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EXPERIMENTAL STUDY ON CONCRETE BY PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH DEMOLISHED 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 project is experimented to reduce the cost of concrete. Aimed at the study, design mix of grade M30 was prepared using IS10262-2019. Thereafter, the replacement of different constituents of concrete, one at a time was carried out by replacing these with the different sieved fractions of crushed demolition waste. The demolished concrete aggregates were mixed with the concrete in 10%, 20%, 30%, 40% and 50%. Cubes were casted with concrete mixes and subjected to curing for 7 days, 14 days, 28 days for cube and their strength is determined. Test result shows that the strength of the concrete increase when the demolished waste is replaced, as the demolished concrete percentage increased the strength of the concrete also increase. For reducing the cost and natural aggregate we can replace with the demolished concrete, so that the strength of the concrete increase.

Keywords: Coarse aggregate, demolished concrete, M30.

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 27.8% of the total population living in cities, which is 13.8% more than the year of 1947. There is a shortage of about 55,000 million m 3 due to the construction of new infrastructure which shows that the demand of the aggregates in future increases. 750 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 number of aggregates is required in the housing and transportation nowadays. During construction waste generated is about 40 kg per m 2 to 60 kg per m^2. Similarly, during renovation, repair and maintenance work 40 kg/m^2 to 50 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 $300kg/m^2$ waste is generated and in case of demolition of semi-permanent building $500kg/m^2$ waste is generated. At present, demolished material are dumped on land or treated as waste, which means they cannot be utilized for any purpose. If

we put the demolished waste on land then the fertility of the soil gets decreases. 23.75 million tons of waste is generated annually in India in the year of 2007 according to Hindu Online.

According to CPCB (Central Pollution Control Board) Delhi, 48 million waste is generated from the construction waste from which only 3% 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 aggregate which is more than 26.8 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. Cement versatility, durability, sustainability and economy have made it the world's most widely used construction material. The term concrete refers to a mixture of aggregate, usually sand and either gravel or crushing stone, held together by a binder of cementitious paste. The paste is typically made up of Portland cement. Demolished concrete 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 aggregate concrete (DAC). The main purpose of this work is to determine the basic properties of DAC made of coarse recycled demolished concrete aggregate then to compare them with the properties of concrete made with natural aggregates concrete. As the demolished 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 aggregates is somehow lesser than the natural aggregates. So concrete made from this demolished aggregate can be utilized where more strength is not required. e.g. Pavements, sidewalls, etc.

Fig. 1: Rigid pavement waste.

2. LITERATURE REVIEW

2.1 General

Vivian et al[2] (2007) reported about RAC generated from concrete debris which has undergone years of services, the resulting RAC bears the weaknesses of lower density higher

water absorption and higher porosity that limit them to lower-grade applications. Investigated by substituting RA 0%, 20% and 100% resulted Improvement in achievement of strength up to 21.19% for TSMA (20% RA replacement after 28days of curing). The use of RAC generally leads to about 10% reduction in compressive and tensile strength, up to 35% reduction in modulus of elasticity, nearly 100% increase in drying shrinkage and 100% increase in permeability. As a result, the durability of RAC is lower than that of normal concrete, the physical and mechanical properties, durability and deformation become worse when increasing the replacement ratio.

Akmal[3] (2011) reported that there is an adequate body of research work on RCA and its uses in India, predominantly conducted by individuals in research and academic institutions. Most of the surveyed research considers the mechanical and strength characteristics of recycled aggregates with little focus on durability issues. There are limited legislations and policies to encourage recycling and use of demolition waste in India. No governmental standards, codal provisions, guide lines and specifications for processing and use of recycled aggregate are currently available in the region.

Belen Gonnzalez[4](2007) reports about characteristics of recycled aggregates are suitable for the production of structural concrete. Particularly worthy of mention are their lower density and higher water absorption levels in comparison with natural aggregates. Replacing 50% of the natural coarse aggregates with recycled coarse aggregates requires 6.2% increase in the amount of cement in order to maintain the consistency of the mixes and avoid having to alter the w/c ratio. This increase leads to possibility of producing recycled concrete (with and without silica fume) that, using a consistency defined slumps between 5cm and 10cm, is capable of reaching strengths of 30Mpa at 28days. Addition of 8% silica fume to mixes containing recycled aggregates was found to be beneficial in terms of compressive strength. Reduction in static elastic modulus in RCA.

Ahmed[6] (2015) investigated and compared the properties of natural and recycled aggregates and concluded test results as the recycled concrete aggregate have less unit weight, lower specific gravity, higher water absorption, and higher loss Angel's abrasion than natural aggregates. The concrete made from recycled coarse aggregate shows improved workability and needs more free water for same value of slump. The compressive strength for concrete made from recycled aggregate could be higher than the concrete made with natural aggregate if the water-cement ratio and the mix proportion is kept the same as that of original concrete.

Etxabarria (2007) et al[20], in this study Four different recycled aggregate concretes were produced; made with 0%, 25%, 50% and 100% of recycled coarse aggregates, respectively. The mix proportions of the four concretes were designed in order to achieve the same compressive strengths. The influence of the order of materials used in concrete production (made with recycled aggregates) with respect to improving its splitting tensile strength was analyzed.

Padmini (2001) et al[21]**,** investigated the properties of recycled aggregates derived from parent concrete (PC) of three strengths, each of them made with three maximum sizes of

aggregates. The relative physical and mechanical properties of fresh granite aggregate are investigated.

Crentsil (2009) et al[22], performance tests have been carried out for fresh and hardened properties of concrete made with commercially produced coarse recycled concrete aggregate and natural fine sand. Enhanced fresh and hardened concrete properties of the investigated recycled concrete aggregate as compared to aggregate derived from laboratory-crushed concrete arise primarily from improved aggregate grading and quality achievable in plant crushing operations.

Khatib (2005) [23] investigated on the properties of concrete containing fine recycled aggregate are investigated. Recycled aggregate consisted of crushed concrete (CC) or crushed brick (CB) with particles less than 5 mm in diameter.

Amnon Khatz (2003) [24], investigated concrete having a 28-day compressive strength of 28MPa was crushed at ages 1, 3 and 28 days to serve as a source of aggregate for new concretes, simulating the situation prevailing in precast concrete plants. The properties of the recycled aggregate and of the new concrete made from it, with nearly 100% of aggregate replacement, were tested.

Doming Cabo (2009) et al[25], studied to determine the creep and shrinkage variations experienced in recycled concrete, made by replacing the main fraction of the natural aggregate with a recycled aggregate coming from waste concrete and comparing it to a control concrete.

3. OBJECTIVE AND METHODOLOGY

3.1 Objective of the study

- To develop mix design methodology for mix 30MPa.
- To determine the workability of freshly prepared concrete by Slump test.
- To determine the compressive strength of cubes at 7, 14, 28 days.

3.2 Methodology

The methodology we follow for recycling of concrete are as follows.

- Select a grade of concrete for which a conventional mix is to be done.
- Now, materials required for preparation for conventional concrete must be brought and material testing must be done in the laboratory before mix is prepared.
- All the physical tests on the aggregates have to be done according to IS codes.
- Also find the properties of the cement which is used in the mix
- Now, using IS 10262:2019 design the suitable mix for required grade of a conventional concrete by considering the physical properties of the material.

- Using the above mix design prepare the mix and workability test has been done and 9 cubes are casted to find the 7 days, 14days and 28 days strength of the concrete.
- Now, phase I of the project is completed next phase is preparing the concrete by utilizing demolished concrete as a part of coarse aggregate.
- Demolished concrete is collected from the site seeing that it does not contain any chemicals
- Now, using hammer make break the concrete waste into suitable size.
- Physical properties of this demolished concrete are been found and accordingly we adjust the water content for the new mix design and we find strength of the concrete by preparing the cubes of different proportions of coarse aggregate and demolished concrete.
- Now, the cubes are tested for compressive strength and compare for best combination of RCA and CA.

4. EXPERIMENTAL WORK

4.1 Material used

4.1.1 Cement

Cement is a binder material, Ordinary Portland Cement used in the investigation was found to be Ordinary Portland Cement (53 grade) confirming to IS: 12269 – 1987.

Table. 1: Physical properties of cement.

Property	Result
Standard Consistency	31%
Initial Setting Time	41min
Final Setting Time	315min
Specific gravity	3.15

4.1.2 Fine aggregate

River sand passing through 4.75mm IS sieve and confirming to zone-1 of IS:383 (1987a) was used. The specific gravity was found to be 2.67.

4.1.3 Coarse aggregates

It is crushed stones of maximum size 20mm and retained on 4.75mm IS sieves. The specific gravity was found to be 2.74.

4.1.4 Dismantling of concrete

The concrete from the dismantled buildings is taken and by using hammer we break the concrete blocks into 20mm size aggregates as we do this manually, we get irregular shapes

and hence after preparing of the recycled aggregate we need to sieve the material through IS 20mm sieve and hence we get the required size of the aggregate.

4.2 Mix Design

Adopted Grade of concrete used-M30

Table. 2: Quantities of materials in cement concrete.

Material	Quantity
Cement (grade 53)	394.32 Kg/m^3
Water	197.16 liters
Fine aggregate	678kg/m^3
Coarse aggregate	1130 Kg/m^3
Water: cement	0.44

Volume of cube = 1.1 X (0.003375) = 0.0037125 m^3

Table. 3: For single cube material weights.

Mix	Cement (Kg)	FA (Kg)	CA (Kg)	RCA (Kg)	Water (lit)
0%	1.464	2.517	4.195	0	0.732
10%			3.775	0.4195	
20%			3.356	0.839	
30%			2.9365	1.2585	
40%			2.517	1.678	
50%			2.0975	2.0975	

4.3 Recycled coarse aggregates used in Concrete

4.3.1 Mixing

The dry components (cement, fine aggregates, coarse aggregates and recycled coarse aggregates) are introduced into the pan mixer and mixed thoroughly for 4 minutes initially. Later Water is introduced for proper mixing. Wet mixing is continued for another 2 minutes to 5mintues for uniform mixing of concrete ingredients. Concrete can now be tested for workability.

4.3.2 Placing and Compaction

Placing the concrete in cube moulds and compaction by manual. Delay in placing and compaction causes evaporation of water which should be avoided. Concrete was cast in pre-

oiled cast cube iron moulds in 3 layers by tamping each layer with greater than 35 blows and cylinder iron moulds in 3 layers by tamping each layer with 35 blows. Then the tamped moulds were placed on the vibrator for compaction and surface finished neat.

4.3.3 Curing

Concrete attained strength and hardened due to curing for 28days. After the casting of cubes, they are left for 24 hours to dry and then demoulded the casted cubes. They are cured in a curing tank for 3, 7, 14, 28 days.

4.4 Testing

4.4.1 Workability test on Fresh Concrete

Slump test

The apparatus used for doing slump test were slump cone and tampering rod. The internal surface of the mould was thoroughly cleaned and applied with a light coat of oil. The mould was placed on a smooth, horizontal, rigid and non-absorbent surface. The mould was then filled in four layers with freshly mixed concrete, each approximately to one-fourth of the height of the mould. Each layer was tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross section). After the top layer was rodded, the concrete was struck off the level with a trowel. The mould was removed from the concrete immediately by raising it slowly in the vertical direction. The difference in level between the height of the mould and that of the highest point of the subsided concrete was measured. This difference in height in mm was taken as the slump of the concrete. The results of slump test are tabulated in Table 4. Also the results are graphically represented in Fig. 2.

Fig. 2: Slump cone test subsidence.

4.4.2 Harden properties of Concrete

Compressive strength test on concrete cubes (IS 516-1959)

The concrete was poured in the mould and tamped properly so as to not have any voids. Concrete cube specimens of size 150*150*150 mm were cast to develop 28 days

compressive strength 25 MPa. Control concrete cubes were cast using potable water as per mix design. After 24 hours these specimens were removed from the moulds and the test specimens were put in water for curing. The top surface of these specimens was made even and smooth. This was done by putting cement paste and spreading smoothly on whole area of specimen. These specimens were tested by compression testing machine after 7 days, 14days and 28 days curing. Load was applied gradually at the rate of 140 kg/cm2 per minute till the specimens failed. For all the trials I to VI, the cube specimens were cured properly and tested to determine the compressive strength at the age of 7, 14 and 28 days and the respective results are given in Table 4. Also the results are graphically represented in Fig. 3. The compressive strength was computed by using:

Compressive strength (N/mm^2) = load applied (kN) / area of specimen (mm^2)

5. RESULTS AND DISCUSSIONS

As per experimental programmed results for different experiments were obtained. They are shown in table format or graph, which is to be presented in this chapter.

5.1 Workability Test

5.1.1 Slump Test

The Slump test was performed on the concrete to check the workability. The following results were obtained, according to which it can be concluded that with the increase workability when bacteria added to the concrete. The results obtained for Slump test are shown below in Table. 4.

Table. 4: Results of slump test.

RCA (%)	Slump value (mm)
0	90
10	102
20	110
30	118
40	124
50	130

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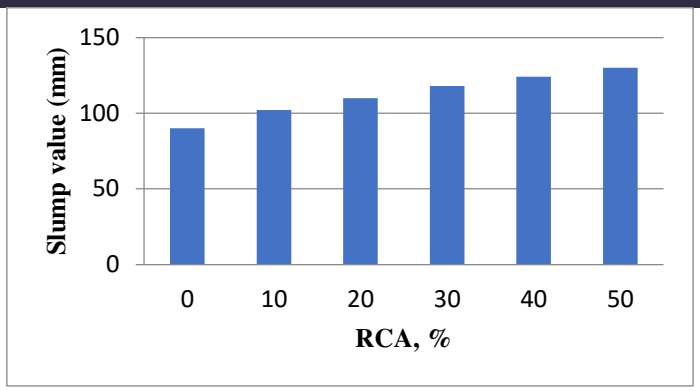

Fig. 3: Slump test results.

The above fig. 3 shows the slump results. It was observed that, the slumps were increases with increase in the percentage of RCA utilization in the concrete.

5.2 Harden properties of Concrete

5.2.1 Compressive strength test

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of concrete and the results obtained are given in Table 5.

Table. 5: Compressive strength.

RCA (%)	Compressive strength (Mpa)		
	7days	14days	28days
0	16.89	26.1	29
10	17.2	26.72	29.6
20	17.38	27.89	31.3
30	18.1	28	31.8
40	19.2	28.8	32
50	19.76	19.95	33.2

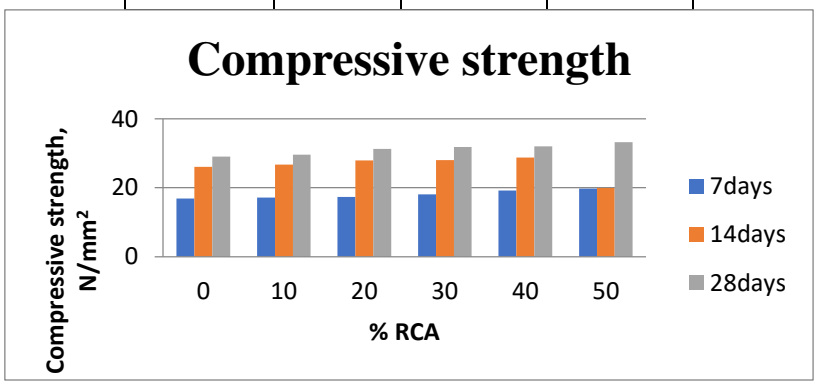

Fig. 4: Compressive strength test results graph.

The above fig. 4 shows the compressive strength results. It was observed that, the compressive strength was increases with increase in the percentage of RCA utilization in the concrete.

6. CONCLUSIONS

1. From test results it shows that strength of the concrete increases when the demolished waste is replaced with the natural coarse aggregates.
2. As the demolished concrete percentage is increased the strength of the concrete also increase.
3. For reduce the cost and natural aggregate we can replace with the demolished concrete, so that the strength of the concrete increase.

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