Effect of Recycled Aggregates on Strength and performance of Recylced Aggregate Concrete

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Abstract- This study is taken up to utilise the recycled coarse aggregate and recycled fine aggregate as replacement of natural aggregate in concrete mix. It is required to find the percentage of recycled coarse aggragate and recycled fine aggregate, as the strength of concrete can not be achieved by using higher percentaged. The purpose of study is to compare between recycled coarse aggregate and recycled fine aggregate with natural coarse aggregate and sand in terms of specific gravity, water absorption, particle size distribution. Further, this stydy will also consider the difference between the performance of Recycled Aggregate Concrete for different percentages of recycled coarse aggregate and recycled fine aggregate i.e for 0%, 10%, 15%, 20%, 25%, 30%, 35% replacement. The present study is an experimental investigation on the behaviour of recycled aggregate concrete (coarse& fine aggregates) with respect to the strength and performance.

1. Introduction

The most common material used in the world is water. After water Concrete is the most important construction material used through out the world in different types of civil engineering activities. Day by day scarcity of quality coarse aggrgate and fine aggregate is taking place. Restrictions on mining of aggregates is increasing day by day due to greater awareness of environmental protection. This leads to search for substitute material. It forces to reuse aggregate extracted from the construction and demolition waste (C&D waste) in new concrete. C&D waste generally contains Concrete rubble as major share. This concrete rubble can be crushed and sorted out for recycled coasre aggregate and fine aggregate. These can be used as a replacement material for natural aggregates in concrete or as a sub-base or a base layer in pavements. The material which is extracted from Construction and Demolition waste and used again in making concrete is called as recycled aggregate. The natural aggregate can be replaced with reused aggregate up to 25%. Beyond this percentaget the strength starts to reduce [1]. Based on the quantity and size of recycled aggregate, a regression model has been modified appropriately by test results[2]. The increase of Recycled aggregate content and w/c ratio decreases the durability of concrete [3]. Concrete with acceptable strength and durability can be produced along with high packing density is achieved [4]. The absorption and drying shrinkage of Recycled Aggregate Concrete linearly increase with the increase of replacement percentage of Recycled Aggregate Concrete, but decrease when certain amount of fly ash is mixed in the Recycled Aggregate Concrete [5]. As the age goes on old structures become unserviceable.

2. Objectives

- To know the percentage use of recycled aggregates in the construction.
- To know the strength and performance of recycled aggregates and other admixtures.
- To know the performance of recycled aggregate concrete.

3. Materials

A. Portland cement

Cement is tested for its physical peoperties in the laboratory as per the Indian standards. When cement reacts with water it liberates considerable heat and this reaction is termed as exothermic. Due to the reaction Calcium Silicate Hydrates are formed, which are responsible for the good properties of concrete. It is better to use cement produced within three months from the date of production.

Table 1. Physical properties of OPC

CHARECTERISTICS	OBSERVED VALUE
N.C	34%
IST	60mins
FST	260mins
S.G	3.10
C.S for 28 days	49.56 Mpa

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B. Fine aggregate

(i) R-Sand

Ordinary river sand is used. Specimens are casted using the sand passing through 2.36 mm sieve. As per the methodology mentioned in IS2386 (Part-I)-1963Sieve analysis for the sand is carried out in the laboratory. Sand plays key role in reducing shrinkage of concrete in the process of curing. Sand will also help in reducing the cost. As the availability of sand is becoming scarce, Manufactured sand can be used in making concrete. Recylced fine aggregate can also be used in making concrete. Sand can be tested as per Indian Standards in the laboratory.

Fig 1 Fine aggregate

Table 2. P.P of fine aggregate

CHARECTERISTICS	OBSERVATION
S.G	2.75
F.M	2.25

(ii) Recycled fine aggregate

Recycled fine aggregate is extracted from demolished concrete members. Recycled fine aggregate used in the stydy is 2.36mm. Quality of recycled aggregate plays vital role in achieving the required strength as they are minimising the voids in the concrete mass. It is useful to make concrete homogeneous. It is to be seived properly before using in the concrete. It should be free from unwanted material.

Fig 2 Recycled Fine aggregate

Table 3. P.P of Recycled fine aggregate

CHARECTERISTICS	OBSERVATION
S.G	2.50
F.M	4.50

C. Coarse aggregate

(i) Fresh crushed coarse aggregate

The coarse aggregate used in the study is 20mm crushed stone. As per IS: 2386-1963 the physical properties are assessed. Coarse aggregate is extracted from different types of Rocks.

Table 4. P.P of coarse aggregate

CHARECTERISTICS	OBSERVED VALUE
S.G	2.64
F.M	5.84
Crushing value	20.02
Impact value	18.75

Fig 3 Coarse aggregate

(ii) Recyced Coarse aggregate

The recycled coarse aggregate used in this stydy is extracted from demolished concrete members after crushing. Recycled coarse aggregate used in the study is of 20mm size. Coarse aggregate give body to the mass of concrete. It plays vital role in reducing shrinkage. It also helps in reducing the cost of concrete as we are using waste material. It is tested as per Indian Standards for knowing the physical properties.

Recycled aggregate is classified into the following types.
Recycled concrete aggregate (RCA): Aggregate extracted from crushed concrete made with Natural aggregate.
Construction and demolition recycled aggregate (CDRA): Aggregate which has not been properly extracted from construction and demolition waste, or Recycled aggregate that is un recognisable due to a lack of information on its composition.

Table 5. P.P of RCA

CHARECTERISTICS	OBSERVED VALUE
S.G	2.75
F.M	6.58
Crushing value	40.37%
Impact value	44.53%

Fig.4. Recycled Aggregate

4. Experimental Investigation

4.1 Concrete design

Mix for M30 grade is done as per IS10262:2009. The results of concrete mix design are as given below. Concrete mix design is done by knowing the physical properties of different ingredients used in it. Before doing mix design it is required to know the grade of concrete required and degree of workability. Water cement ratio plays vital role.

Table 6. Design Mix for M30 grade concrete

Grade of concrete	M30
Cement	362 Kg/Cum
F.A	682.6 Kg/Cum
C.A	1184.4 Kg/Cum
Water	162.9 Kg/Cum

4.2 Compressive strength test

The size of cube used to conduct the compression test in accordance with IS 516: 1959 is 100mm x100mm x 100mm. Three samples are used to test the compressive strength at the age of 3, 7, 28 days curing. Cube casted and de-moulded properly. The cubes removed should be cured for 28days as per Indian Standards in potable water.

Table 7 compressive strength (N/mm^2) for Recycled aggregate concrete

Mix	C.S (N/mm^2) for __ days		Percentage decrease in strength
	7	28	
Mix 1(10%)	27.2	40	-
Mix 2(15%)	25.17	37	7.5
Mix 3(20%)	23.8	34	15
Mix 4(25%)	22.5	32	20
Mix 5(30%)	21.98	31.4	21.5
Mix 6(35%)	19.88	28.7	28.25

4.3 Split Tensile strength test

The dimensions of cylinder used to conduct the split tensile strength test in accordance with IS 5816: 1999 is 100mm x 200mm. Two samples are used to test the split tensile strength test at the age of 7, 28 days curing.

4.4 Rapid Chloride Permeability Test (RCPT)

The size of cylinders used to conduct Rapid chloride permeability test is 100 mm x 50 mm. This test is carried out at the age of 28 days. The RCPT test consists of moulds with electrodes, connecting wires and RCPT machine.

5. Proposed Methodology

The laboratory work is carried out in to two phases. Basic tests were performed on materials in first phase. Specimens were casted in second phase to assess the performance and strength of concrete. The concrete is prepared by reused coarse aggregate and reused fine aggregate with various percentages i.e 10%, 15%, 20%, 25%,30% and 35% and 0.5 water cement ratio. Workability test on Green concrete was done. C.S, S.T.S tests on Hardened concrete were done after 3, 7 and 28 days of curing. Durability of concrete is assessed by using Rapid Chloride test.

6. Results and Discussions

From the results it is observed that when the percentage of replacement of Natural aggregate with reccylced coarse aggregate goes on increasing the strength decrease. At 10 percent replacement compressive strength is 40MPa. At 15 percent replacement compressive strength is 37MPa. There is decrease in compressive strength by 7.5%. At 20 percent replacement the compressive strength is 34MPa.There is a decrese in compressive strength by 15%. At 25 percent replacement the compressive strength is 32MPa. There is a decrease in compressive strength by 20%. At 30 percent replacement the compressive strength is 31.4MPa. There is a decrease in compressive strength by 21.5%. At 35% replacement the compressive strength is 28.7MPa. There is a decrease in compressive strength by 28.25%. Based on the results wecan replace upto 30%. Beyond that required compressive strength is not achieved. If the aggregates are segregated properly required strength can be achieved for higher percentages of replacement. Type of stone fromwhich aggregate is extracted is also important.

7. Outcomes Expected

It is estimated that the recycled aggregates beyond the limits will decreases the workability and strength of concrete. Shape and size of aggregate will affect the strength of the concrete greatly. Further it is estimated that the voids in the concrete will reduce due to reused fine aggregate and increases the strength. Use of recycled aggregate makes concrete economical.

8. References

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