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Use of Demolished Coarse Aggregate Waste in Partial Replacement of Coarse Aggregate in Concrete

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Abstract – There is a large amount of demolished waste generated every year in India and other developing countries. Since very small amount of this waste is recycled or reused. So, disposing this waste is a very serious problem because it requires a large amount of space. This study is a part of comprehensive program wherein experimental investigations have been carried out to evaluate the effect of partial replacement of coarse aggregate by demolished waste on compressive strength and workability of DCAC (Demolished Coarse Aggregate Concrete). For the study 7, 14 and 28 days compressive strengths were recorded. The previous study on this project shows that the compressive strength of the DCAC (Demolished Coarse Aggregate Concrete) is somehow resembles with the conventional concrete if used in a proper amount up to 25%. So in this study we have taken the demolished coarse aggregate 5%, 15%, 25% by weight of the conventional coarse aggregate and the concrete cubes were casted by that demolished coarse aggregate concrete then further tests conducted such as workability , compressive strength for that DCAC and the result obtained are found to be comparable with the conventional concrete.

Keywords— DCA (Demolished Coarse Aggregate); Demolished Concrete Aggregate; Coarse Aggregate; Demolished Waste; Compressive Strength; Slump Test.

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1. INTRODUCTION

Due to rapid development of industries and urban areas waste generation is also increases, which is unfavorably carrying out the environment. At present, in India 29.8% of the total population living in cities, which is 14.8% more than the year of 1947. There is a shortage of about 56,000 millionnm^3 due to the construction of new infrastructure which shows that the demand of the aggregates in future increases. 770 million m^3 additional aggregate is required to fulfill the demand of the road sector. There is a huge gap between the demand and the supply of the aggregates because giant amount of aggregates is required in the housing and transportation nowadays. During construction waste generated is about 50 kg per m^2 to 70 kg per m^2. Similarly, during renovation, repair and maintenance work 50 kg/m^2 to 70 kg/m^2 waste is generated. The waste generated due to demolition of the building is highest among all the wastes. If we demolish permanent building about 350kg/m^2 waste is generated and in case of demolition of semi-permanent building 550kg/m^2 waste is generated.

Environment must be protected for the survival of the human beings and other lives on earth. So environment consciousness, sustainable development and preservation of natural resources should be kept in mind during the construction work and industrialization. At present, demolished material are dumped on land or treated as waste, which means they cannot be utilized for any purpose like housing and transportation. If we put the demolished coarse aggregate waste on land then the fertility of the soil get decreases. 25.76 million tons of waste is generated annually in India in the year of 2008 according to Hindu Online. According to CPCB (Central Pollution Control Board) Delhi, 15.5 million tons out of 49 million waste is generated from the construction waste from which only 4% is utilized in the construction of the embankment.

In 100 parts of the construction waste 40 parts are of concrete, 30parts of ceramics, 5 parts of plastics, 10parts of wood, 5 parts of metal and 10 parts of some other mixed compounds. There is a huge demand of construction coarse aggregate which is more than 27.8 billion in all over the world. There is a quiet increment in the utilization and demand of the natural aggregates in India due to housing, road, construction and infrastructure development. During the time of Second World War the use of demolished coarse aggregate concrete waste was started, it was utilized in the construction of the pavements.

According to Union Environment Ministry 13 million tons of the construction and demolition waste is generated in the year of 2013 but the current method adopted for the management of this waste are landfill mainly which causes a giant amount of the construction and demolished waste deposition and such huge amount affects the environment adversely. In India concrete, bricks, sand, mortar and tile residues are the main materials found in the demolished waste of buildings. This waste can be recycled or process in to the recycled demolished coarse aggregates which can be utilized in the concrete mixes. Demolished coarse aggregate (DCA) is generally produced by the crushing of concrete rubble, then screening and removal of contaminants such as plaster, paper, reinforcements, wood, plastics. Concrete made with this type of recycled demolished concrete aggregate is called Demolished coarse aggregate concrete (DCAC). The main purpose of this work is to determine the basic properties of DCAC made of coarse recycled demolished concrete aggregate then to compare them with the properties of concrete made with natural aggregates concrete. Fine recycled aggregate cannot be applied in the concrete which is used for structures so we can ignore its amount 70-75% aggregates are required for the production of concrete. Out of this 60-65% is of coarse aggregate & 35-40% is of fine aggregate. India is in the top 10 users of the concrete due to rapid growth of infrastructure. For the production of 1 ton of natural aggregate 0.0047 million ton of carbon is emitted which is harmful for the environment. So generation of the carbon is also getting reduced if we use demolished aggregates.

As the demolished coarse aggregate is lighter than the natural aggregate so the concrete made from such aggregate possesses low density but the water absorption of the demolished aggregate is higher than the natural aggregate and the strength of the demolished coarse aggregates is somehow lesser than the natural aggregates. So concrete made from these demolished coarse aggregate can be utilized where more strength is not required e.g. in low rising buildings, in reinforced concrete pavements etc.

II. MATERIALS AND METHODOLOGY

Demolished waste: Demolished coarse aggregate waste is collected from residential building near Science College, Gwalior, Madhya Pradesh. It is light grey in color.

Fig(a) Demolished Coarse Aggregate Concrete

Properties of Demolished Aggregates:

i. Specific Gravity:

The specific gravity in saturated surface dry condition of demolished coarse aggregate concrete was found from 2.5 which is less but satisfying the results. If specific gravity is less than 2.4, it may cause segregation; honeycombing & also yield of concrete may get reduced.

ii. Water Absorption:

The DCAC from demolished concrete be made of crushed stone aggregate with old mortar adhering to it, the water absorption ranges from 0.32%, which is comparatively more than that of the natural aggregates. Thus the water absorption results are satisfactory**.**

iii. Bulk Density:

The bulk density of demolished coarse aggregate is lower than that of natural aggregate, thus results are not satisfactory; due to low Bulk Density the mix proportion gets affected.

iv. Crushing and Impact Values:

The demolished coarse aggregate is comparatively weaker than the natural aggregate against different mechanical actions. As per IS 2386 part (IV), the impact and crushing values for concrete wearing surfaces should not exceed 30% & for other than wearing surfaces 45% respectively. The crushing & impact values of recycled coarse aggregate satisfy the BIS specifications limit. From crushing and impact test it is found that use of recycled coarse aggregate is possible for application other than wearing surfaces.

TABLE (I) PROPERTIES OF RECYCLED AGGREGATES COMPARED WITH NATURAL AGGREGATE

SR. NO.	Properties	Natural Aggregate	Recycled Aggregate
1	Specific Gravity	2.4-3.0	2.5
2	Water Absorption	0.29%-0.3%	0.32%
3	Bulk Density	1678.2 KN/m3	1469.8 KN/m3
4	Crushing Value	18.4%	36.3%
5	Impact Value	17.65%	35.2%

Cement: Jaypee Ordinary Portland cement of 43 grade is used and on batch is utilized throughout the work. This ordinary cement consists of two materials namely argillaceous and calcareous. TABLE (II) shows the physical properties of the OPC which satisfies the requirement of IS: 8112-1989.

TABLE (II) PROPERTIES OF CEMENT

Properties	IS:8112-1989 Recommendations	Obtained Values
Soundness Test	10mm	2.4mm
Fineness Test	<10%	0.98%
Normal Consistency	_	29%
Initial Setting Time	30 minutes (min)	110 minutes
Final Setting Time	600 minutes (max)	350 minutes

Fine aggregate: Locally available river sand of zone-II is used as a fine aggregate it passes through the sieve of 4.75mm. IS: 383 (1970) is followed for fine aggregates.

TABLE (III) PROPERTIES OF FINE AGGREGATE

Properties	Natural fine aggregate
Density	1625 kg/m3
Specific Gravity	2.65
Water Absorption	1.15 %
Fineness modulus	2.73

Coarse aggregate: Locally available crushed stone aggregates are used as a coarse aggregate which have the size of 12mm. Specific gravity and Fineness modulus of the coarse aggregate are 2.63 and 6.20 respectively. IS: 383 (1970) is followed for fine aggregates.

Water: Water cement ratio of 0.47 was used in the recycled concrete and for this purpose potable water was used for mixing and curing purpose.

Concrete: IS: 10262 (2009) is strictly followed in concrete mix. To avoid the balling effect cement content in the mix design was taken as 370 kg/m^3 which satisfies minimum requirement of 300 kg/m^3.

For this study cubes of 150 mm size nominal concrete cube were cast, same size was taken for the cubes which were casted by replacement of coarse aggregate by demolished concrete aggregate. In this study we have taken the demolished aggregate 5%, 15%, 25% by weight of the conventional coarse aggregate then further tests conducted such as workability , compressive strength for 7, 14, 28 days. Compressive Strength of the cubes were tested by using CTM (Compressive Testing Machine) in which compressive load is applied on the specimen till the specimen fails in compression that load at which the specimen fails is termed as compressive strength of the specimen for each percentage three specimens are taken and the compressive strength is the average of the three specimens.

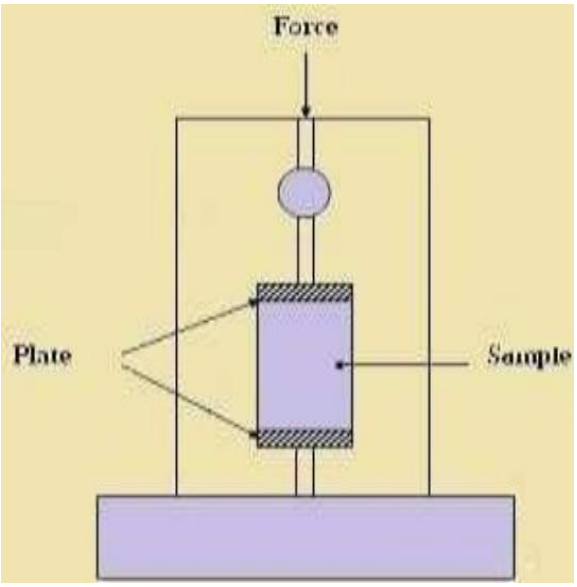


Fig (b) Compressive Strength Test

Workability is measured by the slump test in which the concrete mix is prepared and filled in to a cone of specific dimensions. Initial height of the cone is noted then the cone is removed the concrete inside the cone get reduction in height this is known as final

slump height, the difference between the initial and final slump height of the mix is called slump value.

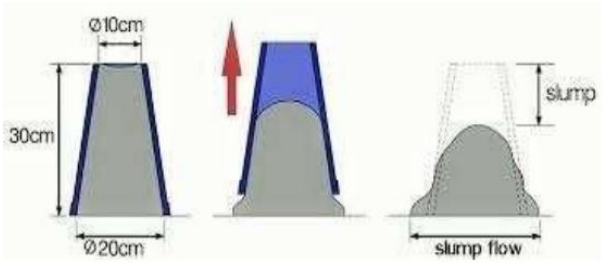


Fig. (C) Slump Test

TABLE (IV) COMPRESSIVE STRENGTH OF M-30 FOR 5% REPLACEMENT OF COURSE AGGREGATE BY DEMOLISHED AGGREGATES

Compressive strength	0% DCA		5% DCA
M-30 (7d)	15.84	N/mm^2	10.47 N/mm^2
M-30 (14d)	28.45	N/mm^2	17.41 N/mm^2
M-30 (28d)	42.84	N/mm^2	35.24 N/mm^2

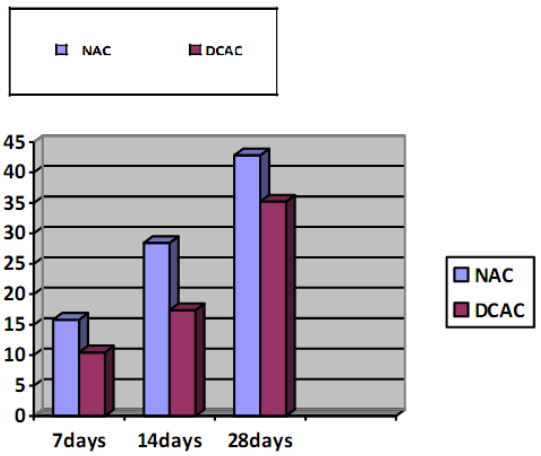
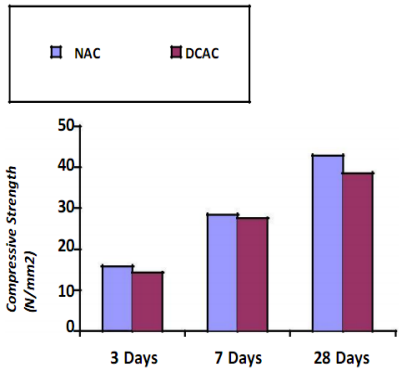


Fig. D 5% DCAC Compressive Strength

TABLE (V) COMPRESSIVE STRENGTH OF M-30 FOR 15% REPLACEMENT OF COARSE AGGREGATE BY DEMOLISHED AGGREGATES

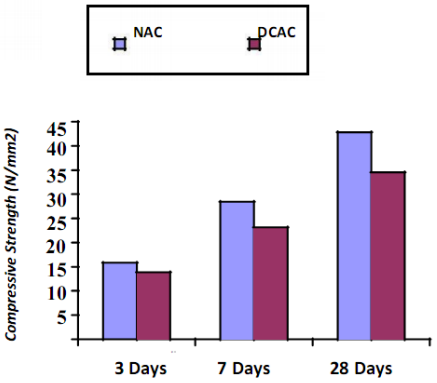
Compressive strength	0% DCA	15% DCA
M-30 (7d)	15.84 N/mm^2	14.25 N/mm^2
M-30 (14d)	28.45 N/mm^2	26.52 N/mm2
M-30 (28d)	42.84 N/mm^2	36.23 N/mm2



Fig(e) 20% DCAC Compressive Strength

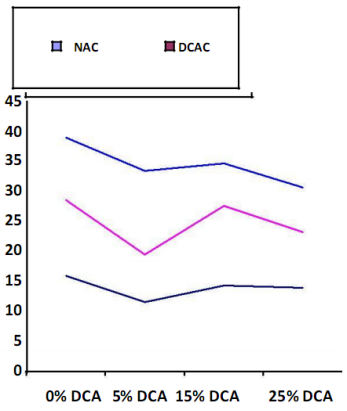
TABLE (VI) COMPRESSIVE STRENGTH OF M-30 FOR 30% REPLACEMENT OF COARSE AGGREGATE BY DEMOLISHED AGGREGATES

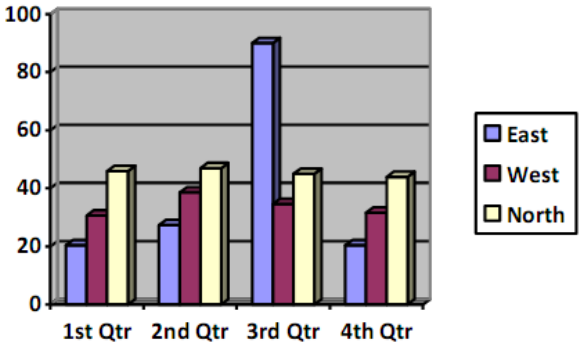
Compressive strength	0% DCA	15% DCA
M-30 (7d)	15.84 N/mm^2	13.87 N/mm^2
M-30 (14d)	28.45 N/mm^2	23.15 N/mm2
M-30 (28d)	42.84 N/mm^2	33.54 N/mm2



Fig(f) 25% DCAC Compressive Strength

COMPARISION OF COMPRESSIVE STRENGTH OF DCAC FOR VARIOUS PERCENTAGES OF DEMOLISHED COURSES AGGREGATE



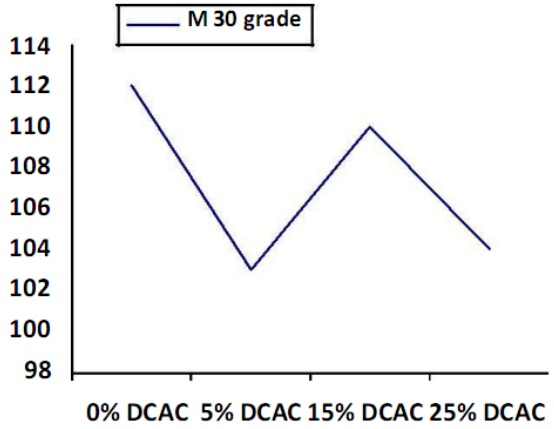


Fig(g) Compressive Strength of different percentage of DCAC

TABLE (VII) SLUMP VALUES OF CONCRETE

Types of concrete	Slump for 0% DCAC	Slump for 5% DCAC	Slump for 15% DCAC	Slump for 25% DCAC
Recycled coarse Aggregate Concrete	112mm	103mm	110mm	104mm

Slump for conventional concrete: 112mm



Fig(h) Slump value of different percentage of DCAC

III. RESULTS AND DISCUSSION

Compressive strength is the maximum compressive stress that, under a gradually applied load, a certain solid material can carry on without fracture. Compressive strength of 7,14 and 28 days of the DCAC shown in the TABLE (III) for 0%, 5%, 15%, 25% replacement of the coarse aggregate by demolished coarse aggregate concrete for M-30 mix. Three specimens for each proportion were cast and tested for comparative study. For 25% replacement of coarse aggregate the 28 days compressive strength is 82.15% of the compressive strength of conventional concrete. A concrete is termed as workable if it is easily placed, transported, compacted, and finished without any segregation. This property is tested by slump test. The results of slump test are mentioned in TABLE (IV) for different percentages of demolished coarse aggregate concrete. The workability of the DCAC is lower than the conventional concrete because the rate of absorption of DC A is higher than nominal aggregate.

IV. CONCLUSIONS

1. Demolished aggregate possess relatively lower bulk crushing, density and impact standards and higher water absorption as compared to natural aggregate.

2. Tests conducted on demolished aggregates and results compared with natural coarse aggregates are satisfactory as per IS 2386.

3. The compressive strength of demolished aggregate concrete is relatively lower up to 15% than natural aggregate concrete.

4. Using demolished aggregate concrete as a base material for roadways reduce the pollution involved in trucking material.

V. FUTURE SCOPE

1. Sustainable development of structures can be achieved by using waste demolished concrete aggregate.

2. We can use the plastic waste also as a coarse aggregate in concrete.

3. Fine aggregate in the demolished concrete can also be utilized in future.

4. Demolished bricks and stones possess the same properties as coarse aggregates.

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