Investigation and Utilization of Construction and Demolition (C&D) Waste into Low-Cost Construction Materials

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Abstract— Total cost of housing construction, building materials contributes to more than 60% of cost in developing countries like India. The increase in the popularity and fashion of construction is growing big on a large-scale. The old structures are demolished to construct new and the solid waste accumulation turns to be higher in alarming rates. In addition the waste generated during the process of construction makes space run out in the sites and it needs to be evacuated. C&D waste collectively called as Construction and Demolition waste has evolved itself as a great threat by polluting the environment and ecosystem. Moreover, the natural resources and materials are depleting quickly, where production of new materials also causes pollution and paves way for Global Warming. Hence a proper method shall be employed in reducing the generation of the waste. This could be achieved by adopting a proper planned progressive systematic approach in recycling the generated debris. To avoid the depletion of the natural resources and reduce the pollution to a considerable quantity, the waste generated in Construction and Demolition process shall be recycled. It shall be achieved by removing the shortcomings in recycling process. This paper illustrates the need and proper reasoning for using and employing the recycled C&D waste in construction activities. The general parameters between the conventional and recycled raw materials (coarse aggregate) are studied, tested and results were obtained. A clear comparative study on the parameters based on physical and mechanical properties shall be done extensively in determining the strength properties of aggregates. A final conclusion shall be arrived based on the obtained results.

Keywords: Construction and Demolition waste, Recycling process, Strength properties, Global warming, Recycled Coarse aggregate

I. INTRODUCTION

India is a developing country and hence requires large amount of resources to develop the infrastructure face of the nation. Since it is the 7th largest nation and the 2nd populous nation in the world, the need for infrastructure development is inevitable.

Due to these facts the construction industry is facing many crises and requires an immediate solution to boom. One such issue is the shortage of raw materials, particularly the shortage of raw materials like fine and coarse aggregates. But we have adopted m-sand for fine aggregate and hence that issue is solved. In case of coarse aggregate, the proper alternative is yet to find and it should be viable. It is not an easy task too as the availability should also be high. To eliminate such hindrances, the coarse aggregates available in the process of construction and demolition as a waste material are made use as a raw material for concrete and construction. To do so, the properties of both Conventional Aggregate (CA) and Recycled Aggregate (RA) are well studied. The compressive strength, Split tensile strength, Flexural strength and the Bond strength of the CA and RA are tested, studied and the final conclusion is arrived based on the results. A complete overview on the results is discussed. The reasons behind the limited usage of RA as raw materials by the construction industries are also discussed.

II. AIM OF THE WORK

The main Aim of the work is to determine whether the target mean strength of both the Recycled and Conventional Aggregate are both the same when used in the structural and other construction activities.

III. NEED OF THIS WORK

1) To promote sustainable development
2) To manage the C&D waste
3) To decrease disposal of wastage
4) To apply Reduce, Reuse, Recycle and Recover
5) To promote awareness in Recycling

IV. SCOPE OF THE WORK

The experimental investigation is carried out by casting required number of cubes, cylinders and prisms to determine the Compressive, Split Tensile, Flexural and Bond Strength of the specimens. The obtained results are compared between the Natural Aggregate Concrete (NAC) and Recycled Aggregate Concrete (RAC) by using 100% virgin natural aggregates and 100% recycled aggregates for normal M30 grade of concrete.

V. RESEARCH SIGNIFICANCE

There are several research papers done in determining the strength and durability of the recycled concrete. In this paper the natural and recycled aggregate concrete specimens are tested and the results are discussed in detail. Moreover the drawbacks and hindrances in the recycling process and the problems in using the recycle waste by industries is discussed briefly.

VI. LITERATURE REVIEW

C&D waste is considered as a great threat to the society when it is not disposed properly. Since it is a challenging task, it should be recycled in a proper manner. Employing a correct mechanism to recycle the C&D waste will reduce the environmental degradation and generate income as less raw materials are used and also reduces the relay on new raw materials. C&D waste management is a tedious task and hence requires a planning procedure to clear the hindrances hidden. Identifying the problems associated with the

managing of C&D waste and using them as a secondary raw material should be done in a progressive systematic approach. Studying the Strength and Durability factors of the recycled waste helps in construction process and research conducted on the C&D waste. Proper experimental study on the strength parameters is done to utilize the C&D waste at sites. Discussion on requirement of a legal system that enforces strict laws to process the C&D waste is done. In addition, the decreasing of dumping the waste in the dump yards and landfills can be decreased in a sensible rate by adopting these procedures properly.

VII. EXPERIMENTAL PROGRAMMES

The materials that are used in this research paper work are

1) Cement
2) Water
3) Fine aggregate
4) Coarse aggregate (Natural & Recycled)

The Recycled waste aggregate is collected from the nearby site and then well crushed and sieved. The physical properties of both the coarse and fine aggregate are studied as per IS2386:1963[7] and IS383:2016[8]. The table 1 and 2 represents the properties of Cement, Fine and Coarse aggregate. The Portable water that is free from chemicals and impurities is used for the study.

SI.No.	Properties of Cement	Test Results	IS:12269-1987[9] Specifications
1	Specific Gravity	3.13	-----
2	Normal Consistency	34%	-----
3	Initial Setting Time	43 min.	Not less than 30 minutes
4	Final Setting Time	260 min.	Not more than 600 minutes
5	Fineness	3150 $cm^2/gm.$	Should not be less than 2250 $cm^2/gm.$
6	Compressive Strength	54.5 MPa.	53MPa.

Table 1: Physical properties of Cement

Property		Natural Aggregate	Recycled Aggregate	Fine Aggregate
Bulk Density	Loose	1506kg/m^3	1489kg/m^3	1677kg/m^3
	Compacted	1729kg/m^3	1689kg/m^3	
Aggregate Impact value		12.6%	18.3%	-
Crushing strength MPa		22.26%	21.4%	-
Fineness Modulus		7.11	7.21	3.06
Specific Gravity		2.79	2.83	2.65
Water Absorption (%)		2%	2%	0.89

Table 2: Physical properties of Aggregates

VIII. MIX PROPORTIONING

The M30 grade of concrete was used. The mix design was carried out as per the IS 10262:2009[10]. Extra water of 1% (by weight of cement) was added to 'Recycled Aggregate Concrete' as the recycled aggregate absorbs more water which is relatively high when compared to natural aggregates. The major properties of the raw materials like cement, fine aggregate, coarse aggregate (natural and recycled) were investigated. The recycled aggregates are completely replaced in the place of natural aggregates.

Material	Quantity (kg/m^3) for Natural aggregates	Quantity (kg/m^3) for Recycled aggregates
Grade of concrete	M30	M30
Cement in kg	448	448
Fine Aggregate in kg	782	782
Coarse Aggregate (20mm) Natural Aggregates	1062	-
Coarse Aggregate(20mm) Recycled Aggregates	-	1062
Water in litres	197	197

Table 3: Quantity of Materials

IX. RESULTS AND DISCUSSIONS

The Workability of the Natural Aggregates and the Recycled Aggregates are assessed with the help of Slump cone test and the Compaction factor test. Based on the observations, the slump is found to be 78mm and the compaction factor values is found to be 0.87 for M30 grade of recycled aggregate concrete. The improvement in the workability is due to the change of fraction of coarse aggregate.

A. Compressive Strength

The concrete specimen of 150mm cubes are casted, cured and are tested on regular intervals of 7, 14, and 28 days for Compressive strength under the uniaxial loading as per IS: 516-1999[11]. The target strengths are achieved by the M30 grade concrete specimens using both Natural and recycled aggregates. Since the obtained results have very less differences, the production and employing the recycled aggregates and replacing the natural aggregates on 100% is encouraged. In case of need of addition of extra water is required, the mitigation of aggregates is done by adding the Super plasticizers that are also called as High Range Water Reducers.

The results after testing the specimens at a regular interval of 7, 14 and 28 days is tabulated in the table and a graphical representation is done to interpret the results

Type Of Aggregate	Grade Of Concrete	Compressive Strength Of Concrete		
		7 days	14 days	28 days
Natural Aggregate	M_{30}	19.6 N/mm^2	23.4 N/mm^2	29.2 N/mm^2

Recycled Aggregate	M_{30}	18.5 N/mm^2	21.2 N/mm^2	28.3 N/mm^2

Table 4: Compressive Strength of concrete

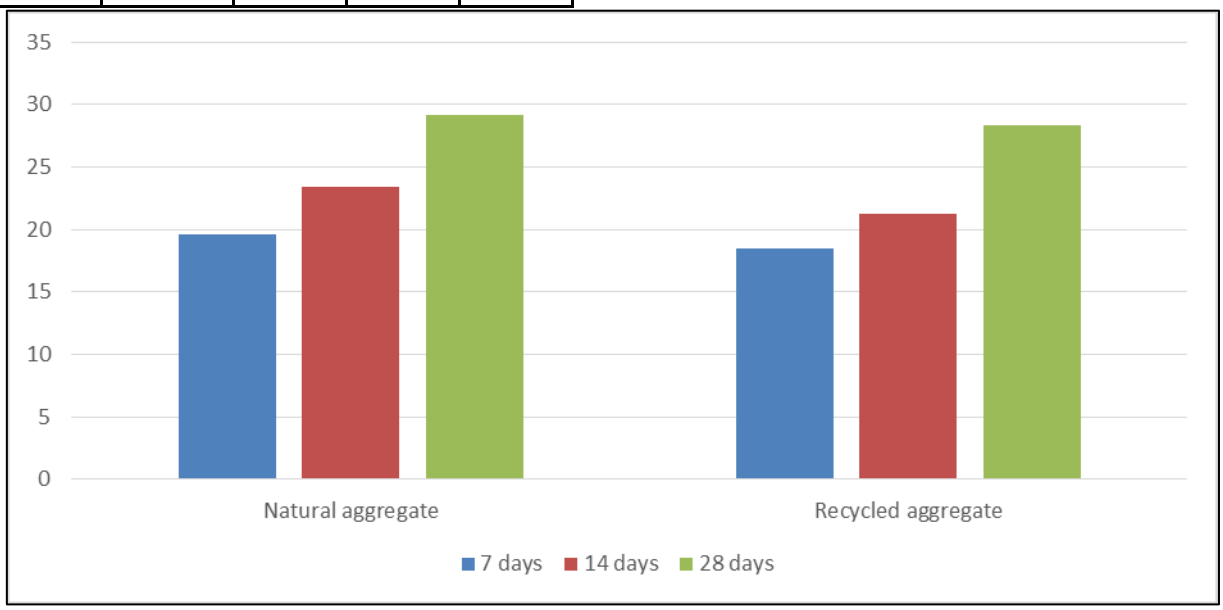

Fig. 1: Graphical representation of Compressive Strength of Concrete

B. Split Tensile Strength

The concrete specimen of cylinder 150mm in diameter and 300mm in height is casted and cured with M30 grade of concrete to carry out the investigation. After the completion of curing at regular intervals of 7, 14 and 28 days, the specimen are tested to study the Split tensile strength of concrete as per the IS: 516-1959[12]. The split tensile strength of the natural aggregates is competitively high than the natural aggregates due to the presence of weak Interfacial transition Zone (ITZ). Though the weak ITZ causes inconsistency in shape, size, age and the grade of the concrete, it is not in a high scale here. This can also be improved by the addition of fibres and the mineral admixtures to the concrete.

The results after testing the specimens at a regular interval of 7, 14 and 28 days is tabulated in the table and a graphical representation is done to interpret the results.

Type Of Aggregate	Grade Of Concrete	Split Tensile Strength Of Concrete		
		7 days	14 days	28 days
Natural Aggregate	M_{30}	2.27 MPa	2.44 MPa	2.807 MPa
Recycled Aggregate	M_{30}	2.12 MPa	2.31 MPa	2.62 MPa

Table 5: Split Tensile Strength of concrete

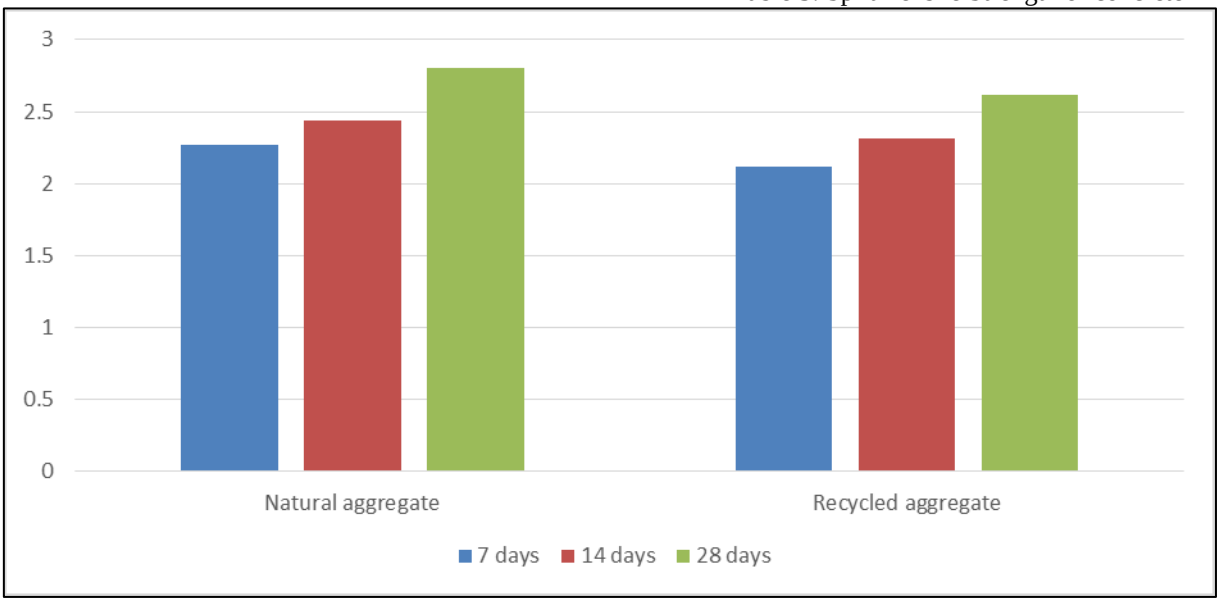

Fig. 2: Graphical representation of Split Tensile Strength of Concrete

C. Flexural Strength

The concrete specimen of Prisms of size 100mm*100mm*500mm in height, width and length is casted and cured with M30 grade of concrete to carry out the investigation. After the completion of curing at regular intervals of 7, 14 and 28 days, the specimen are tested to study the Flexural strength of concrete as per the IS: 516-1959[11]. The Flexural strength of the natural aggregates is competitively high than the natural aggregates due to the presence of weak Interfacial transition Zone (ITZ). Though the weak ITZ causes inconsistency in shape, size, age and the grade of the concrete, it is not in a high scale here. This can also be improved by the addition of fibres and the mineral admixtures to the concrete.

The results after testing the specimens at a regular interval of 7, 14 and 28 days is tabulated in the table and a graphical representation is done to interpret the results.

Type Of Aggregate	Grade Of Concrete	Flexural Strength Of Concrete		
		7 days	14 days	28 days
Natural Aggregate	M_{30}	3.36 MPa	3.77 MPa	4.16 MPa
Recycled Aggregate	M_{30}	3.22 MPa	3.61 MPa	4.01 MPa

Table 6: Flexural Strength of concrete

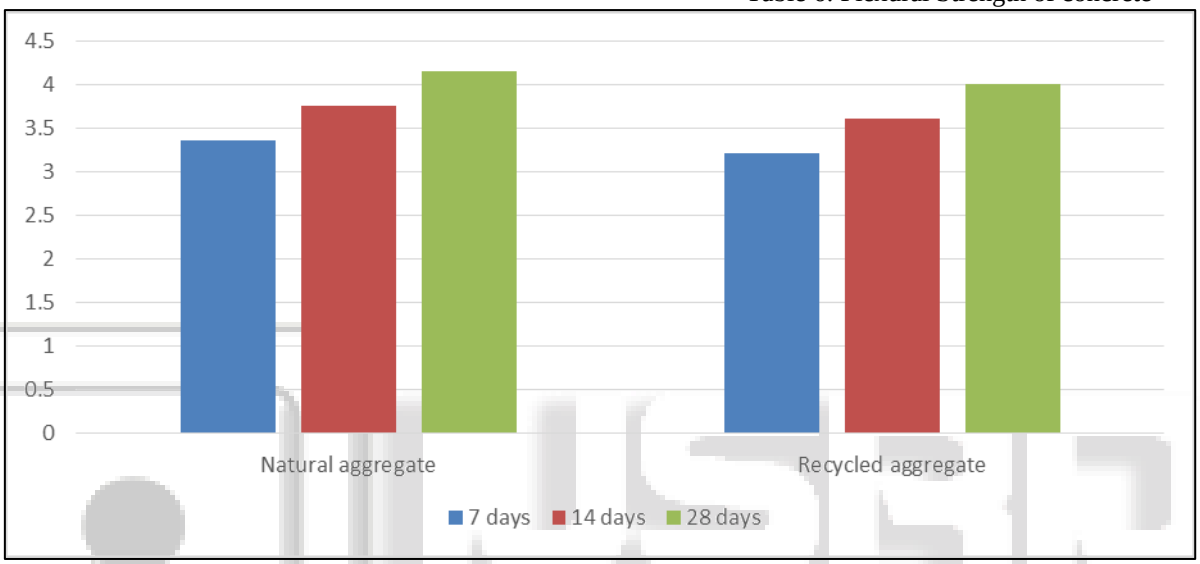

Fig. 3: Graphical representation of Flexural Strength of Concrete

D. Bond Strength

The concrete specimen of cylinder 150mm in diameter and 300mm in height is casted. A 16mm diameter reinforced rod is inserted to 20mm deep into the cylinder and cured with M30 grade of concrete to carry out the investigation. After the completion of curing at 28 days interval, the specimen are tested to study the Bond strength of concrete as per the IS: 2700-1967Part-1[12]. The Bond strength of the natural aggregates is competitively high than the natural aggregates due to the presence of weak Interfacial transition Zone (ITZ). Though the weak ITZ causes inconsistency in shape, size, age and the grade of the concrete, it is not in a high scale here. This can also be improved by the addition of fibres and the mineral admixtures to the concrete.

The results after testing the specimens at an interval 28 days is tabulated in the table and the results are interpreted.

Type of Aggregate	Grade of Concrete	Ultimate Bond Stress
Natural Aggregate	M30	4.4 MPa
Recycled Aggregate	M30	4.2 MPa

Table 7: Bond Strength of Concrete

X. CONCLUSIONS

The complete research work focusses on the determination of the strength properties of the recycled aggregates used in the concrete. After studying various research works done by many research scholars, the basic concept is understood. To go ahead with the research work, the waste materials are collected from the nearby site and then crushed well. They are sieved to get a regular size and shape. These aggregates are tested initially for their properties and based on these properties, the proper Mix proportions is arrives based on the codal provisions. Using this mix, the specimens are casted and cured well. At regular intervals these specimen are removed and tested for their strength properties and the results are noted down. Based on the results obtained, a conclusion is arrived. The recycled aggregates can be used replacing the natural aggregates in the concrete for commercial use. There are very less shortcomings in it. After the rectification, these recycled aggregates prove to be higher in strength than the natural aggregates. Moreover, the advantages in using the recycled aggregates is very high when compared to their disadvantages. Since the obtained results vary on a small marginal scale, the deviations are negligible. Hence the usage of recycled aggregates over the natural aggregates is advisable. For obtaining very high

strengths, the aggregates has to be treated and well-conditioned.

Providing a large employment opportunities, these recycling business would be the future of the construction industry thereby saving the nature and eco-system. This research work concludes that the usage of recycled aggregates does not decrease or interfere with the strength of the concrete.

XI. FUTURE WORK

Highly extensive research work is required on the durability of recycled aggregate concrete for structural applications, since durability also plays a vital role in the properties of concrete.

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