Partial Replacement of Coarse Aggregates with Demolition Waste In Construction

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ABSTRACT

India will be producing 2.2 billion tons of construction and demolition waste by 2025 as per 2012 world bank report. We are having limited land area and the second highest population in the world, so we can't afford the wastage of natural resources. So, we must have to start the recycling and reuse of C&D waste for protection of our environment and prevention of pollution. Recycling of C&D waste is done by crushing the waste in the machine, after that crushed material is sieved in order to get particular sized aggregate. It has been established that C&D can be reuse for new construction work as well as for renovation of existing projects. It will serve as dual benefits of saving landfill space and will reduced the amount of extraction of raw material for new construction work. Government policies and laws should be reformed to motivate and make C&D waste management mandatory for all types of construction activities. In the present study we will use the demolished waste like old Concrete for partial replacement of coarse aggregates.

Keywords: Demolition waste, Coarse aggregate, OPC (43) grade, recycling.

1. INTRODUCTION

The construction activity requires several inputs like concrete, steel, brick, stone, clay, mud, wood, glass etc. However, the concrete remains the main construction material used in construction industries. Concrete consumption in the world is estimated at two and a half tons per capita per year. 2.62 billion tons of cement, 13.12 billion tons of aggregate, 1.75 billion tons of water is necessary to prepare this volume (Mohammed et al. 2014). The generation of aggregates in itself is a lengthy and tedious process as it involves the cutting of mountains or breaking river gravels or boulders, or breaking clay bricks. All these processes demand the huge inputs like labor, machinery and transportation etc. The working of machinery and transportation of the processed material (aggregates) also results in the environmental pollution and at the same time we are utilizing the natural resources. The recycling of demolished concrete will also result in to creation of additional business opportunities, saving money and saving the cost of disposal.

At present, the amount of global demolished concrete is estimated at 2–3 billion tons. 20% of normal aggregates can be saved by recycling of demolished concrete. The amount of demolished concrete will be increased to 7.5–12.5 billion tons in the next 10 years (Mohammed et al. 2014). Globally, cities generate about 1.3 billion tone of solid waste per year. India had generated 530 MT constructions and demolition waste in 2013, a 2014 report by CSE, New Delhi. In 2010, a sub-Group under the Working

Group on Solid Waste was constituted by the MoEF recommended segregation of the waste at source, development of institutional mechanisms for waste collection, reuse and reprocessing, formulation of standards, and amendments to the MSWM Rules, 2000 for sensuring collection, utilization and safe disposal of C&D waste (Centre for Science and Environment, New Delhi 2014). Even then till today practically there is no proper framework for management of construction and demolition waste in the India which has resulted in illegal dumping of waste here and there.

2. LITERATURE REVIEW

C & D waste: Demolition waste is the waste produced by demolishing or renewing the old buildings made up of concrete (Hegde et al. 2018). Now days most of the buildings are renovated as per new requirement. The renovation of old buildings produces 10 times the waste as compared to new construction (Centre for Science and Environment, New Delhi 2014). Building waste production of 2 to 3 billion tonnes per annum is estimated at global level, of which 30-40 % is concrete (Vilas and Guilberto (2007) The composition of waste is shown in figure 1.

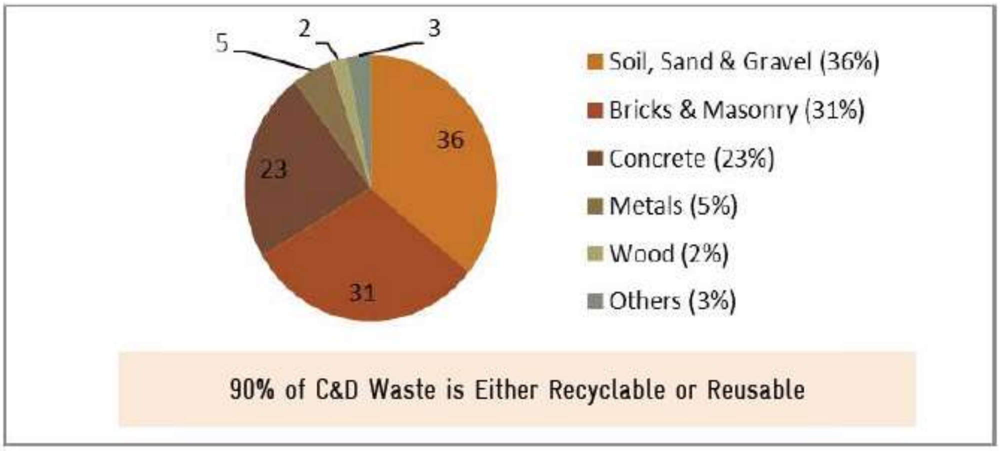

Figure 1 Composition of Construction and demolition waste in India

(Pappu, Saxena et al., 2007) showed 14.5 million tones/year C&D waste in India. CPCB estimated quantum of solid waste generation in India to be 48 million tonnes per annum for year 2000, out of which 12 to 14.7 million tonnes was from construction industry (Pappu, A. and, M. Saxena, et al. (2007) and TIFAC, Ed. (2000). Thus, it is highly recommended to recycle the demolished waste in order to prevent the environmental pollution and reduction in the construction cost.

Classification of C&D waste: The classification of C&D waste facilitates the final destination of the waste. According to the Brazilian National Waste Policy C&D waste are classified as follows (Rodrigo Eduardo Córdoba, et al., 2017): Class A – reusable or recyclable waste as aggregates, such as ceramic components (bricks, blocks), grout and concrete; Class B – recyclable waste for other destinations, such as plastics, metals, wood and gypsum; Class C – waste without economically viable technologies or applications for recycling or recovery; Class D – hazardous waste, such as paints, oils and asbestos.

C&D Waste Management Policy in India: In 2016, the Ministry of Environment, Forest and Climate Change (MoEFCC) notified the Construction & Demolition Waste Management Rules, 2016 to regulate the handling and management of C&D waste generated in India. According to the new rules, various stakeholders involved in C&D waste generation and management have been assigned specific responsibilities. Local government entities are designated to play a central role in organizing C&D

waste management in their jurisdiction and targets/timelines have been set for implementation (Achu R. Sekhar et al., 2017).

C&D Waste Reuse and Recycling: According to CPCB solid waste generation in India is 48 million tons per annum, out of which 25% is from construction industry. TIFAC (Technology Information, Forecasting and Assessment Council) has estimated that 12 to 14.7 million tons waste is produced from construction industry per annum out of which 7-8 million tons are concrete and brick waste. 70 percent people are not aware of the recycling techniques and 30 percent people are not even aware of recycling possibilities Going through literature it is found that many researchers have investigated the partial replacement of aggregates by demolished concrete waste. Monish et al., 2013 studied that the compressive strength of recycled concrete up to 30% coarse aggregate replacement (C. A. R.) by demolished waste. At the end of 28 d has been found to be comparable to the conventional concrete (Mohd Monish, et al., 2013).

Vijayvenkatesh Chandrasekaran observed that the Recycled aggregates are found to possess a relatively low bulk density, high crushing and impact values and high-water absorption as compared to natural aggregate. The variations are dependent on the original concrete from which the aggregates have been obtained. Gadde, 2017 Studied Partial Replacement of Coarse Aggregate by Demolished Concrete and concluded that particular mix obtained had high strength in between 25 – 50 percent replacement (Gadde, Kumar, and K. Abhiram 2017). In a study carried out by (Soutsos et. al., 2011) showed that there were no practical problems with the use of recycled demolition aggregate in the manufacture of building blocks. They also concluded that there was no requirement to increase the cement content to maintain the required strength, and therefore there would be no additional cost to the manufacturers if they use recycled demolition aggregate for concrete building block production (Soutsos, Tang, and Millard 2011). The crushed ceramic waste can also be used as partial replacement of conventional coarse aggregate up to 40 percent, without affecting the design strength (Kamala and Rao 2012). These studies have shown the possibilities of using C&D waste in construction.

3. MATERIALS AND METHODS

Materials Test on Cement:- Ordinary Portland Cement 43 grade was used in the casting the specimens.

Table (1): Properties of Cement

S.No	Properties	Observed Value
1	Normal consistency	28%
2.	Inital setting time	110 mint
3	Final setting time	320 mint
4	Soundness	2.5mm
5	Fineness	0.95%
6	Specific Gravity	3.15

Fine aggregate: The code to be referred to understand the specification for fine aggregates is: IS 383:1970. Sand of size less than 4.75 mm was used as fine aggregate. The Specific gravity of fine aggregate and fineness modulus was 2.63 and 2.80.

Coarse aggregate: The code to be referred to understand the specification for coarse aggregates is: IS 383:1970. Hard granite broken stones of less than 20mm size were used as coarse aggregate Demolished waste- Demolished waste as a pozzolanic material was used to partially replace with coarse aggregate.

Table (2): Properties of Aggregate

S. No	Properties	Natural Coarse Aggregate	Recycled Coarse Aggregate
1	Specific Gravity	2.84	2.45
2	Impact Value	15.20	19.30
3	Water Absorption	0.95	5.62
4	Crushing Test	20.5	22
5	Size of Aggregate	20mm	20mm

Test Specimens: - The specimen consisting of 150mm×150mm×150mm cubes for compressive strength and 150mm diameter and 300 mm height of cylinder casted for split tensile strength. Using different percentage demolished concrete 20mm size for M25 grade of concrete mix were casted and tested

Curing of Concrete: - The casted cube and cylinder immersed in potable water for 7, 28 days. The curing temperature of water in tank is maintained 27-30-degree Celsius.

Concrete Mix Design

Mix Design: A mix design is a method of calculating the amount of coarse aggregate, fine aggregate, cement content and water content. Mix design of concrete was done as per IS 10262: 2009 [Digpal Singh Raghuwanshi, 2017]

<u>Specification of Materials: -</u>

Grade Designation= M25
Type of Cement= OPC43 Grade
Maximum Nominal size of aggregate =20mm
Workability= 75mm (Slump)
Admixture = Auramix200
Water Cement Ratio = 0.50
Fine Aggregate Zone= Zone2
S.G of Cement=3.15
S.G of Fine Aggregate = 2.63
S.G of Coarse Aggregate= 2.84
Method of Concrete Placing = Manual
Exposer Condition-Mild

Trial Mix-1
Mix Proportion for Normal Concrete
Cement- 383.2 kg/m^3
Fine Aggregate (Sand)- 800.94 kg/m^3

Coarse aggregate = 1087.75kg/m^3
Water= 191.6 kg/m^3
Admixture= 2.09kg/m^2
W/C Ratio= 0.5

Trial Mix-2
Mix Proportion for replacement of 10% Concrete aggregate by Demolised M25 concrete
Cement- 383.2 kg/m^3
Fine Aggregate (Sand)-800.94Kg/m^3
Coarse Aggregate - 978.975 kg/m^3
Demolished aggregate- 108.775 kg/m^3
Admixture-2.09kg/m^3
Water- 191.6kg/m^3
W/C Ratio- 0.5

Trial Mix-3
Mix Proportion for replacement of 15% Concrete aggregate by Demolished concrete
Cement- 383.2 kg/m^3
Fine Aggregate (Sand)-800.94Kg/m^3
Coarse Aggregate - 924.59 kg/m^3
Demolished aggregate- 163.16 kg/m^3
Admixture- 2.09kg/m^3
Water- 191.6 kg/m^3
W/C Ratio- 0.5

Trial Mix-4
Mix Proportion for replacement of 20% Concrete aggregate by Demolished M25 concrete
Cement- 383.2 kg/m^3
Fine Aggregate (Sand)-800.94Kg/m^3
Coarse Aggregate - 870.2 kg/m^3
Demolished aggregate- 217.55 kg/m^3
Admixture-2.09kg/m^3
Water- 191.6 kg/m^3
W/C Ratio- 0.5

Test on Fresh Concrete
- Slump Cone Test
- Compaction Factor Test

Table (3): Comparison Between Workability of Different Concrete

S.No	Type of concrete	%of Replacement	Slump Value (mm)	Compacting Factor
1	Normal Concrete	0	75	0.920
2	RCA Concrete	10	80	0.925
3	RCA Concrete	15	85	0.931
4	RCA Concrete	20	90	0.945

Test on Hardened Concrete

- Compressive strength
- Split tensile Strength

Table (4): Compressive strength of Concrete in N/mm^2

Type of concrete	%Replacement of RCA	After 7Days	After 28Days
Normal Concrete	0%	22.81	28.73
RCA Concrete	10%	21.73	28.07
RCA Concrete	15%	21.25	27.25
RCA Concrete	20%	20.39	26.36

Table (5): Split Tensile Strength of concrete in MPa

Type of concrete	%Replacement of RCA	After 7 Days	After28 Days
Normal concrete	0%	2.64	3.63
RCA Concrete	10%	2.53	3.30
RCA Concrete	15%	2.40	3.23
RCA Concrete	20%	2.22	3.15

4. RESULTS AND DISCUSSION

The water absorption, impact value and bulk density of RCA is higher than natural coarse aggregate. The strength of concrete for production of RCA has effect on absorbability and specific gravity of recycled replacement of coarse aggregate with recycled in different proportion had been done. The proportion replacement was 100:0, 90:10, 85:15, and 80:20 with 0%, 10%, 15% and 20% respectively. The cube of concrete was tested for compressive strength after 7 and 28 days of curing. The results indicated that the compressive strength and split tensile strength of demolished concrete decreased with increasing the percentage of RCA (recycled coarse aggregate) in concrete as compared to conventional concrete.

The comparison of Compressive strength and split tensile strength of normal concrete with that of recycled concrete has been shown in Figure 2 & Figure 3.

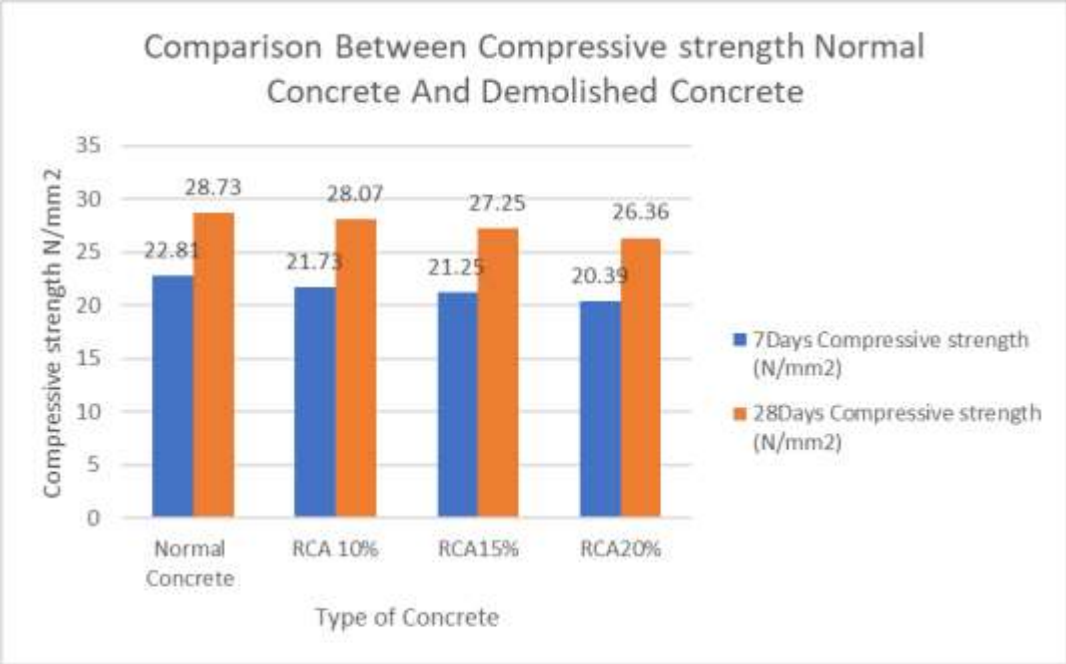

Figure 2 Comparison Chart of Compressive strength Test

Figure 3 Comparison Chart of Split Tensile Strength

The Slump value of concrete is increased by increasing the percentage of recycled aggregate and the results are presented in Table No - 1 Workability of demolished concrete with replacement of recycled coarse aggregate observed to be increased slightly as compared to conventional concrete.

The use of recycled coarse aggregate up to 20 Percent did not affect the functional requirement of structure as per calculated test result.

5. SUMMARY

The C&D waste generation in India is increasing day by day due to fast growth of urbanization and industrialization. Hence there is need to minimize and handle the C&D waste efficiently to ensure sustainable development of the country. Recycling of C&D waste is done by crushing the waste in the machine, after that crushed material is sieved in order to get particular sized aggregate. Heavy particles are crushed again for size reduction purpose.

These sieved wastes can be used as coarse and fine aggregate for construction and other works. It will serve as dual benefits of saving landfill space and will reduced the amount of extraction of raw material for new construction work. Government policies and laws should be reformed to motivate and make C&D waste management mandatory for all types of construction activities. 3Rs policy and use of waste minimizing technologies e.g. design for deconstruction and reuse of materials should be adopted to minimize C&D waste. Indian Roads Congress and ISI have specified that the aggregate crushing value of the coarse aggregates used for cement concrete pavement at surface should not exceed 30%. For aggregates used for concrete other than for wearing surfaces, the aggregate crushing value shall not exceed 45%, according to the IS (Indian Standard) code.

6. CONCLUSION

In the present study we had used the demolished waste like demolished concrete for partial replacement of coarse aggregates in varying percentage. To study the behavior of demolished concrete which includes slump value, compressive strength and split tensile strength as compared to conventional concrete. The Specimen were casted with 10%, 15% and 20% replacement of recycled coarse aggregate and tested after 7 & 28 days in Laboratory.

The following conclusions were made during the study: -

1. As we observed that the demolished concrete found to lower bulk density, higher workability, crushing strength, impact value and water absorption value as compared to normal concrete.
2. Use of recycled coarse aggregate up to 20% did not affect the functional requirement of structure as per calculated test result.
3. The 10%, 15% and 20% recycled coarse aggregate replaced with normal concrete. It resulted that the strength of demolished concrete decreased as compared to normal concrete.

By use of recycle coarse aggregate in concrete reduce the cost of project and prevent the environment from pollution which are polluted by blasting and quarrying of aggregate this is turn directly reduce the waste impact of construction on environment.

REFERENCES

1. Mohammed, Tarek Uddin et al. 2014. “Recycling of Brick Aggregate Concrete as Coarse Aggregate.” Journal of Materials in Civil Engineering B4014005(January): 1–9
2. Centre for Science and Environment, New Delhi, India. 2014. DEMOLITION WASTE
3. Achu R. Sekhar, Krishna Chandran, Vaibhav Rathi, Training Manual on Construction and Demolition Waste Management in India for Cities and Towns, (2017), New Delhi, India.
4. Hegde, Ramakrishna et al. 2018. “A Study on Strength Characteristics of Concrete by Replacing Coarse Aggregate by Demolished Column Waste.” International Journal of Engineering Ressearch & Technology 7(6): 386-95.
5. Mohd Monish, Vikas Srivastava, V.C. Agarwal, P.K. Mehta and Rakesh Kumar, (2013), Demolished waste as coarse aggregate in concrete, J. Acad. Indus. Res. Vol. 1(9) .
6. Monish, Mohd et al. 2013. “Demolished Waste as Coarse Aggregate in Concrete.” Jounal of Academia and Industrial Research 1(9): 540–42.
7. Pappu, A., M. Saxena, et al. (2007). “Solid Wastes Generation in India and their Recycling Potential in Building Materials.” Building and Environment 42: 2311-2320.
8. Soutsos, Marios N., Kangkang Tang, and Stephen G. Millard. 2011. “Concrete Building Blocks Made with Recycled Demolition Aggregate.” Construction and Building Materials 25(2): 726–35. http://dx.doi.org/10.1016/j.conbuildmat.2010.07.014.
9. Kamala, R, and B Krishna Rao. 2012. “Reuse of Solid Waste from Building Demolition for

the Replacement of Natural Aggregates." International Journal of Engineering and Advanced Technology 2(1): 74–76.

10. Rodrigo Eduardo Córdoba, José da Costa Marques Neto, Cristine Diniz Santiago, Erica Pugliesi, Valdir Schalch (2017), Alternative construction and demolition (C&D) waste characterization method proposal, Eng Sanit Ambient, vol.24, no. 1, 199-212
11. Vilas and Guilberto (2007). "Construction and Demolition Waste Management: Current Practices in Asia." International Conference on Sustainable Solid Waste Management, Chennai, India.