Destructive Strength Properties of Recycled Coarse Aggregate

Chetna M Vyas, Darshana R. Bhatt

Abstract— Due to a critical shortage of natural aggregate, the availability of demolished concrete for use as recycled coarse aggregate (RCA) is increasing. Use of waste concrete as RCA conserves natural aggregate, reduces the impact on landfills, save energy and can provide cost benefit. Recycled aggregates are the materials for the future. The application of recycled aggregate has been started in many Asian & Western countries for construction projects. Research Paper reports the basic strength properties of recycled coarse aggregate. It also compares these properties with natural aggregates. Basic changes in all aggregate properties were determined. Basic concrete properties like compressive strength, pull out strength are explained here for different combinations of recycled coarse aggregate with natural aggregate. The compressive strength, pull out strength is used to determine the maximum resistance of a concrete to axial loading of the concrete specimens that having different percentage of recycled coarse aggregate replacement. The testing is just carried out after 28 days of casting. The resting specimen was 100mm diameter and 200 mm height for M25 grade concrete. There were total of six batches of concrete mixes, consists of every 20% increment of recycled aggregate replacement from 0% to 100%.

Keywords— recycled coarse aggregate (RCA), compressive strength, pull out strength.

I. INTRODUCTION

The basic requirement for recycled coarse aggregate (RCA) concrete is that should be sound and hard with normal weight. The RCA shall not contain excessive amount of dirt, dust, plaster and any other injurious foreign matter which may adversely affect RCA concrete. Because of porosity the RCA may loss its workability and strength more rapidly than traditional concrete. So the RCA concrete may require more water to achieve required workability and strength. Compressive strength of concrete can be defined as the measured maximum resistance of a concrete to axial loading. Compressive strength is measured for hardened concrete specimens.

The pull out test is performed to assess in-situ concrete strength. As name suggests, this method involves the measurement of the force required to pull-out a specially shaped steel rod from a concrete surface. The test can be performed either on an insert cast into concrete in the formwork or on an insert fixed into a hole drilled into hardened concrete. The former is called the cast-in method which is pre-planned. It has value in the testing for specification compliance. The drilled hole method offers a greater flexibility and is more appropriate for field surveys of hardened concrete.

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The approach offers the advantage of providing a more direct measure of strength, and at a greater depth than surface hardness testing by rebound methods, but still requires only one exposed surface.

II. EXPERIMENTAL METHOD

A. Materials:

a) Cement

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grade (Sanghi OPC) conforming to IS:8112-1989 is be use.

b) Aggregate

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is good gradation of aggregates. Good grading implies that a sample fractions of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, lower shrinkage and greater durability.

c) Coarse Aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 are used. The Flakiness and Elongation Index were maintained well below 15%.

d) Fine aggregate

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is wash and screen, to eliminate deleterious materials and over size particles.

TABLE -1
PROPERTIES OF FINE AGGREGATE

Sr no	Particulars	Sand
1	Source	Ananad, Gujarat
2	Zone	Zone II (IS: 383-1970)
3	Specific gravity	2.5
4	Fineness modulus	2.77
5	Density	1752 Kg/m³

e) Recycled coarse aggregate:

The recycled coarse aggregate is procured from demolished concrete structures. This demolished concrete structure is located in Anand District in Gujarat State.

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Fig: 1 recycled coarse aggregate

TABLE -2 PROPERTIES OF NATURAL & RECYCLED AGGREGATES

Sr no	Particulars	Natural agg.	Recycled agg.
1	Source	Ananad, Gujarat	Ananad, Gujarat
2	Max. aggregate size	20mm	20mm
3	Specific gravity	2.84	2.74
4	Fineness modulus	7.08	7.47
5	Density	1805.62 Kg/m³	1660.44 Kg/m³
6	Impact value (%)	8	12.92

f) Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Water cement ratio used is 0.50 for M25 concretes.

B. Methods

a) Design Mix

A mix M25 grade was designed as per IS 10262:2009 and the same was used to prepare the test samples. The design mix proportion is shown in Table 3

TABLE -3 CONCRETE MIX PROPORTIONS

w/c ratio	Proportion	Cement (kg/m^3)	Sand (kg/m^3)	Coarse Agg. (kg/m^3)	Water (kg/m^3)
0.5	1:2.12:3.46	360	763.51	1245.73	180

TABLE-4 DETAIL OF TESTS AND TEST SPECIMENS FOR M25 GRADE CONCRETE EACH MIX

Sr. no.	Tests	Test Age	No. of Specimens	Specimens
1	Compressive Strength (100 mm dia x 200mm)	28 days	18	cylinder
2	Pull-Out Strength (100 mm dia x 200mm)	28 days	18	cylinder

TABLE -5 DETAILS OF ALL MIX BATCHES

Sr. No.	Mix	Recycled coarse aggregate
M25	My1	0 %
	My2	20 %
	My3	40 %
	My4	60 %
	My5	80 %
	My6	100 %

III. EXPERIMENTAL SET UP

Testing for compressive strength (destructive test): Confirming Indian Standard Specification: IS 516 – 1959
Apparatus: A 200 tonne capacity compression testing machine was used for this test.

Compressive strength of concrete can be defined as the measured maximum resistance of a concrete to axial loading. Compression test is the most common test used to test the hardened concrete specimens because the testing is easy to make. The strength of the concrete specimens with different percentage of recycled aggregate replacement can be indicating through the compression test. The specimens used in the compression test were the resting specimen was 100mm diameter and 200 mm height. Three specimens were used in the compression testing in every batch. Differences of the strength among the different percentage of recycled coarse aggregate used in the age of 28 days also indicated through the compression test.

Fig:2 Setup of Compression Test

Testing for Pull-Out strength (destructive test):

As the name suggests, this method involves the measurement of the force required to pull-out a specially shaped steel rod or some similar device from a concrete surface. The test can be performed either on an insert cast into concrete in the formwork or on an insert fixed into a hole drilled into hardened concrete. The former is called the cast-in method which is preplanned, and will thus be of value only in the testing for specification compliance, whereas the latter called drilled hole method offers a greater flexibility and is more appropriate for field surveys of hardened concrete. In both cases, the value of the test depends upon the ability to relate pull-out forces to concrete strength. An important features of method is that the relation between pull out force and concrete strength is relatively unaffected by mix characteristics and curing history. The approach offers the advantage of providing a more direct measure of strength, and at a greater depth than surface hardness testing by rebound methods, but still requires only one exposed surface.

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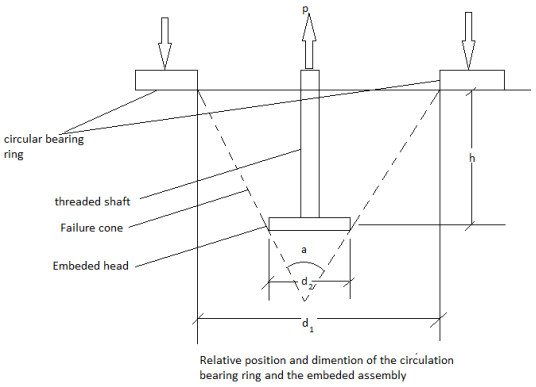

Fig:3 Setup of pull-out Test

The assembly is pulled out hydraulically against a circular bearing ring. A cone of concrete is pulled out with the assembly and the force required to achieve this is translated to compressive strength by the use of an empirical relation given by Eq.

$$\text{Pull out strength, } fp = \frac{P}{A}$$

Where P and A are the pulling force and failure surface area, respectively. The area A may be calculated from Eq

$$A = \frac{\prod}{4} (d_1 + d_2) [4h^2 + (d_1 - d_2)2]^{0.5}$$

Where,

d_1= internal diameter of bearing ring =50mm

d2 = diameter of pull out insert head = 22.5mm

h = distance from insert head to the surface =21mm

Fig: 4 Setup of Pull out Test

IV. TEST RESULTS

TABLE 6- COMPRESSIVE & PULL OUT STRENGTH OF CYLINDER (100 mm DIA X 200 mm HT) FOR M25 GRADE CONCRETE 28 DAYS

Sr. No.	mix	Average Compressive strength in N/mm^2	Average Pull out Strength in N/mm^2
1	My1	28.01	7.54
2	My2	22.28	8.43
3	My3	34.88	8.90
4	My4	20.62	8.20
5	My5	15.66	7.90
6	My6	8.91	7.38

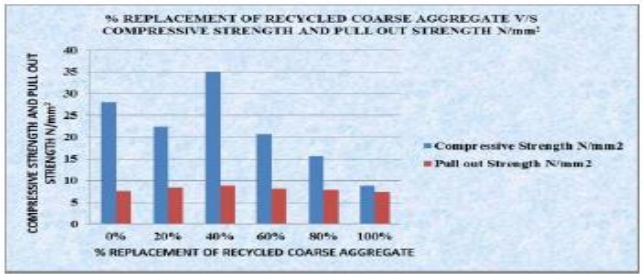

Fig: 5 % replacement of recycled coarse aggregate v/s Compressive & Pull out Strength of cylinder (100 mm dia x 200mm ht) for M25 Grade Concrete 28 days

V. CONCLUSION

- The compression test result indicates an increasing trend of compressive strength up to 40% replacement of recycled aggregate & then it decreases at the 100% replacement of recycled aggregate after 28 days.
- The results also show that the concrete specimens with 40% replacement of recycled aggregate get the highest strength when compared to the concrete specimens with different percentage of recycled aggregate.
- The results shows that the pull out strength is gradually increasing up to the replacement of 40% recycled aggregate than it is decreeing to the replacement of 100% recycled aggregate.
- The results also shows that the concrete specimens with 40% replacement of recycled aggregate get the highest pull out strength when compared to the concrete specimens with different percentage of recycled aggregate which is in agreement with the compressive strength results.
- Hence the recycled aggregate can be used in concrete with 40% replacement of natural coarse aggregate.

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