushing, grading and washing. This removes contaminant materials such as reinforcing steel, remnants of formwork, gypsum board, and other foreign materials. The resulting coarse aggregate is then suitable for use in concrete. The fine aggregate, however, generally contains a considerable amount of old cement paste and mortar. This tends to increase the drying shrinkage and creep properties of the new concrete, as well as leading to problems with unworkable mix and strength. Therefore, many transportation departments have found that using 100% coarse recycled aggregate but with only about 10% to 20% recycled fines works well. Regarding the results of most of the previous research that has been done so far, the application of Recycled Aggregate is mostly currently in low quality/strength concrete, for example, pavement base and slab rather than used in structural concrete. The most common application of Recycled Concrete Aggregate is the use in concrete sub-base in road construction, bank protection, noise barriers and embankments, many types of general bulk fills and fill materials for drainage structures.

Demolition of concrete structures

Classification of Recycled Aggregate (RA)

RA are obtained from the deconstruction and demolition waste which are typically made out of different construction materials such as concrete, bricks, tiles, stone, timber, glass, plastics and metal (Güneyisi et al., 2016). The deconstruction and demolition waste can be categorized as recycled concrete aggregates (RCA), (Cardoso et al., 2016). RCA are originated from demolished concrete structures, excess or returned concrete from construction site and tested concrete (Gesoglu et al., 2015). According to some specifications (e.g. LNEC-E471 guideline (LNEC-E471, 2006)), it comes to the consensus that RCA comprise a minimum of 90% (by mass) of Portland ordinary cement-based fragments and NA (Cardoso et al., 2016). Recycled masonry aggregates originated from crushed masonry materials including brick, stone, concrete block (Cardoso et al., 2016). Mixed RA sourced from mixed demolition wastes and a mixture of different construction materials including concrete, ceramic, bricks, tiles, wood, etc. However, RCA is the most suitable alternative aggregate for the replacement of NA in the conventional concrete and SCC. RCA are crushed into different particle sizes including coarse and fine aggregates. In comparison with coarse RCA, fine RCA contain a higher amount of adhered mortar which result in great heterogeneity of concrete and significantly affect the mechanical performance of cement composite. There is a broad consensus on the incorporation and acceptable quality of coarse RCA in concrete products. Existing specifications allow the use of coarse RCA in concrete products at various substitution ratios from 20% to 100%, however, fine RCA are usually not allowed to be used in any ratio in most cases.

Need for the Present Work

Concrete is widely utilized material in the construction activity because of its easy availability of the cement, sand, gravel and water and also handled easily with low service maintenance. The ingredients of concrete are available at economical cost and are durable, offers good fire resistance and are strong in compression. Due to these factors these materials are used drastically which caused a scarcity and polluting the environment. So in order to overcome the scarcity of the aggregates and save the environment the use of RCA's in concrete production is taken in to deliberation.

Objectives of the Study

- To produce a concrete with the use of locally available materials (i.e. Recycled aggregate concrete).
- To study the strength properties of green concrete with partial replacement of natural aggregates.
- To investigate the effect of recycled coarse aggregate on the strength of concrete.
- To investigate the effect of recycled coarse aggregate on the workability of concrete.
- To determine the optimum percentage of recycled coarse aggregate in the concrete.

II. REVIEW OF LITERATURE

Winston et al., (2004) [5] discussed the latest application experience of using recycled aggregate in construction projects in Hong Kong and recommends a broader scope of use of recycled aggregates in areas other than ready mixed concrete.

Michał et al., (2005) [6] Carried out test to determine compressive strength. Concrete mixtures were produced at recycled aggregate content equal: 0%, 25%, 50% and 75% of coarse aggregate. Compressive strength of recycled aggregate concrete showed a decrease of up to 6% compared to natural aggregate concrete. Recycled aggregate concrete water absorption was higher compared to NAC because of remains of mortar on its rough surface.

Ismail et al., (2009) [7] described the effect of size of recycled aggregate on compressive strength. The 100% of RA used in concrete mix to replace the natural coarse aggregate in concrete with 100 x 100 x 100 cube mm were cast with target compressive strength is 25 MPa. The 28-day compressive strength was crushed at 3, 14, 28 days are reported found that the size of 10mm and 14 mm of RA in

RAC is quite similar performance with 10mm and 14mm size of natural aggregate in natural aggregate concrete.

Garg and Jain (2014), studied on green concrete: efficient & eco-friendly construction materials. It presents the feasibility of the usage of by product materials like fly ash, quarry dust, marble powder/granules, plastic waste and recycled concrete and masonry as aggregates in concrete. It concluded that, it focuses on known benefits and limitations of a range of manufactured and recycled aggregates. Use of concrete product like green concrete in future will not only reduce the emission of CO2 in environment and environmental impact but it is also economical to produce.

III. MATERIALS AND METHODOLOGY

Portland cement

Cement used is Ordinary Portland cement. (OPC). The colour of the cement is due to iron oxide. In the absence of impurities, the colour of cement is gray. Ordinary Portland cement (OPC) – 53 grade (KCP) is used.

Following tests will be conducted, on cement:

1. Consistency limit test:- Three samples were tested
2. Initial setting time and final setting time

Sand

The sand used in the investigation will be ordinary river sand. The sand passing through 4.75 mm sieve will be used in the preparation of specimens. Sieve analysis for the sand will be carried out in the laboratory as per the procedure mentioned in IS2386 (part-I)-1963. The sizes of sand vary between 2 mm to 4.75 micron.

Coarse aggregate

The coarse aggregate used in the investigation will be 20 mm size crushed granite stone obtained from quarries. The physical properties will be determined as per IS: 3286-1963.

Recycled coarse aggregate

The recycled aggregate used in this project are taken from the demolished concrete members. These concrete wastes are crushed and Recycled coarse aggregates were produced. Recycled coarse aggregate used in the investigation will be 20 mm size.

Impurities in Recycled Coarse Aggregate

The performance of recycled coarse aggregate can be reduced due to the presence of impurities, which emanated from demolition process including porous mortar and cement paste attached to the parent aggregate. The effect could also lead to general reduction in characteristics of recycled aggregate concrete. Some of the impurities identified through visual inspection from the recycled coarse aggregate. The average percentage impurities present in the recycled coarse aggregate amounted to about 5% of the total mass of the sample. Although there is visual evidence to show the presence of adhered mortar on the parent material, it was practically impossible to estimate their percentage. However, the adhered mortar does not seem to be of significant quantity but its impact on the characteristics of recycled coarse aggregate concrete cannot be neglected.

Experimental Program

- Concrete mixes were made; NAC and RAC were produced using natural sand as fine aggregate.
- NAC mixes were used fully Natural Aggregate as coarse aggregate in concrete mix.
- Mean while RAC mixes were used demolished waste concrete aggregate as partially or fully replacement of Natural Aggregate as coarse aggregate.
- These mixes were designed according to concrete mix design.
- The concrete mixtures were prepared with a water-cement (w/c) ratio 0.4, 0.45, 0.50
- The slump target is between 70mm to 190mm for NAC and RAC mixes.
- Fresh concrete testing (slump test), (compaction factor test);
- Filling of steel moulds (cube, cylinder and beam) and compaction using tamping rod and vibrating table
- Covering fresh concrete filled moulds with polyethylene bag to prevent loss of moisture due to evaporation;
- De-moulding of concrete sample after 24 hours;
- Storage of hardened concrete sample in the curing tank about 20oCfor maximum 28 days;
- Testing of hardened concrete at 28 days curing age

The combination in concrete mixes after this will be called as RA00, RA10, RA20, RA30, RA50 and RA100.

Table No 1 (N-A Natural Aggregates/ R-A Recycled Aggregates)

Mix Designation	Description
RAC-0	100% N-A + 0% R-A
RAC-10	90% N-A + 10% R-A
RAC-20	80% N-A + 20% R-A
RAC-30	70% N-A + 30% R-A
RAC-50	50% N-A + 50% R-A
RAC-100	0% N-A + 100% R-A

IV. RESULTS AND DISCUSSIONS

General

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. Compressive test which is done to study the compressive strength i.e.; fck and Split tensile test to study the tensile behavior.

Workability

The slump results are presented in Table below. It can be observed that concrete mixes at 0.4 had a lower slump compared to 0.45 and 0.50 concrete mixes. On the other hand, when replacement of RA is increased in concrete mixes, the slump of concrete mixes is decreased. It was expected because recycled aggregate is high in water absorption.

Table No 2 W/C ration and Slump values

Mix Designation	W/C RATIO	SLUMP (mm)
RAC-0	0.40	129
	0.45	131
	0.50	160
RAC-10	0.40	120
	0.45	128
	0.50	169
RAC-20	0.40	115
	0.45	125
	0.50	168
RAC-30	0.40	100
	0.45	115
	0.50	165
RAC-50	0.40	80
	0.45	85
	0.50	164
RAC-100	0.40	42
	0.45	48
	0.50	155

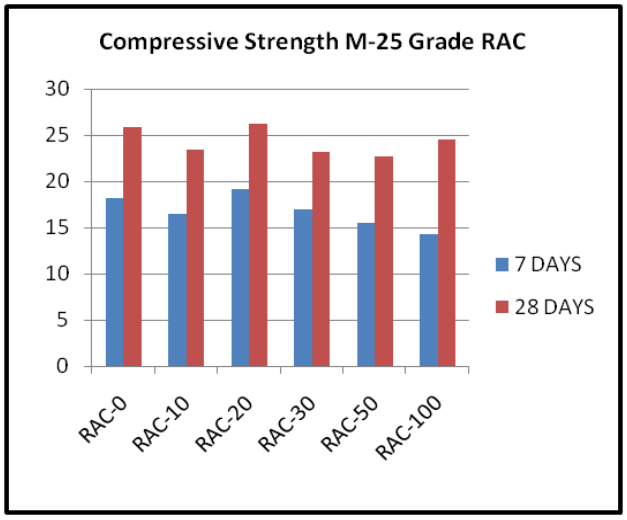
Compressive strength

The concrete was mixed in high capacity tilting drum mixer. The minimum 15 specimens were cast for each type of recycled aggregate i.e. demolished and e-waste aggregate thereby making more than 30 specimens. Five sets of cubes were cast replacing fresh aggregate by coarse aggregate from demolished waste @ 0%, 5%, 10%, 15% and 20% by weight. 0% demolished waste means only fresh concrete has been used in both the mixes. All the specimens were re-moulded after 24 hours and cured by putting in water. Compressive strength of cubes has been determined using the compression testing machine.

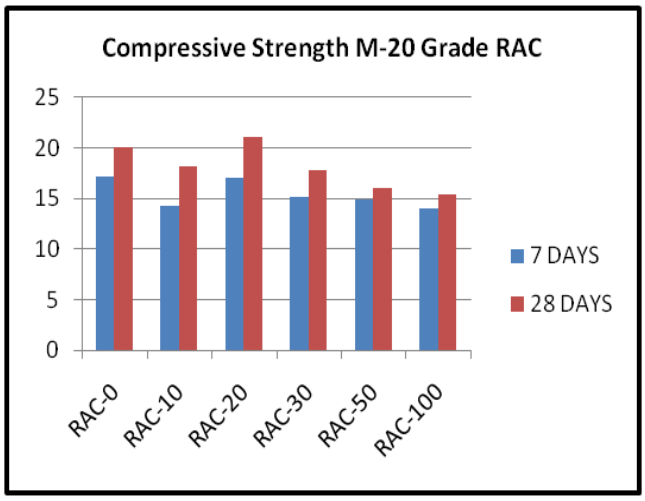
Table No 3 Compressive strength values

MIX	GRADE	Compressive Strength (N/mm^2)	
		7 days	28 days
RAC-0	M-20	17.11	20.1
	M-25	18.13	25.89
RAC-10	M-20	14.30	18.23
	M-25	16.41	23.40
RAC-20	M-20	17.10	21.14
	M-25	19.12	26.22
RAC-30	M-20	15.12	17.80
	M-25	16.95	23.22
RAC-50	M-20	14.95	16.09
	M-25	15.53	22.71
RAC-100	M-20	14.01	15.44
	M-25	14.21	24.55

Graph No 1 Analysis of Compressive strength for M-20 Grade RAC



Graph No 2 Analysis of Compressive strength for M-20 Grade RAC



SUMMARY AND CONCLUSIONS

The following conclusions have been made based on the results of this study:

1. With the same w/c ratio, the slump value decreases if percentage of demolished aggregates is increased.
2. The compressive strength of Recycled Aggregate Concrete was lower than that of Natural Aggregate Concrete but if 20% demolished waste is used then it will give more characteristics strength to that of natural aggregate used concrete.
3. Strength decreases with 30% replacement and with 10% and 20% of demolished waste it gives more result as compared to normal aggregate concrete.
4. The relationship of w/c ratio and compressive strength of demolished waste concrete is inversely proportional.
5. Recycled concrete can be effectively used in low cost housing where slab load is not high , it can also be used in the construction of boundary wall columns and for other construction where compressive load is not too much .
6. By using recycled aggregates in concrete problem of dumping demolished waste can be minimized.
7. Using recycled aggregates in concrete also reduces environmental pollution, which would otherwise would have been produced during crushing of gravels as coarse aggregate for concrete

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