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EXPERIMENTAL STUDY ON STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CONVENTIONAL AGGREGATES WITH RECYCLED AGGREGATES

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Abstract : Construction and demolition waste constitute one of the major components of waste generated worldwide. Very large quantities of aggregates are used in construction. When the useful life of the structure is over it will be demolished, and all the demolished wastes just find their way to landfills. Finding large areas for landfills is becoming very difficult. On the other hand, continuous extraction and quarrying of natural aggregates for construction is causing depletion of natural resources. The recycling of demolished construction waste aggregates to be used in new engineering application provides a promising solution to both problems. So, in order to reduce construction cost and resolving housing problems faced by the low-income communities of the India. This project/research includes an experimental study on concrete by taking partial replacement of coarse and fine aggregate with demolished waste to determine the compressive strength and flexural strength and results are compared with normal concrete.

Index Terms **-** Compressive strength, Flexural strength, Construction & Demolished waste, Recycled aggregates

I. INTRODUCTION

Concrete is the prime construction material used in practice. Constituents of concrete are binding material(cement), fine aggregate and coarse aggregate and water. Aggregates are naturally available and depleting day by day due to over exploitation for the sake of development activities. Owing to growing demand aggregates will not be available in plenty in near future as their stack is limited. It is worthwhile to seek alternative for naturally available aggregate. Owing to growing construction activities and renovation of structures, demolition wastes are produced in large quantities which are kept in abundance in low lying area or at disposal sites. The land over which the demolition wastes are disposed, deprives further land use forever for other purposes. These increased quantities of demolition debris, the continuing shortage of dumping sites, increase in the cost of disposal land transportation and above all the concern about environmental degradation.

Recycled aggregates are the aggregates produced from the processing of previously used construction materials such as concrete or masonry. Recycled aggregates consist of hard, graduated fragments of inert mineral materials, including sand, gravel, crushed stone, slag, rock dust, or powder.

WHY RECYCLED AGGREGATES ?

1) Due to rapid growth in population and urbanization, the natural resources are depleting.
2) The construction industry is facing non availability of good quality aggregates within reasonable distances.
3) High cost of good quality crushed aggregates, as compared to Recycled aggregates.
4) An enormous increase in the quantity of waste materials and the shortage of dumping sites.
5) Shortage of dumping sites has resulted in sharp increase in transport and disposal costs.
6) High dumping cost for demolished waste, because it has to be dumped away as for as possible form construction site.

Construction industry is one of the fastest growing industries in the world hence producing waste at a greater extent than expected. The waste so produced can be reused by converting it into usable form contributing directly or indirectly to the environment. Following are the scope of recycled aggregates:

1) Decrease in the amount of disposal of demolished waste hence more availability of land.
2) Recycled aggregate can be used as earth filling in road construction.
3) Can be used in construction of rigid pavements.
4) Recycled aggregates can be used as ballast in railways.
5) Recycled aggregate with upgraded properties can be used as a replacement for natural aggregate.

Figure 1: Recycled Aggregate

II. OBJECTIVES

1) To study the utilization of demolished and construction waste as a replacement of natural aggregates.
2) To study the properties of demolished and construction waste aggregate.
3) To use of the demolished and construction waste aggregate in the new concrete as the recycled concrete aggregate reduces the environmental pollution as well as providing an economic value for the waste material.
4) To compare the compressive strength of normal concrete with recycled aggregate concrete by varying percentage of fine and coarse aggregate with recycled fine and coarse aggregate.

III. METHODOLOGY

1) This involves the detailed discussion on previous journals papers to the use of demolished concert waste in partial replacement of fine and coarse aggregate.
2) Finding the materials properties of fine aggregate, coarse aggregate Recycled fine aggregate, recycled coarse aggregate, conforming to IS: 2386-1963.
3) Finding the properties of Ordinary Portland Cement of 53 Grade cement.
4) Calculating mix design finding the mix proportion for Ordinary Portland Cement, fine aggregate, coarse aggregate Recycled fine aggregate, recycled coarse aggregate, water - cement ratio, and casting the cubes and beams.
5) Analysis the compressive strength, flexural strength for different mix proportion and finding optimum mix proportion.

IV. LITERATURE REVIEW

Manish Kumar Singh, Dilip Kumar (2019): "UTILIZATION OF DEMOLISHED CONCRETE AND CONSTRUCTION WASTE AS COARSE AGGREGATE IN CONCRETE". Construction and Demolished waste is used as the coarse aggregate in new concrete. In research, it is shows that 0 to15% replacements of recycled aggregate as natural aggregate gives a good comparatively result. Construction and Demolished waste concrete may be an alternative to the conventional concrete. Water required producing the same workability increases with the increase in the percentage of demolished waste. Use of the waste aggregate in the new concrete as the recycled concrete aggregate reduces the environmental pollution as well as providing an economic value for the waste material. Usage of recycled aggregates can not only preserve the finite raw materials, but also reduce energy consumption and overall construction costs. Density of the concrete will decreases as the percentage of replacement of demolished and construction waste aggregate increases from 0% to 25%.

Vikas Srivastava, Mohd Monish, Raushan Ranjan and P.K.Mehta (2018): "DEMOLISHED WASTE IN CONCRETE". THE WATER REQUIRED FOR PRODUCING THE SAME WORKABILITY IN RECYCLED CONCRETE INCREASES WITH THE INCREASE IN THE PERCENTAGE OF USE OF DEMOLITION WASTE, IRRESPECTIVE TYPE OF REPLACEMENT VIZ. CEMENT, FINE AGGREGATE, COARSE AGGREGATE. M-25 RECYCLED CONCRETE CAN BE PRODUCED BY REPLACING 10% OF CEMENT WITH BUILDING DEMOLISHED POWDER, REPLACING 20% OF FINE AGGREGATE WITH RECYCLED FINE AGGREGATE, REPLACING 30% OF COARSE AGGREGATE WITH RECYCLED COARSE AGGREGATE ONE AT A TIME. HOWEVER WITH FURTHER INCREASE IN DEMOLITION WASTE, THE STRENGTH AND WORKABILITY DECREASES.

Prakash Somani, Brahmtosh Dubey, Laukesh Yadav, Jitendra Kumar, Abhishek Kumar, Manipal singh (2016): "USE OF DEMOLISHED CONCRETE WASTE IN PARTIAL REPLACEMENT OF COARSE AGGREGATE IN CONCRETE". For 30% replacement of coarse aggregate the 28 days compressive strength is 82.65% of the compressive strength of conventional concrete. Demolished aggregate posses relatively lower bulk crushing, density and impact standards and higher water absorption as compared to natural aggregate.

Sai Kiran Kumar, B.Ravi Kumar, K.Ravi Reddy, V.Subhashini, S.K.Ayesha, Pragada Rambabu (2017): "DEMOLISHED WASTE AS COARSE AGGREGATE". Replacement of natural coarse aggregate by 60% artificial aggregate gives the maximum compressive strength. The concrete mix is more workable when 60% of CA is replaced by Demolished concrete as the slump values and compacting factor values are high when compared to conventional mix. Finally the concrete mix with 60% of aggregate replaced by Demolished concrete gives the best mix with high compressive strength with high workability.

V. MATERIALS

CEMENT: Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being affected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS: 4032-1988.

Table 1: Properties of cement

SL.NO	Properties	Test results	IS: 4013-1963
1.	Standard consistency	28.5%	24% - 34%
2.	Initial setting time	35min	Minimum of 30min
3.	Final setting time	480min	Maximum of 600min
4	Specific gravity	3.02	3.15
5	Fineness	5%	10%
6	Compressive strength		
	3days strength	29.2 Mpa	Minimum of 27Mpa
	7days strength	44.6 Mpa	Minimum of 40Mpa
	28days strength	56.6 Mpa	Minimum of 53Mpa

FINE AGGREGATES: M Sand is a industrial granular material which is mainly composed of finely divided rocky material and mineral particles. Hence, it is used as fine aggregate in concrete. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity, moisture content, bulk density, bulking, Water absorption in accordance with IS: 2386-1963.

Table 2: Properties of fine aggregate

Sl.No	Properties	Test Result	I.S Recommendation
1	M Sand zone	Zone- III	IS 383 Table- 3
2	Specific gravity	2.51	IS 2386 - 1963
3	Fineness modulus	4	IS 2386 - 1963
4	Moisture content	1%	----------
5	Water absorption	1.39%	IS 2386 - 1963

COARSE AGGREGATES: Crushed aggregates of 20mm and downsize produced from local crushing plants were used. The aggregate exclusively passing through 20mm sieve size and retained on 6.3mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density, moisture content in accordance with IS: 2386-1963. The individual aggregates were mixed to induce the required combined grading. The specific gravity and water absorption.

Table 3: Properties of coarse aggregate

Sl.No	Properties	Test Results	I.S Recommendation
1	Nominal size used	20mm and down	----------
2	Specific gravity	2.9	IS 2386 - 1963
3	Moisture content	0.1%	IS 2386 - 1963
4	Water absorption	0.15%	IS 2386 - 1963

WATER: Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.45 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding take place, so that the concrete becomes weak, but most of the water will absorb by the fibers. Hence it may avoid bleeding. If water content exceeds permissible limits, it may cause bleeding. If less water is used, the required

workability is not achieved. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

RECYCLED FINE AGGREGATE: Demolished concrete waste of fine aggregates is containing some amount of cement it is getting from local areas. The demolished concrete waste of fine aggregate is finer than M sand. water absorption is more in demolished concrete waste of fine aggregate. The demolished concrete waste of fine aggregate was partially replaced in place of coarse aggregate by the percentages of 30 %, and 60% along with replacement of fine aggregate with demolished concrete waste of fine aggregates also.
The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity, and bulk density in accordance with IS: 2386- 1963. The individual aggregates were mixed to induce the required combined grading.

Table 4: Properties of recycled fine aggregate

SL.No	Properties	Test Result	I.S Recommendation
1	Specific gravity	3.37	IS 2386 - 1963
2	Fineness modulus	4.1	IS 2386 - 1963
3	Moisture content	1%	----------
4	Water absorption	0.24%	IS 2386 - 1963

RECYCLED COARSE AGGREGATE: Demolished concrete waste of coarse aggregate getting from local crushing plant Crushed aggregates of 20mm and down size produced from planet were used. The aggregate exclusively passing through 20mm sieve size and retained on 6.3mm sieve is selected. The Demolished concrete waste of coarse aggregate is more water absorption compare to natural coarse aggregate. The demolished concrete waste of coarse aggregate were partially replaced in place of coarse aggregate by the percentages of 30 %, 60% and 100% individually and along with replacement of fine aggregate with Demolished concrete waste of fine aggregate also. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density, moisture content in accordance with IS: 2386-1963. The individual aggregates were mixed to induce the required combined grading.

Table 5: Properties of recycled coarse aggregate

SL.No	Properties	Test Results	I.S Recommendation
1	Nominal size used	20mm an Down	----------
2	Specific gravity	2.9	IS 2386 - 1963
3	Moisture content	10.5	IS 2386 - 1963
4	Water absorption	0.15%	IS 2386 - 1963

VI. EXPERIMENTAL DETAILS

Different types of mixes were prepared by changing the percentage of replacement of coarse and fine aggregates with Demolished waste. Total 3 types of mixes are prepared along with conventional mixes. The aggregates are replaced by 30%, 60%, and 100% of demolished waste of coarse aggregate and the fine aggregates.

Table 6: Replacement of aggregate in percentage by volume

Sl.no	Mix designation	Replacement of aggregate in percentage by volume				Specimens
		NFA(%)	RFA(%)	NCA(%)	RCA(%)	
1	Conventional	100	0	100	0	3
2	30%	70	30	70	30	3
3	60%	40	60	40	60	3
4	100%	0	100	0	100	3

VII. RESULTS AND DISSCUSSIONS

COMPRESSIVE STRENGTH RESULTS: A total of 24 cubes of size 150 x 150 x 150mm were casted and tested for 7,14 and 28 days. The test results are tabulated below.

Table 7: Compressive strength results

SL. No	Mix designation	Aggregate Replacement (%)	Compressive strength of M35 grade N/mm^2		
			7 days	14 days	28 days
1	Conventional	0	23.5	30.5	35
2	30%	0	15.25	19.25	24.75
3	60%	60	13.35	16.6	20.51
4	100%	100	9.75	12.5	17.25

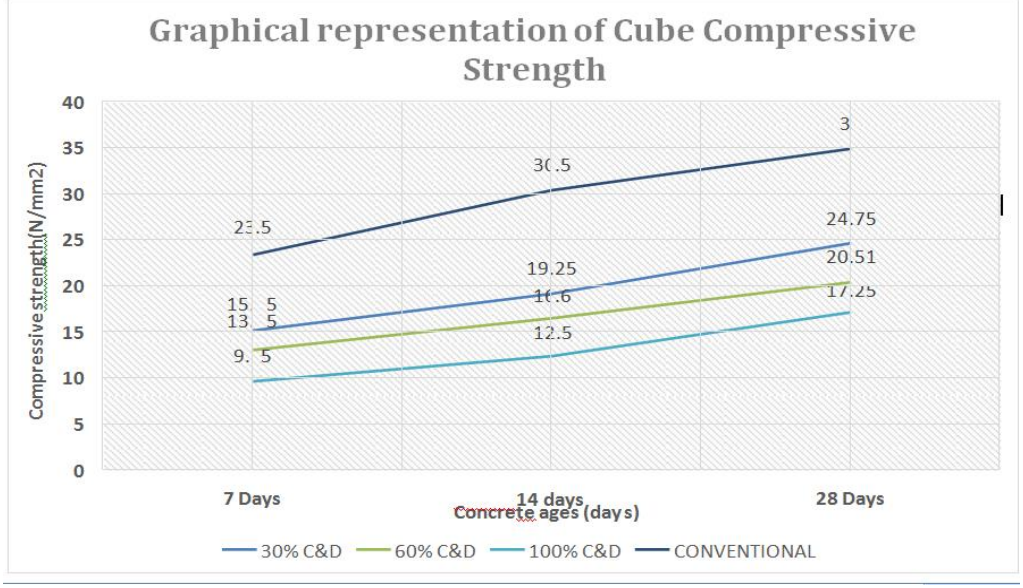

Figure 2: Compressive strength of concrete

FLEXURAL STRENGTH RESULTS: The flexural test was conducted for all the mix only since it has the highest compressive strength to compare it with conventional i.e., A Total of 4 beams were casted and tested as follows.

Table 8: Flexure strength results

SL. No	Mix designation	Aggregate Replacement (%)	Flexural strength of M35 grade N/mm^2
			28 days
1	Conventional	0	6
2	30%	30	4.8
3	60%	60	4.1
4	100%	100	3.5

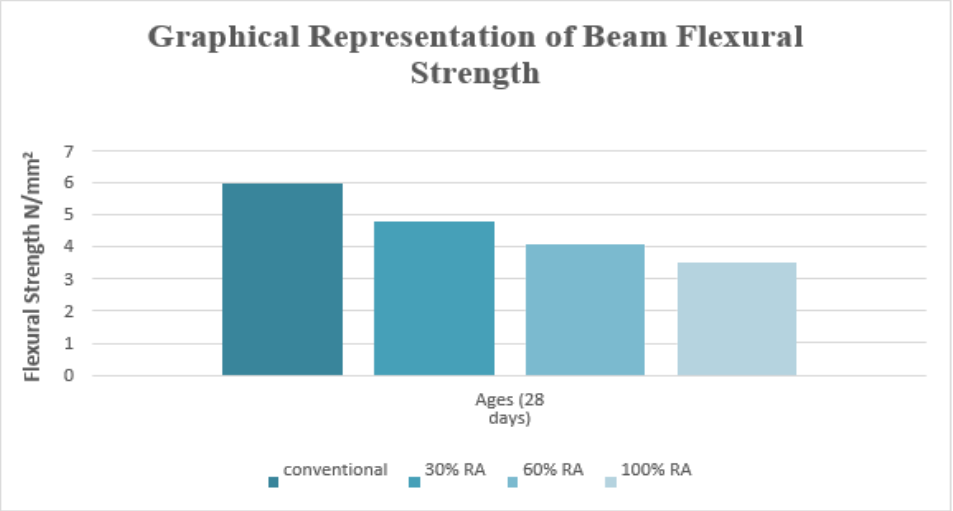

Figure 3: Flexural strength of concrete

VIII. CONCLUSIONS

The following conclusions are made based on the experimental investigations on compressive strength, and flexural strength considering the environmental aspects also:

1) The use of recycled aggregates from construction and demolition wastes is showing prospective application in construction as an alternative to primary (natural) aggregates. Recycled aggregates are found to possess relatively lower bulk density, higher crushing and impact values and higher water absorption as compared to natural aggregate.
2) The compressive strength of recycled aggregate concrete is relatively lower than natural aggregate concrete. However, these variations are dependent on the original concrete from which the aggregates have been obtained.
3) The replacement of coarse aggregate by 40% and fine aggregate by 10% of demolished waste having good compressive strength and flexural strength compared to normal concrete. Use of demolished waste aggregate in concrete can be an alternative to the conventional concrete.
4) Usage of recycled concrete aggregate can not only preserve the finite raw material, but also reduce energy consumption and overall construction cost. Use of Demolished waste aggregate in the concrete as the recycled aggregate reduces the environmental pollution as well as providing economic value for the waste material.

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