Deconstruction Waste Management through Recycling of Demolished Coarse Aggregate in Pavements

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Abstract— The construction industry is responsible for 50% of the solid waste generated worldwide. Governments around the world formulate legislation and regulations concerning recycling and re-using building materials, aiming to reduce waste and environmental impact. In addition, previous researches mainly focused on construction waste management. There are few studies about the deconstruction waste management focusing on demolition. To fill this gap, this paper aims to develop a framework using a purpose of improving multiple uses and thus developing a deconstruction waste management system to improve demolition efficiency, effective recycling and effective cost savings. In particular, to identify and measure recyclable materials, as well as to develop a plan for the recycling process. Concrete continues to be the foremost consumed construction material within the world, solely next to water. This truth is because of its appealing properties of high compressive strength and therefore the property of mould ability to any conceivable form. Due to speedy increase in construction activities, it's vital to assess the number of construction and demolition waste being generated and analyse the practices required to handle this waste from the purpose of waste management and disposal and additionally with relevancy waste utilization in concrete from the property aspects. Construction and Demolition (C&D) waste constitutes a serious portion of total solid waste production within the world, and most of it's employed in landfills. This study reports some attention-grabbing results of the use of recycled coarse aggregates in concrete from construction and dismantled waste. Due to high demand for construction activities in recent years in Bharat and every one over the planet, the natural aggregates resources area unit remarkably waning day by day.

Key words: Recycling Building Material, Deconstruction, Sustainability, Waste Management, Multiple Applications

I. Introduction

The environmental downside arising from unscientific and indiscriminate disposal of Municipal Solid Waste (MSW) may be a real menace for the entire society. These wastes area unit increasing day by day thanks to increase in population, urbanization, and industrialization. Solid Waste Management (SWM) is considered as one of the most immediate and serious environmental problem particularly in developing countries. MSW includes wastes like product packaging, newspapers, workplace and schoolroom papers, bottles and cans, boxes, wood pallets, food scraps, grass clippings, clothing, furniture, appliances, automobile tires, consumer electronics, batteries, excluding construction and demolition debris, bio-solids (sewage sludge's), industrial process wastes, etc. These materials, over time, have cared-for be handled one by one. Reducing carbon foot print due to less crushing. The use of Recycled Aggregates for the production of concrete involves breaking demolished concrete into materials with specified size and quality. These materials will then be combined to provide combination of a planned grading and therefore may be employed in concrete. In India, despite handiness of big quantity of demolition waste, very few efforts have been done on the utilization of this waste to wealth. Therefore, A systematic study has been undertaken to utilize Recycled Coarse Aggregate as a partial replacement for Natural Coarse Aggregates for development M25, M40 grade concrete. The Recycled Coarse Aggregates are used intrinsically (unwashed) moreover as in washed kind for comparison purpose with management concrete victimization Natural Aggregates. Engineering properties and durability aspects of the hardened concrete prepared with the replacement of Natural Coarse Aggregates with Recycled Coarse Aggregates are discussed.

As widely known from scientific literature, Recycled Coarse Aggregates (RCA) are particularly characterized by significantly higher water absorption capacity and lower mechanical properties with respect to the "Natural" gravel and sand employed to produce ordinary concretes. The reason for such behaviour could be the higher porosity that is characterizing the outer layers of crushed concrete particles or debris. Since this outer structure of Recycled Coarse Aggregate is clearly affecting the relevant physical and mechanical properties of Recycled Aggregate Concrete, a certain attention is usually paid to monitor these effects, possibly by means of their additionally induced water content, in terms of workability at the fresh state and strength of the hardened material. The experimental activities described in this work were carried out at the Laboratories. Rubblization is a construction and engineering technique that involves saving time and transportation costs by reducing existing concrete into rubble at its current location rather than hauling it to another location. Rubblization has primary applications: creating a base for new roadways.

In road construction, an alternative way of recycling demolished construction waste concrete by means of rubblization where cost is no longer a issue to execute the process. As mentioned a worn-out Portland cement concrete can be rubblized and then overlaid with a new surface, usually asphalt concrete. Specialized equipment breaks up the old roadway into small pieces to make a base for new pavement. This saves the expense of transporting the previous pavement to a disposal website, and purchasing/transporting new base materials for the replacement paving. The result is a smoother pavement surface than would be obtained if a layer of asphalt were to be applied to the unbroken concrete surface. The technique has been used on roads since the late Nineteen Nineties, and is also being used for concrete airport runways. The rubblizing process provides many benefits versus other methods of road rehabilitation, such as crack and seat or removal and replacement of a concrete surface including: rubblizing a concrete surface is 46% less costly than take away and commutation concrete; rubblizing reduces road reconstruction time, from days of lane closures to hours, providing large savings to contractors and reduced impact on travelling public. To investigate the potential of such processing procedures on the final properties of concrete, Six batches of Mix M25,M40 concrete samples characterized by a 10% Coarse Aggregates replacement ratio (in equivalent volume) were produced. The mixtures were designed by taking into account the main properties of both Natural and Recycled components, such as grain-size distribution, water absorption capacity and specific mass. Then, an experimental programme was performed to analyse the rheological behaviour and the time evolution of the relevant mechanical properties of concrete made with Recycled Aggregates and the results are compared with ordinary concretes.

II. Methodology

The materials required for the concrete mix were collected from different sources. Then those materials were tested to know all the properties of materials. Obtained residues, aggregates and other materials when sieved, and then distinguished the materials into various alternate purposes in constructions. The fines obtained from the demolished waste used as a replacement for the fine aggregates in cc pavement where it reduces the heat of hydration as well as increases or maintains the same strength as mentions in cement functions in it. The present work has been undertaken to study the effect of Recycled Coarse Aggregate on the mechanical properties of concrete, when coarse-aggregates is replaced by Recycled Coarse Aggregates in different percentages i.e. 0%, 10%, 20%, 30%, 40%, 50%. The main parameter investigated was cube compressive strength and flexural strength. The tests were conducted on M25 and M40 grade of concrete with a water cement ratio 0.44. In this study, M25 and M40 grades of concrete mixes were prepared as per IS: 10262-2009. In this mix design constant water cement ratio of 0.44 with targeted slump of 25-75mm by the replacement of 0%, 10%, 20%, 30%, 40%, & 50% of coarse aggregate with Recycled Coarse Aggregate was maintained. Based on the design mix the concrete mix is prepared, slump cone test & compaction factor test was conducted on fresh concrete for knowing workability of concrete. Specimens of dimensions 150mm x 150mm x 150mm cubes for compressive strength were casted. A total number of 36 concrete cube specimens were to be cashed out of which 18 concrete cube specimens for 7 days & remaining 18 concrete cube specimens for 28 days for each 10% increase of Recycled Coarse Aggregate were casted to study the corresponding compressive strength.

A. Recycling of Aggregates from the Demolished Waste

The Aggregates which were recycled from the debris of demolished waste is known as the Recycled Coarse Aggregates.

B. Collection of Demolished Waste

The demolished waste of footings, slab., etc. in HPCL, Visakhapatnam, the age of the demolished waste were 7 years. The demolished waste consists of concrete along with the reinforcement. The concrete was separated from the reinforcement and the required quantity of 50kgs of Recycled Coarse Aggregates was collected. The demolished waste obtained from the site were exposed to weather (i.e., to sun & rain). The aggregates separated from the concrete and were taken to then processing.

C. Processing of Recycled Aggregates

The recycled aggregates received from the demolished waste were processed in the following steps:

1) The aggregates are separated from the concrete of 20mm maximum size. The cement & fine material should be removed up to 90% which was in contact with the concrete. The aggregates should be washed with water of required pressure and then dried to sun drying.
2) The first process is generally performed on demolition waste to produce RCAs. In addition, the second one was specially carried out to possibly enhance the quality of RCAs and, with this, the mechanical properties of Recycled Aggregates Concrete (RAC). The third was performed in order to remove the cement or fine attached to the aggregates. Thus, several experimental tests were performed on RAC samples to determine their key physical and mechanical properties and possibly compare the results with the corresponding samples made with ordinary natural aggregates, characterized by specific mass, grain size distribution and so on.

III. Materials Characterization

A. Cement

Ordinary cement of grade i.e., OPC53 satisfying the requests of IS: 4031-1968. The physical properties of respective grade cement.

B. Fine Aggregates

Sand is the one of the main components, grading zone-III of IS 2386 (Part-3)-1963 was used with specific gravity of 2.61 and moisture content of 0.3% at 24 hours.

C. Coarse Aggregates

Mechanically crushed stone from a quarry with 20mm maximum size, satisfying to IS 2386 (Part-3)-1963 was used. The specific gravity was found to be 2.79 and moisture content is 0.15% at 24 hours.

D. Recycled Coarse Aggregates

Aggregates obtained by the process of construction and demolition waste area unit referred to as recycled aggregates. Recycled Coarse Aggregate for the experimental analysis was procured from the C & D waste of footings in HPCL, Visakhapatnam. The specific gravity was found to be 2.65 and moisture content is 0.43% at 24 hours.

Fig. 1: Recycled Coarse Aggregate

S.No.	Properties	TestResults	Recommended IS Code	Code Requirement
1	Specific Gravity	3.1	IS: 4031-1968 Part-4	3.1-3.18
2	Standard Consistency	34%	IS: 4031-1988 Part-4	33-35mm
3	Initial Setting Time	45min	IS: 4031-1988 Part-5	<30min
	Final Setting Time	2Hr45min	IS: 4031-1988 Part-5	>600min
5	Fineness	2.267%	IS: 4031-1988 Part-2	10 % residue on 90 µ sieve (max)
6	Compressive strength, MPa			
	3 days	30.10	IS: 4031-1968	27 MPa (Min)
	7 days	38.20		37 MPa (Min)
	28 days	50.23		53 MPa (Min)

Table 1: Physical Properties of Cement

S.No.	Properties	Value	Recommended IS Codes
1	Specific gravity Zone III sand	2.61	IS 2386 (Part-3)-1963
2	Moisture content	0.4%	IS 2386 (Part-3)-1963
3	Bulk density	1.718 Kg/m^3	IS 2386 (Part-3)-1963
4	Fineness modulus	2.72	IS 2386 (Part-3)-1963
5	Bulking of sand	18 % at 6 % of water added	IS 2386 (Part-3)-1963
6	Water absorption	7.4%	IS 2386 (Part-3)-1963

Table 2: Physical Properties of Fine Aggregate

S.No.	Properties	Value	Recommended IS Codes
1	Specific gravity	2.79	IS 2386 (Part-3)-1963
2	Moisture content	0.15% for 24 hrs	IS 2386 (Part-3)-1963
3	Bulk density	1.738 Kg/m^3	IS 2386 (Part-3)-1963
4	Fineness modulus	1.93	IS 2386 (Part-3)-1963
5	Los angles abrasion	23.4%	IS 2386 (Part-3)-1963
6	Water absorption	3.6%	IS 2386 (Part-3)-1963

Table 3: Physical Properties of Coarse Aggregate

S.No.	Properties	Value	Recommended IS Codes
1	Specific gravity	2.65	IS 2386 (Part-3)-1963
2	Moisture content	0.43% for 24 hrs	IS 2386 (Part-3)-1963
3	Bulk density	1.577 Kg/m^3	IS 2386 (Part-3)-1963
4	Fineness modulus	1.96	IS 2386 (Part-3)-1963
5	Los angles abrasion	31.2%	IS 2386 (Part-3)-1963
6	Water absorption	5.05%	IS 2386 (Part-3)-1963

Table 4: Physical Properties of Recycled Coarse Aggregate

IV. RESULTS & DISCUSSIONS

MIX PROPORTION	VALUES	
	SLUMP	COMPACTION FACTOR
0%RCA	70	0.9
10%RCA	57	0.9
20%RCA	37	0.85
30%RCA	0	0.93
40%RCA	33	0.86
50%RCA	34	0.87

Table 5: Results of Workability Tests on Fresh Concrete

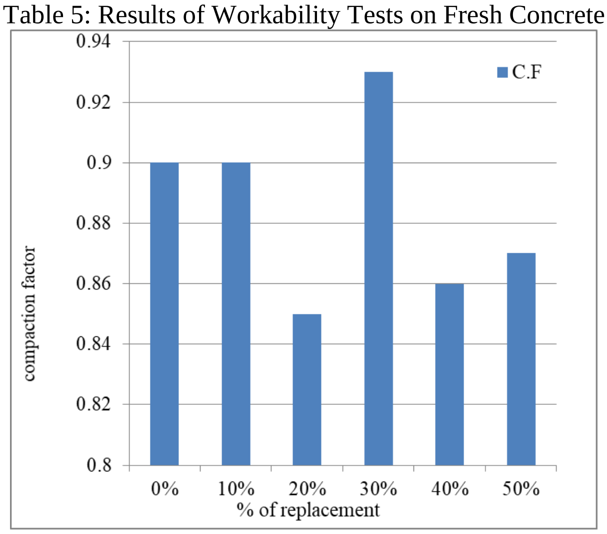

Fig. 2: Mix Proportion Vs Slump

The above graph shows the variation of slump and compaction factor values for different replacements of Recycled Coarse Aggregates in Recycled Aggregate Concrete along with conventional concrete.

Compressive strength of M25 concrete for various percentages of Recycled Aggregate Concrete is given below:

S.No.	COMPRESSSIVE STRENGTH (N/mm^2)	
	7 DAYS	28 DAYS
1	20.4	26.67
2	19.5	24.44
3	19.5	25.78`
AVERAGE	19.8	25.63

Table 6: Compressive Strength of M25 Concrete without Any Additions

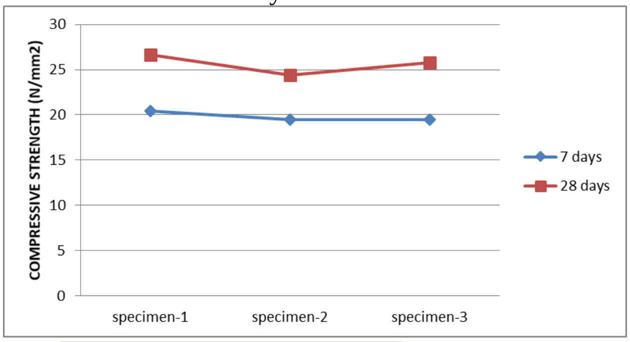

Fig. 3: Compressive Strength of M25 Concrete without Any Additions

Average compressive strength of M25 concrete mix for different percentages of recycled coarse aggregate:

S.No.	% OF REPLACEMENT OF RCA	Compressive Strength (N/mm^2)	
		7 DAYS	28 DAYS
1	0 %	19.8	25.63
2	10 %	15.11	23.11
3	20 %	13.60	21.33
4	30 %	13	21.03
5	40 %	20.74	30.07
6	50 %	16.3	25.18

Table.7: Average Compressive Strength of M25 Concrete Mix for Different Percentages of Recycled Coarse Aggregate

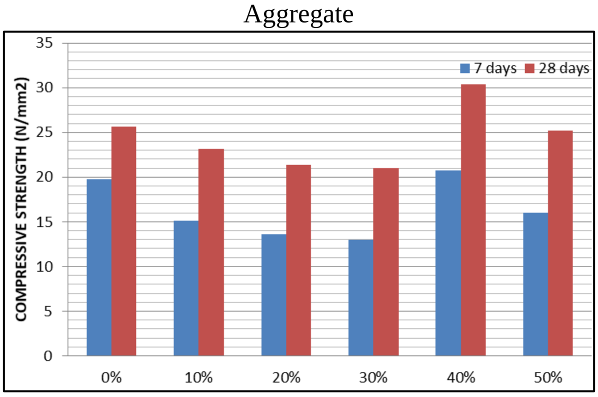

Fig. 4: Compressive Strength of M25 Concrete For Different Percentages Of Recycled Coarse Aggregate

The above graph shows that the Compressive strength of Recycled Aggregate Concrete is lower than the Normal concrete upto 30% replacement of Recycled Coarse Aggregate, and from 30% there is an increase in the Compressive strength of Recycled Aggregate Concrete than Normal Concrete.

Water absorption of M25 concrete for various percentages of RAC is given below:

S.No.	Percentage of replacement	Water absorption values
1	0%	6.67 %
2	10%	7.52 %
3	20%	8.04 %
4	30%	8.79 %
5	40%	6.52 %
6	50%	6 %

Table 8: Water Absorption Test

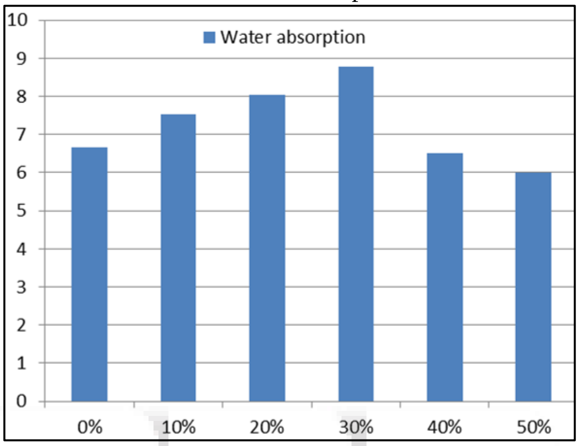

Fig. 5: Water Absorption Test

Other Various Application of Methodologies Use of RCA Were As Follow

- It can sometimes actually be used as the aggregate in new concrete.
- It can be crushed to a fine, uniform appearance and used in landscaping.
- It can be crushed and turned into new base layers for new roads.
- Large chunks can be used for erosion control avoidance.
- It Can be used for construction gutters, pavements etc. as providing the min size of the aggregates and also the fines for the replacement of the cement of concrete waste.
- Production of RAC also results in generation of many by-products having many uses such as a ground Improvement material, a concrete addition, an asphalt filler etc. This is seen as been essential to reduce the total amount of waste going into landfill, especially in the urban areas where land is very scarce.
- By providing these obtained fines from recycled concrete we can reduce the heat of hydration in cement and by providing same dependent strength to the dry lean concrete in rigid pavements.
- In flexible pavements partial replacement of sub base course aggregates to attain same strength as original aggregate in the same time maintaining the reduction of cost of aggregate.
- All retained by-products of unused waste is also used as a back fillings. The RCA is used as a embankments next after to the paves for flexible pavements to avoid soil

erosion in high levels and even in some limit to of floody areas to minimize the effect cause to some rate.

– The residues passed below the 4.75μ sieve those fines are also used as asphalt type of material for the flexible pavements on BT roads as a wearing surface coat powder which to be blended with original material functions on it.

V. Conclusions

Recycling and reuse of building wastes have been found to be an appropriate solution to the problems of dumping hundreds of thousands tons of debris accompanied with shortage of natural coarse aggregates. The use of recycled coarse aggregates in concrete prove to be a valuable building materials in technical, environment and economical. Recycled Coarse Aggregate possess relatively lower bulk density and higher abrasion values, water absorption as compared to Natural Coarse Aggregate.

The compressive strength of recycled aggregate concrete is relatively lower than natural aggregate concrete. And the flexural values is also better compared to the natural aggregate used. The variation also depends on the original concrete from which the aggregates have been obtained. The durability parameters studied confirms suitability of NCA & RCA in making durable concrete structures of selected types. (Check the value of bulk density and water absorption) (As we written that bulk density and water absorption will change so check the values). There are several reliable applications for using recycled coarse aggregate in construction. There is an increase after 30% when recycled coarse aggregate is used up to 30% it's decreasing.

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