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Effect on strength of concrete by partial replacement of natural aggregates with recycled aggregates

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ABSTRACT

India is surging ahead with a renewed focus on urbanization & industrialization to maintain a sustainable growth & development. However, with the ever-increasing population, rapid urbanization & industrialization the waste generation, as a result, natural resource consumption is also rising at the equal pace. The construction industry has gained fast growth in the recent decade due to above-mentioned sectors, which is directly proportional to Increase in demand for construction materials are huge for the construction activities which results in the generation of huge amount of construction waste. The production of waste due to the demolition of the structures is 10 times more than construction waste generated. So, there is a need for management of construction and demolition waste, as it is distinct from municipal solid waste. Construction and demolition waste to be considered as high volume, high risk since lakes, open lands, dumping yards, rivers, and roads are being encroached. That waste can be considered as a resource, either for reuse in its original form or recycling or energy recovery and public concerns about the environment, it is desirable to recycle materials from building demolition. Building material account for about half of the solid waste generated they have an environmental impact at every step of the building process. Despite this, most Construction and Demolition waste end up in Prodigious landfills happening in India. So, this study/survey limited to know strength of mixes in which natural aggregates are partially replaced with recycled aggregates in 0% , 20% 35% ,50% and 100%, cement and concrete consumed by Hyderabad, present methodology of handling construction and demolition waste and amount of c&d waste generated in Hyderabad.

***Keywords**: Recycled aggregate, Compressive strength, Tensile strength, Flexural strength, Impact strength, Solid waste, Recycling, Concrete construction, Demolition and waste management*

1. INTRODUCTION

In Hyderabad, the construction sector had a key role in the economic and social development of the city. The interest in the management of construction and demolition wastes (hereafter, C&D Wastes) arises as a result of the increased waste generation behind the housing boom of the past decades. Since then, C&D management has become an environmental problem, not because of its hazardous nature (since it is mostly inert) but for the lack of treatment of these wastes, which are taken to landfill in an uncontrolled way. This situation ties down the landfill space increases the number of illegal dumping and generates social opposition to the environmental degradation caused by the demolition process.

C&D waste a major part of the total municipal solid waste production and generated whenever any construction/ demolition activity takes place which is heavy, having high density, often bulky and occupy large storage space either on the road or municipal waste bin. It is routine to see large piles of such waste, which is heavy as well, a pileup on roads especially in large projects, resulting in traffic jams and disruption hence appropriate management of this waste is required.

With an enormous increase in the number of disposable materials on one hand and a continuing Shortage of dumping sites on the other, the waste disposal problems are assuming serious and at times, even alarming proportions. Protection of the environment and conservation of the rapidly decreasing natural resources should be the essence of sensible development.

Rapid industrial development poses serious problems of C&D waste disposal. On the other side, there is a critical shortage of natural aggregate for production of new concrete which increases in rainy season on the enormous amounts of demolished concrete produced from weathered and old structures creates severe ecological and environmental problem. Recycling of aggregate materials from construction and demolition waste may reduce the demand-supply gap in both these sector. Concrete and masonry waste can be recycled by segregating, crushing and sieving as per code provision. This recycled aggregate can be used to make concrete for road construction and building material. During the survey, we have visited 30+ ready-mix concrete plants, 120+ dismantling contractors, and dumpsite and construction sites in and around Hyderabad

While recycled aggregates square measure normally utilized as secondary aggregates in construction, to push recycled concrete aggregates in wider applications, it's to fulfill the wants for its meant use in this study experiments square measure conducted to check the result of exchange natural coarse aggregates by recycled aggregates on the properties of concrete. The recycled coarse combination is obtained from field razed concrete. Workability and strength characteristics square measure investigated by exchange natural coarse aggregates by recycled aggregates. the various proportion replacements of natural coarse aggregates by recycled aggregates thought-about square measure third, 20%, 35%, 50%, and 100%.The strength properties investigated on hardened concrete embrace compressive strength, lastingness, flexural strength and impact strength.

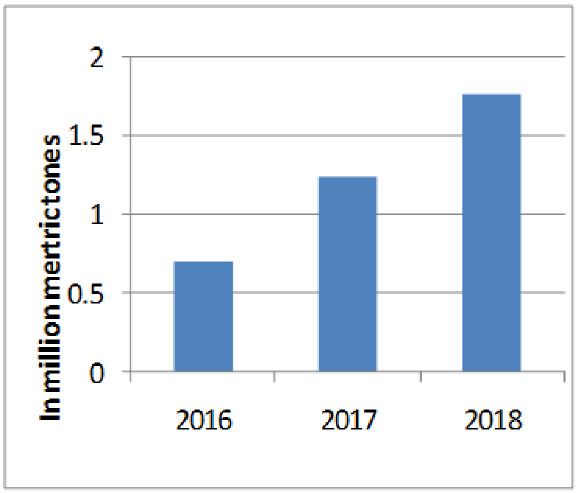
1.1 The objective of the study is to know: Present methodology of handling c&d waste and amount of c&d waste generated in Hyderabad

In normal, 90-95% of the total construction waste can be recycled and which can reduce the load on landfills which is around 25% of the total waste generated in Hyderabad. However, little has been done to manage and utilize C&D waste in a scientific manner. Always, private demolition contractors dump C&D waste in low- lying land secretly for a price or in an unofficial manner along roads or another public land. This increased illegal dumping is putting severe pressure on scarce urban land and is resulting in decreasing lifespans of the landfill.

C&D waste is a subset of municipal solid waste (MSW) and management of MSW is a mandatory function of all Urban Local Body's (ULB"s) under the Municipal Solid Waste (Management and Handling) Rules, 2000". The paucity of funds has not been an issue as the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) programme of the Ministry of Urban Development laid special emphasis on MSW management. However, despite huge investments and encouragement from the Central Government to invest in and adapt to the MSW (M&H) Rules 2000, only four out of 45 municipal corporations that were granted assistance under JNNURM for waste management have been able to complete their projects. The principal reasons reported for non-compliance were lack of technical knowledge, lack of community participation, and financial resources.

At the start as it's aforementioned that there's no adequate or satisfactory information for accessing to the present issue. this is often as a result of there's no separate restrictive framework for handling the development and demolition waste management in India because it is taken into account within the municipal solid waste management. Thanks to that it's obtaining troublesome to access the data or to handle the development and demolition waste management. As report ready by the MoEF (Ministry of surroundings and Forest) in 2008 calculable that zero.53 million tons/day of waste is generated within the country. Thereon basis the 210 million tons of MSW is created annually, table one shows the estimate ready by the central government of India. however as per the globe bank report says Asian countries produce around concerning 1000kg per capita each year, it suggests that the figure that expressed by the MoEF is extremely not up to the globe bank report figure. This show in India is underestimating the development and demolition waste handling. The figure below with graphical illustration shows construction and demolition waste production per day in Hyderabad.

In reference to above all contexts, data from GHMC, Newspapers, research papers, survey and from other means we have predicted the quantities of C&D waste generation



Graph 1: C&D waste estimation

Table 1: C&D waste estimation

Year	C&D waste generated in (M mt)
2016	0.732
2017	1.25
2018	1.762

1.2 Physical and mechanical Properties of recycled aggregate

1.2.1Research significance

Recycled aggregates area unit rarely used in structural applications; instead, they need to be been used as fillers in construction and in low-level applications, thanks to material defects appreciate massive water absorption capability and their elongated and angularity. The experimental results offer an encouraging trend towards utilization of recycled combinations from field destroyed concrete by mixing with natural aggregates in creating recycled aggregate concrete for structural applications. Experimental program**:**

1. To evaluate the properties of Recycled Coarse Aggregate and compare it with the Natural Coarse Aggregate Concrete.
2. To evaluate the performance of Recycled Aggregate Concrete in terms of its Compressive Strength, Flexural Strength and Split Tensile strength Days of curing and compare it with that of Natural Aggregate Concrete.

1.2.2 Mix proportion

The main parameter being % replacement of conventional aggregate with RCA. The two mixes with no RCA were taken as control specimens for comparison.

0%, 20%, 35%, 50% and 100% replacements were considered for both M30 and M35. For each mix 6cubes, 3cylinders and 3 prisms were cast and different mechanical properties like flexural strength and split tensile strength in addition to compression strength were determined. Finally, the optimum percentage of replacement is arrived to give the same strength as conventional aggregate.

The compression tests were carried out 28 days, whereas all other tests were carried out at 28 days. Ordinary Portland cement 53-grade brand conforming to I.S.I standard is used in the present investigation. The cement is tested for its various properties as per IS code. The results on cement are shown in table 2:

Table 2: Physical Properties of Portland cement 53 Grade IS: 269-2015

S. No.	Property	Test results
1	Normal consistency	31.5%
2	Specific gravity	3.14
3	Initial setting time Final setting time	30 min 160 min
4	The compressive strength of cement mortar cubes 7 days 28 days	 33 N/mm^2 53 N/mm^2

1.2.3 Properties of Aggregates

The sand is tested for various properties like specific gravity, bulk density etc., in accordance with IS 2386-1963(28). Grain size distribution of sand shows that it is close to the zone-2 of IS 383-1970(29).

Machine crushed angular granite metal from a local source is used as coarse aggregate. It is from impurities such as dust, clay particles, and organic matter etc. The coarse aggregate is also tested for its various properties. Properties of sand are shown in table 3 below.

Table 3: Properties of Aggregate

S. No.	Properties	Fine aggregate	Natural Coarse aggregate	Recycled Coarse aggregate
1	Specific Gravity	2.55	2.96	2.48
2	Density	1607.79kg /m^3	1517kg/m^3	1320kg/m
3	Fineness Modulus	2.64	6.85	6.78
4	Impact Value	-NA-	6.61 %	14.03%
5	Crushing Value	-NA-	21.42 %	32.50 %
6	Water absorption (percentage)	-NA-	0.4	2.37
7	Fineness Modulus	-NA-	6.8527	6.7758

1.2.4 Concrete mix Design and Testing

To investigate the Recycled aggregate, concrete cubes, beams, and cylinders replacing natural aggregate mix design were prepared. The mixes M-30 and M-35 grade were designed according to the ACI method using Absolute volume method. As suggested in the earlier literature with slight modification using IS code method. The exact method of mix design can be suggested at the end of the present investigation which will be continued even after the present examination.

Concrete cubes of size 150x150x150 mm were tested for compressive strength as per IS: 516-1959. To induce tensile strength, cylindrical specimens of size 150mm diameter and 300mm were tested as per IS:5816-1999. For flexural strength, beam specimens of size 100x100x500mm were tested. 2 point loading was adopted on an efficient span of 400mm to induce pure bending, whereas testing the beam specimens as per IS:516-1959. For impact strength, cylindrical specimens of 150mm diameter and 60mm height were ready and tested on Schruder's impact testing machine. A hammer of 45.4N was born from a height of 0.457m. No of blows needed to cause the 1st crack and final failure was noted all the way down to calculate impact strength.

1.2.4.1 Workability results: Table 4 below gives the workability test results as measured from slump test carried out with different percentage replacement of natural coarse aggregates by recycled aggregates. From the slump cone factor results, it was observed that as the percentage replacement of natural coarse aggregates by recycled aggregates is increased there is a marginal decrease in workability the slump values for recycled aggregate concrete (100% replacement) shows a decrease of about 13.3% for M30 and 17.1% for M35.

Table 4: Slump cone values

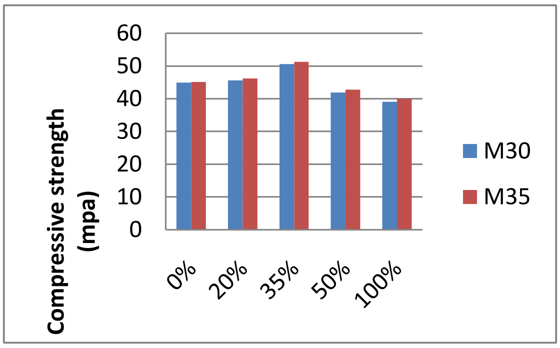
S. No.	Slump values with respect to % replacement of Rac	M30 (mm)	M35 (mm)
1	0%	75	76
2	20%	73	74
3	35%	70	68
4	50%	68	66
5	100%	65	63

1.2.4.2 Compressive strength test results: Referring to table 5 and graph2 28 days strength of M30 are as follows. There is an increase of 17.43% for control specimen over the expected strength at that point of time and an increase of 19.35% for 20% replacement, 32.28% for 35% replacement which is optimum and then percentage increase started, decreasing and it is higher than the expected strength at that point of time. The percentage increase being 9.5% for 50% replacement and 2.2% for 100% replacement.

Referring to same table and graph for M35 at 28days the percentage increase for control specimen was 4.27% over expected strength at that point of time and 6.97% for 20% replacement, 18.68% for 35% replacement which is the optimum value and then percentage decrease started decreasing which 1% slightly less than expected value for 50% replacement and 7% decrease for 100% replacement. In all the cases of replacement, there is an increase in strength only for 7days strength, as there is a decrease in strength at 28days for 50% and 100% replacement.

Table 5: Compressive strength of concrete at 28 Days of curing

% Replacement of Rac	Average 28 Days compression test (MPa) M30	Average 28 Days compression test (MPa) M35
0%	44.92	45.10
20%	45.65	46.24
35%	50.60	51.33
50%	41.91	42.84
100%	39.10	40.05



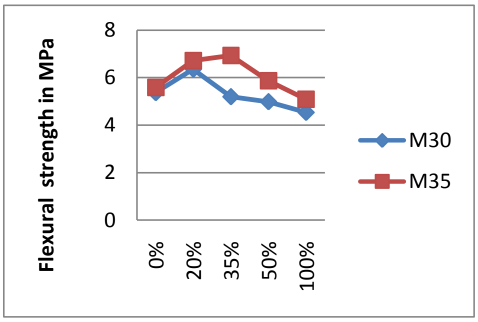
Graph 2: Showing the variation of the Compressive strength of M-30 and M-35grade concrete at 28D of curing

1.2.4.3 The Flexural strength of concrete: From Table 6 and Graph 3, it is observed that by replacing the natural aggregate with recycled aggregate the flexural strength values are followed.

The percentage increase in flexural strength is more than that in the codal provisions both for M30 and 35 for all replacement, but the optimum value of 6.36% increase observed for 20% replacement for M30 and the optimum value of 6.9% was observed for M35 at 50% replacement.

Table 6: Flexural strength of concrete at 28 Days of curing

Percentage of RCA	M-30 Grade (Mpa)	M-35 grade (Mpa)
0%	5.37	5.59
20%	6.36	6.72
35%	5.2	6.94
50%	4.99	5.87
100%	4.54	5.09



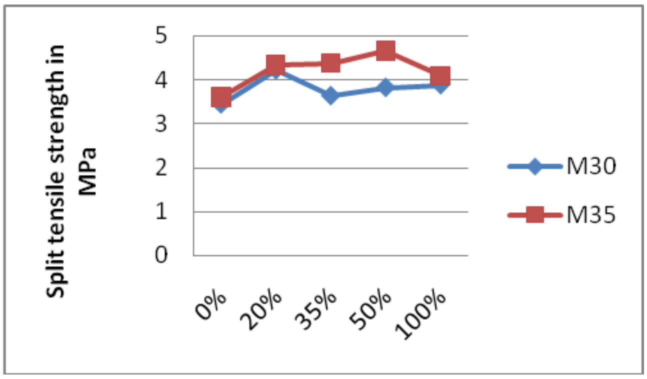
Graph 3: Showing the variation of the Flexural strength of M-30 and M-35 grade concrete

1.2.4.4 Split tensile strength: From Table 7 and Graph 4, it is observed that by replacing the natural aggregate with recycled aggregate the split tensile strength values are followed.

The optimum value was observed at 20% replacement though it is marginally less than the codal provision for M30 concrete. For M35 concrete the optimum value obtained at 50% replacement though marginally less than the codal provision.

Table 7: Split Tensile strength of concrete at 28 Days of curing

Percentage of RCA	M-30 Grade	M-35 Grade
0%	3.44	3.60
20%	4.23	4.34
35%	3.63	4.38
50%	3.82	4.66
100%	3.88	4.09



Graph 4: Showing the variation of the split tensile strength of M-30 and M-35 grade concrete

2. CONCLUSION

Natural resources are not unlimited. There is a global need to protect our environment and preserve our scarce natural resources for the next generations. .Recycling of Construction and demolition materials can help precious landfill space. On the basis of our comparative analysis of test results of the basic properties of concrete with different percentages of coarse recycled aggregate content (0%, 20%, 35%, 50% and 100%), the following conclusions are made:

- As per the tests conducted during this investigation for M30 & M35 mixes at 28days, the optimum value of replacement is 35%.
- At 7days, in cases of M30 & M35, there is an increase in strength in all cases of replacement.
- However for 28days strength, there is an increase in strength in all cases for M30, but for M35 after the optimum value of 35% replacement, there is a decrease in strength.
- When saturated surface dry aggregates were used. It is observed that there is a decrease in w/c ratio which is essential for higher strength.
- For replacement of natural aggregates by recycled aggregates up to 35%, the effects are marginal; indicating that recycled aggregate from field demolished concrete can be blended with natural aggregates up to 35% without any modification in the mix design for M30 and M35 grade concrete applications. Which reduces the load on environmental.

The Total C&D waste generated = 1.2M metric tons in Hyderabad for the year of 2017 which is going to increase up to 1.7M metric tons in 2018. These values show the potential market in recycling as well which reduces the load on environmental

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