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Construction Industry Waste Management- An Experimental Case Study Of Recycled Aggregate Concrete

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ABSTRACT: *The rapid economic growth of country has lead to heavy investment in construction of new infrastructure and replacement of older infrastructure. This has lead to a new variety of solid waste that environmental engineers have to contend with namely, Construction & Demolition (C&D) waste. It has been reported that a portion of this waste can be recycled and reused as aggregate. Recycled aggregate is eco-friendly, economical and solves the construction industry waste management problem. It has, however, not been commercialized on a large scale yet (due to lack of extensive results, though research efforts are currently underway) and is so far been used in the construction of roads on a very minor note. Here the recycled aggregate properties have been studied along-with the strength properties of concrete. In this research work, a comparison between natural aggregate (NA) and recycled aggregate (RA) has been done and various proportions of NA: RA (0:100, 60:40, 70:30, 80:20 and 100:0) have been experimentally tested for efficacy of use in two concrete mixes (M20 and M25). Tests on aggregates such as Impact Value Test, Abrasion Value Test, Aggregate Crushing Test, and of concrete such as Compression Test has been carried out in both the mixes to come to a specific conclusion.*

Keywords - *Abrasion Value, Compressive Strength, Crushing Value, Impact Value, Natural Aggregate, Recycled Aggregate, Recycled Aggregate Concrete.*

I. Introduction

Any construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, mud, wood, and so on. However, the cement concrete remains the main construction material used in construction industries. For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize and lead to proper utilization of energy. To achieve this, major emphasis must be laid on the use of wastes and by-products in cement and concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. In that case, the aggregates considered are slag, power plant wastes, recycled concrete, mining and quarrying wastes, waste glass, incinerator residue, red mud, burnt clay, sawdust, combustor ash and foundry sand. The enormous quantities of demolished concrete are available at various construction sites, which are now posing a serious problem of disposal in urban areas. This can easily be recycled as aggregate and used in concrete. Research & Development activities have been taken up all over the world for proving its feasibility, economic viability and cost effectiveness. When structures made of concrete are demolished or renovated, **concrete recycling** is an increasingly common method of utilizing the rubble. Concrete was once routinely trucked to landfills for disposal, but recycling has a number of benefits that have made it a more attractive option in this age of greater environmental awareness, more environmental laws, and the desire to keep construction costs down. Table I shows the quantity of C&D wastes generated per year.
Research work is being carried out to determine whether it can be used for heavy construction works, however extensive results are not yet available. Recycled aggregates are currently used for low construction works such as construction of pavements etc. The contribution of this paper emphasizes on the aggregate properties where they are tested and compared with natural aggregate. Focus has been laid on one of the strength characteristics of recycled aggregate concrete to come to a specific conclusion related to the strength parameters of RAC and thereby the possibility of using recycled aggregates in construction industry while also managing this waste from C&D activities.

Table 1. Quantity of Constituent Generated per Annum

Constituent	Quantity Generated in million Tons p.a. (Range)
Soil, sand & gravel	4.20 – 5.14
Bricks & masonary	3.60 – 4.40
Concrete	2.40 – 3.67
Metals	0.60 – 0.73
Bitumen	0.25 – 0.30
Wood	0.25 – 0.30
Others	0.10 – 0.15

Source: Technology Information, Forecasting and Assessment, Department of Science and Technology, Government of India

II. METHODOLOGY

Recycled aggregate was arranged from site of IL&FS Environmental Infrastructure and Services Ltd at Burari, New Delhi. On the basis of consideration of two concrete mixes, i.e. M20 and M25, the standard proportions are considered i.e. 1:1.5:3 and 1:1:2 respectively. The water-content of M20 and M25 is 0.5 and 0.45 respectively. The concrete mix design has been carried out using IS 456:2000. Recycled aggregate of 20 mm has been used. 43 grade Ordinary Portland cement (OPC) has been used. 3 different mixes of natural aggregate (NA) and recycled aggregate (RA) i.e. NA: RA have been considered for experimental purposes such as (NA: RA) 60:40, 70:30 and 80:20 respectively; which gives the composition as follows:

Table 2. Composition of Concrete Mixes

Material	**M20 (Weight in kgs)**	**M25 (Weight in kgs)**
Cement	4.19	5.77
Sand	7.96	9.23
Aggregate	15.95	14.62
Water	1.89	2.89

III. AGGREGATE IMPACT VALUE TEST

The aggregate impact value test was performed according to the standard procedure and the following results were obtained.

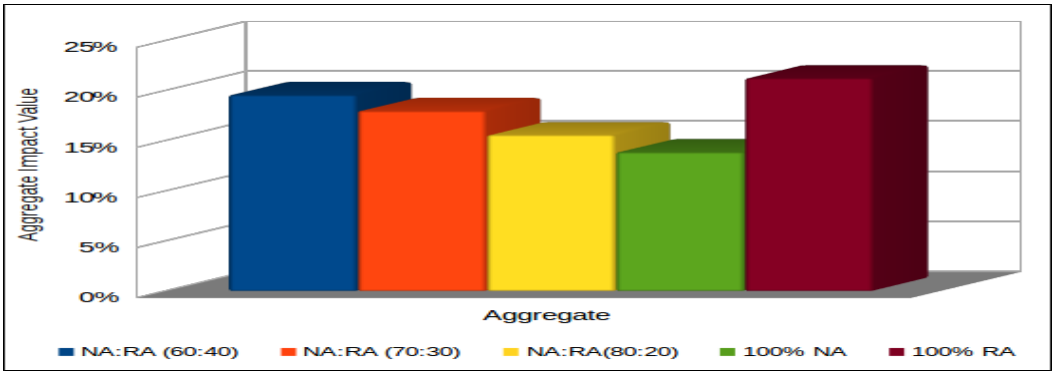

Fig.1. Aggregate values for various mix proportions of natural and recycled aggregate

Table 3. Recommended Aggregate Impact Values

S.N.	**Aggregate Impact Value**	**Classification**
1	<20%	Exceptionally strong
2	10-20%	Strong
3	20-30%	Satisfactory for road surfacing
4	>35%	Weak for road surfacing

According to the recommended values as specified by Indian Road Congress, higher the aggregate impact value, lower is its impact strength. The aggregate with less than 20% of the aggregate impact value is exceptionally strong. So the natural aggregate is exceptionally strong and can be used for wearing course. Focusing on the recycled aggregate, the recycled aggregate has the highest aggregate impact value of 21.27% which makes it satisfactory for road surfacing. The mixes of NA: RA of 60:40 and 70:30 are strong with values of 19.6 % and 18% respectively, making it suitable for wearing course again, but the mix of NA: RA of 80:20 has given the best result amongst all the mixes and RA as well i.e. of 15.6% and makes it exceptionally strong.

IV. AGGREGATE ABRASION VALUE TEST

The aggregate abrasion value test was performed according to the standard procedure and the following results were obtained.

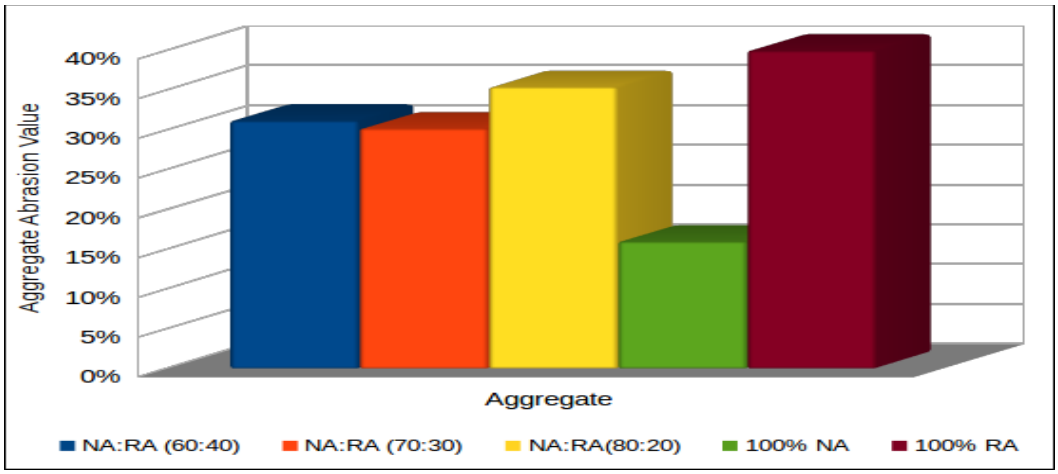

Fig.2. Aggregate Abrasion values for various mix proportions of natural and recycled aggregates

Table 4. Recommended Aggregate Abrasion Values

S.N.	Type of pavement	Max permissible abrasion value in %
1	Water bound macadam sub base course	60
2	WBM base course with bituminous surfacing	50
3	Bituminous bound macadam	50
4	WBM surfacing course	40
5	Bituminous surface dressing, cement concrete surface course	35
6	Bituminous concrete surface course	30

According to the recommended values as specified by Indian Road Congress, Higher the aggregate abrasion value, lower is it abrasion strength. Natural aggregate has the abrasion value of 16% and can be recommended for all types of pavements. Recycled aggregate has the abrasion value of 40% recommended for 5 types of pavements from 40% to 60% as shown above in the table. NA: RA of 60:40 has abrasion value of 31.2% and NA: RA of 80:20 has abrasion value of 35.42% may be recommended for all pavements except bituminous concrete surface course and 70:30 of 30.2% lies in the same criteria of natural aggregate. So, the mix of NA: RA of 70:30 is the best amongst all mixes and also RA in terms of aggregate abrasion value result.

V. AGGREGATE CRUSHING VALUE TEST

The aggregate crushing strength test was performed according to the standard procedure and the following results were obtained.

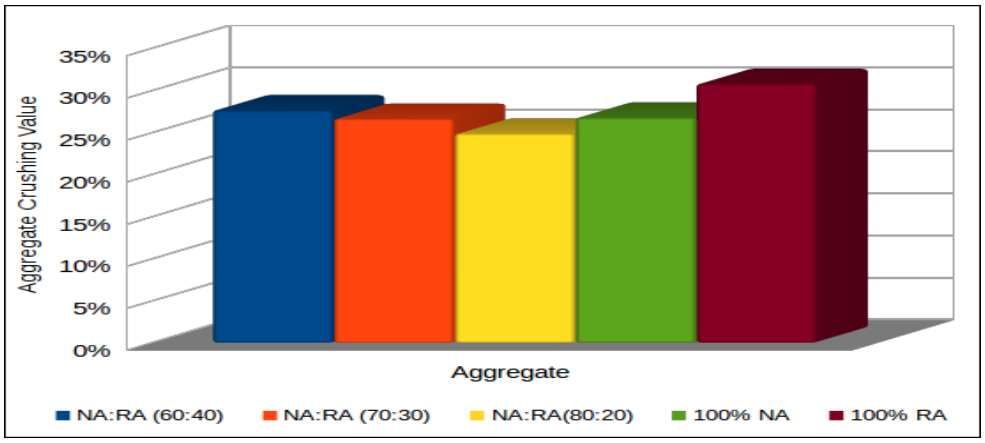

Fig.3. Aggregate Crushing Values for various mix proportions of natural and recycled aggregates

Indian Road Congress recommends that the aggregate crushing value should not exceed 30%. Recycled aggregate obtained crushing value of 30.77% which can still be considered. The aggregate crushing value of NA: RA of 60:40, 70:30 and 80:20 are 27.63%, 26.64% and 24.86% respectively with that of natural aggregate of 26.76%. The mix of NA: RA of 80:20 proved to be the best as it gave the best results amongst all the case studied here. Higher is the crushing value; lower is its crushing strength.

VI. COMPRESSIVE STRENGTH TEST OF RAC

The compressive strength test of recycled aggregate concrete (RAC) was performed according to the standard procedure and the results were obtained as follows:

Fig.4. Procedure of compressive strength test being executed

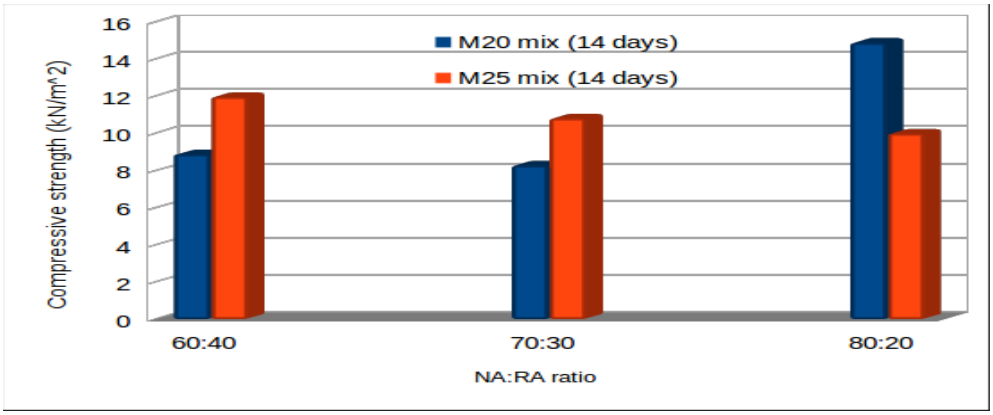

Fig.5. Compressive Strength of M20 and M 25 mix with various mix proportions of natural and recycled aggregates at 14 days respectively

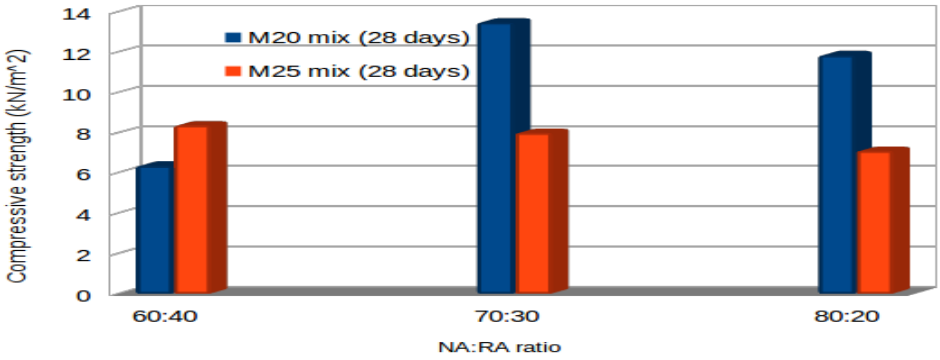

Fig.6. Compressive Strength of M20 and M 25 mix with various mix proportions of natural and recycled aggregates at 28 days respectively

The compressive strength of RAC decreased on the 28th day as compared to the 14th day for both M20 and M25 mixes and all NA: RA proportions, except for one case (Fig. 5.6). It didn't attain the recommended compressive strength of 20 MPA and 25 MPA respectively on the 28th day. It is possible that adding recycled aggregate to the concrete resulted in increased water demand resulting in decreased compressive strength of the concrete cube sample. Another possible reason of these unexpected results is the lack of any admixtures in our concrete mixes Natural aggregates would attain more compressive strength than recycled aggregate for obvious practical reasons.

VII. CONCLUSION

The NA: RA mix of 70:30and 80:20 have consistently given better results as compared to mix proportion of 60:40 and thus, may be recommended for sustainable and economic development of concrete. So, it is still suitable for low level construction works like that of pavements etc.The compressive strength results of the recycled aggregate were somewhat ambiguous and can be improved by adding admixtures like chemical admixtures etc. Certain concrete strength tests may be executed to analyze RCA in terms of its strength parameters. Our investigation shows that instead of dumping C&D waste, it can be processed to obtain recycled aggregate and used in the construction of pavements etc. This may turn out to be economical as it will save cost, help us manage this waste (reuse instead of landfilling) and lead to sustainable development in construction industry.

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