International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.8, pp 465-473, 2017

Enhancing the Strength properties of Recycled Aggregate Concrete by Experimental Investigation

Muthuraman[1], R.Anuradha[2]*, Blessy Jothi[3], KVenkatraman[4], L Yadheeswaran A[5], Kishore .R[6], M.Mathavan[7],

[1,3,4,5,6,7]Department of Civil Engineering , V V College of Engineering, Tisaiyanvilai, India
[2]Department of Civil Engineering, SNS College of Technology, Coimbatore, India

Abstract : Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. Aggregate Replacing method, which is effective in reducing both cost and environmental impact from the view of concrete waste generated by the demolition of large scale buildings [1]. And it was found that RCA replacement by 30% (RCA30%) of NA does not lead to any significant difference in strength and stiffness compared to concrete containing 100% NA in concrete. However, observed for RCA30% which must be considered in structural design. The scope of this project is to determine and compare the strength of concrete by using different percentage of recycled aggregates. In this project we are going to replace the Recycled Concrete Aggregate of 40%, 50% and 60%, and also we are decided to add Steel Fibre with Recycled Concrete Aggregate in order to increase the Compressive Strength, Split Tensile Strength and Flexural Strength of Concrete.
Keywords : Recycled Aggregate Concrete, Steel Fibre, And Special Concrete.

1.0 Introduction

According to CSIRO construction and demolition waste makes up to around 40% of the total waste each year (estimate around 14 million tons) going to land fill. Recycling is the act of processing the used material for use in creating new product[2]. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris.

1.1 Comparison of RCA and NA

Recycled aggregate has the rough, textured, angular and elongated particles where natural aggregate is smooth and rounded compact aggregate. The rough – texture, angular and elongated particles require much water than the smooth and rounded compact aggregate when producing the workable concrete. The void content will increase with the angular aggregate where the larger sizes of well and improved grading aggregate will decrease the void content [3]. It also stated that natural resources are suitable for multiple product and higher product have larger marketing area, but recycled aggregate have limited product mixes and the lower product mixes may restrain the market. The density of the recycled concrete aggregate is lower than natural aggregate and the weight of recycled aggregate is lighter than natural aggregate[4,5] The following Figure 1shows the Natural and Recycled Concrete Aggregate.

Fig 1 Natural and Recycled Concrete Aggregate

The strength of recycled aggregate is lower than natural aggregate. Natural aggregate are derived from a variety of rock sources, whereas Recycled aggregate are derived from debris of building constructions and roads.

2.0 STUDY OF MATERIAL PROPERTIES

2.1 Tests for cement

In general cement is a binder, a substance which sets and hardens independently, and can bind other materials together. The volcanic ash and pulverised brick additives which were added to the burnt lime to obtain a hydraulic binder which was later referred to as cementum, cimentum, and cement.

Cements used in the construction are characterised as hydraulic or non-hydraulic. The most important use of cement is the production of mortar and concrete the bounding of natural or artificial aggregates to form a strong building material which is durable in the face of normal environmental effects [6,7,8]. The most commonly used type of cement is Ordinary Portland Cement.

2.2 Fineness test (is: 4031 -part-5-1988)

The rate of hydration, hydrolysis and consequent development of strength in cement mortar depends upon the fineness of cement. The shrinkage and cracking of cement will increase with fineness of cement. 100g of cement taken in a standard IS sieved no 90µ. The air which get lump is broken down and the material was sieved continuously for 15 minutes using sieve shaker. The residue left on the sieve is weighted.

Table 1 Fineness test

S.No	Observation	Trail 1	Trail 2	Trail 3
1	Weight of Sample (g)	100	100	100
2	Weight of material Retained (g)	4.5	4	5
3	% of residue left on the sieve 90 µ	95.5	96	95

Thus from the results we infer that the fineness of the cement is 4.5% and as per IS 4031 (part5):1988[9], the fineness of cement should not exceed 10% for Ordinary Portland cement. The consistency value of cement is 26% and as per IS 4031 (part5):1988, the consistency of cement should be 26% to 30% for Ordinary Portland cement.

2.3 Initial setting time (IS: 4031 -part-5-1988)

It is the time period between the time water is added to cement and time at which 1mm square section needle fails to penetrate the cement paste, placed in the vicat's mould 5 to 7mm from the bottom of the mould.

A net cement paste with 0.85 times of water required is prepared to give a standard consistency. The time at which the water is added is noted. The vicat mould is filled with the cement paste in 3-5 minutes. The surface of the paste is smoothened, making ait level with the top of the mould. The needle is gently lowered of the surface of the paste and is quickly released allowing it to sink into the paste by its own weight. The procedure is repeated until the needle is failed to pierce the block for about 5-7mm measured from bottom and the time is noted using stop watch. The difference between the timing will give the initial setting time.

The following Table 2 shows the Initial Setting Time values of cement.

Table 2 Initial Setting Time

S.No	Time in minutes	Pointer reading from top
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	5	0.5
7	10	0.5
8	15	1
9	20	1
10	25	2
11	30	4
12	35	5
13	40	6

2.4 Consistency (IS: 4031 -PART-5-1988)

Standard consistency of a cement paste is defined as that consistency which will permit a vicat plunger having 100mm dia and 50mm length to penetrate to a depth of 33 to 35mm from top of the mould.

400g of cement is taken and a paste with a weight quantity of water is prepared. The paste is filled in the mould within 3 to 4 minutes. The mould is shaking well to exit air. A standard plunger of 10mm diameter and 50mm long is attached to the vicat apparatus and bought down to touch the surface of the paste in the test block and is quickly released to sink in to the paste by its own weight . The depth of penetration of the plunger is noted. The second trial is conducted by adding 23% of water and the depth of penetration is noted. Similarly, number of trials was conducted, till the plunger penetrate to a depth of 33mm to 35mm.

The particular % of water which allows the plunger to penetrate to a depth of 33 to 35mm is the % of water required to produce the cement paste of standard consistency (P).The following Table 3 shows the consistency test values of cement .

2.5 Final setting time (IS: 4031 -part-5-1988)

The procedure is similar to initial setting time. In this procedure needle with annular collar is inserted in the vicat apparatus. Time for penetration is noted every 3minites. It procedure is repeated until the attachment fails to make an impression on the test block.The following Table 4 shows the Final Setting Time of cement.

Table 3 Final Setting Time

S.No	Time in minutes	Pointer reading from top
1	95	16
2	110	25
3	125	30
4	140	36
5	165	40

The Final setting time of cement is 165 minutes and as per IS 4031 (part5):1988, the Final setting time of cement should not be greater than 10hr for Ordinary Portland cement.

2.6 Specific Gravity

The ratio between the weight of a given volume of cement and weight of an equal volume of water. The dry specific gravity of bottle is weighted w1 (g). the bottle is filled with distilled water and weighted as w2 (g). The specific gravity bottle is dried and filled with kerosene and is weighted as w3 (g). Some of the kerosene is poured out and the weighted is measured as w4 (g). 100g weighted of cement is taken as w5 (g). The following Table 4.5 shows the Specific Gravity of cement

Table 4 Specific Gravity of Cement

Description	Trail 1	Trail 2	Trail 3
Wt. of empty bottle (w_1)	29g	29 g	29 g
Wt. of bottle + water (w_2)	85 g	85g	85 g
Wt. of bottle + kerosene (w_3)	73 g	73 g	73g
Wt. of bottle + cement + kerosene (w_4)	101.5 g	99.5 g	103.5 g
Wt. of cement (w_5)	38 g	35 g	41 g

2.7 Tests for fine aggregate

Fine aggregates consist of mainly sand which may be natural, manufactured or a combination of both. It consists of clean and durable particles generally spherical or cubical in shape. The use of flat or elongated fine aggregate particles should be restricted and also care should be taken to ensure that there are no contaminating substances - dirt, dust, mud, and construction debris - present in fine aggregates. Fine aggregates particle size varies from 0.075 to 0.425 mm.

2.8 Specific Gravity (IS 2386 -Part-3:1963)

The ratio between the weight of a given volume of aggregate and weight of an equal volume of water. pycnometer is dried thoroughly and it is weighed as W1 gram. Take one third part of sand in the Pycnometer, weighed it as W2.The Pycnometer is filled with water up to the top. Then it is shook well and stirred thoroughly with the glass rod to remove the entrapped air. After the air has been removed, the Pycnometer is completely filled with water up to the mark. Then outside of the Pycnometer is dried with a clean cloth and it is weighed as W3 grams. The Pycnometer is cleaned thoroughly. The Pycnometer is completely filled with water up the top. Then outside of the Pycnometer is dried with a clean cloth and it is weighed as W4 grams. Specific Gravity of Fine Aggregate = 2.60

Specific gravity of fine aggregate is found to be 2.6 and as per IS 2386 (part3):1963, the specific gravity of fine aggregate should be 2.4 to 2.7.

2.9 Sieve Analysis (IS 383:1970)

A sieve analysis is a practice to assess the particle size distribution of a granular material.

The sample be brought to an air-dry condition before weighing and sieving this may be achieved either by drying at room temperature or heating at a temperature of 100°c to 1100°c. The air-dry sample shall be weighted and sieved successively on the appropriate sieves starting with the largest size sieve.

Fineness Modulus = 3.275
Fineness modulus of fine aggregate = 3.275
Sand conforming Zone II
As per IS 383:1970, Table 4, the sieve analysis shows the soil belongs to zone II of soil classification.

2.10 Moisture Content

It is the quantity of water contained in a material such as soil, rock, ceramics, fruit or wood.

This test helps to determine the water absorption (or) surface moisture of fine aggregate by displacement of water. Take some quantity of sand in china clay dish, weigh it as W1 and place it in oven for 24 hours. After 24 hours take the sample and weigh it, let it be W2. The following Table 5 shows the Moisture content test values of fine aggregate.

Table 5 Moisture Content

S.No	**Observation**	**Trail 1**	**Trail 2**	**Trail 3**
1	Weight of empty container (W1)	30	30	30
2	Weight of container + Sample (W2)	90	95	85
3	Weight of container + dry soil (W3)	88	94	83.5
4	Moisture Content	2.2	1.06	1.8

Moisture content

Moisture content on fine aggregate = 1.68%

2.11 Tests For Coarse Aggregate

Coarse aggregates consist of aggregates larger than fine aggregates and their sizes vary from 2.0 to 4.75mm [10]. These tend to improve quality and bond characteristics and generally results in a higher flexural strength of concrete.

2.12 Sieve analysis

A sieve analysis is a practice to assess the particle size distribution of a granular material.

The sample be brought to an air-dry condition before weighing and sieving this may be achieved either by drying at room temperature or heating at a temperature of 100°c to 1100°c. The air-dry sample shall be weighted and sieved successively on the appropriate sieves starting with the largest size sieve. If sieving is carried out with rest of sieves on a machine not less than 10 minutes sieving will be required for each test. The following Table 6 shows the sieve analysis test values of coarse aggregate.

The standard grain size analysis test determines the relative proportions of different grain sizes as they are distributed among certain size ranges.

2.13 Specific Gravity (IS 2386 –part-3:1963)

The ratio between the weight of a given volume of aggregate and weight of an equal volume of water. The container is dried thoroughly and it is weighed W1 grams. Take 200g of the coarse aggregate and it is weighed again with container W2 grams. The sufficient water is added to cover the coarse aggregate half full and is screwed on the top.

It is shaking well and stirred thoroughly with the glass rod to remove to entrapped air.

After the air has been removed container is completely filled with water up to mark. The outside of the container is completely filled with up to mark is dried with a cloth and it is weighted W3 grams. The container is cleaned thoroughly. The container is completely filled with water up to the top. The outside of the container is a dried with a clean cloth and it is weighted W4 gram.

Table 6 Sieve Analysis of Coarse Aggregate

S.No	IS Sieve No	wt. retained	% of wt. retained	% of wt. passing	% of wt. retained
1	20	1.20	24	76	24
2	10	2.38	47.6	52.4	71.6
3	4.75	1.39	27.8	72.2	99.4
4	2.36	0.03	0.6	99.4	100

The following Table 7 shows the specific gravity test values of coarse aggregate.

Table 7 Specific Gravity of Coarse Aggregate

S.No	Observation	Trail 1	Trail 2	Trail 3
1	Wt. of container (W1)	0.630g	0.630g	0.630g
2	Wt. of container + coarse aggregate (W2)	1.030g	1.035g	1.030g
3	Wt. of container + coarse aggregate + water (W3)	1.770g	1.775g	1.775g
4	Wt. of container + water (W4)	1.515g	1.515g	1.515g
5	Specific Gravity of coarse aggregate (G)	2.758	2.793	2.857

Specific gravity of coarse aggregate is found to be 2.78 and as per IS 2386 (part3):1963, the specific gravity of coarse aggregate should be 2.6 to 2.9.

2.14 Water Absorption Test

The amount of water absorbed by a composite material when immersed in water for a stipulated period of time.The container is dried thoroughly and it is weighed W1 grams. Take 200g of the coarse aggregate and it is weighed again with container W2 grams. The sufficient water is added to cover the coarse aggregate half full and is screwed on the top. It is shaking well and stirred thoroughly with the glass rod to remove to entrapped air.

After the air has been removed container is completely filled with water up to mark. The outside of the container is completely filled with up to mark is dried with a cloth and it is weighted W3 grams. The container is cleaned thoroughly. The container is completely filled with water up to the top. The 20 outside of the container is a dried with a clean cloth and it is weighted W4 gram. Then the container is filled with sample and water. Keep it for 24 hours and then the sample is weighted W5 gram.

2.15 Natural Aggregate

The following Table 8 shows the Water Absorption test values of natural coarse aggregate.

Table 8 Water Absorption Test for NA

S.No	Observation	Trail 1	Trail 2	Trail 3
1	Wt. of Empty Container (W1)	0.830g	0.830g	0.830g
2	Wt. of Container + Sample (W2)	2.830g	2.830g	2.830g
3	Wt. of Container+Sample+Water (W3)	4.410g	4.425g	4.415g
4	Wt. of Container + Water (W4)	2.170g	2.180g	2.175g
5	Wt. of Container+Wet aggregate (W5)	2.850g	2.840g	2.845g
6	Percentage of absorption	2	1	1.5

Water absorption for Coarse aggregate: = × 100 = 1.5 %

4.3.3.2 Recycled Aggregate

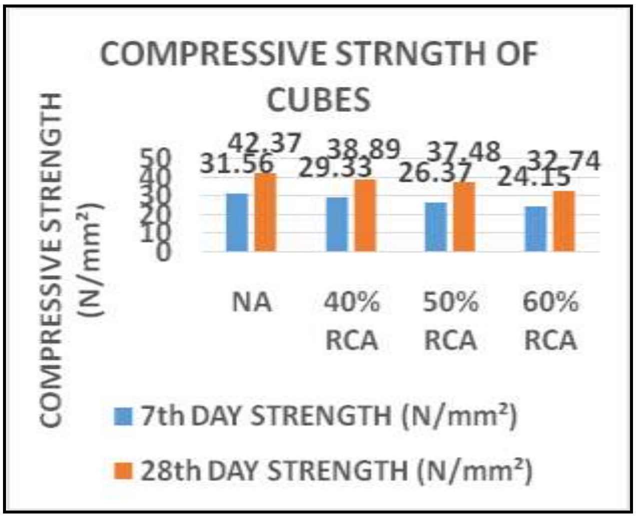
The following Table 9 shows the Water Absorption test values of Recycled coarse aggregate.

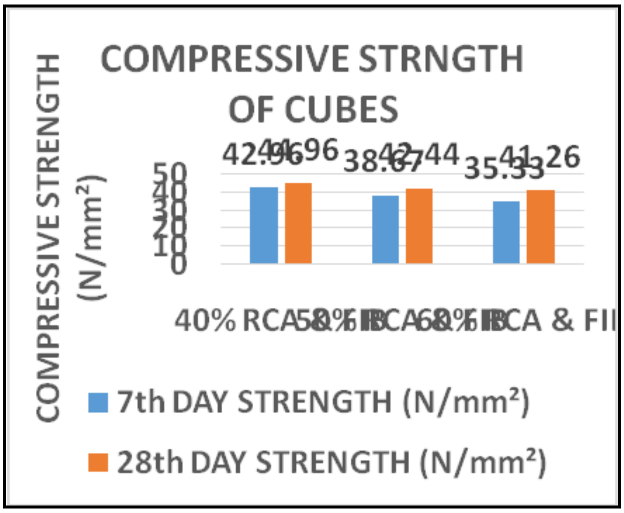
Table 9 Water Absorption Test for RCA

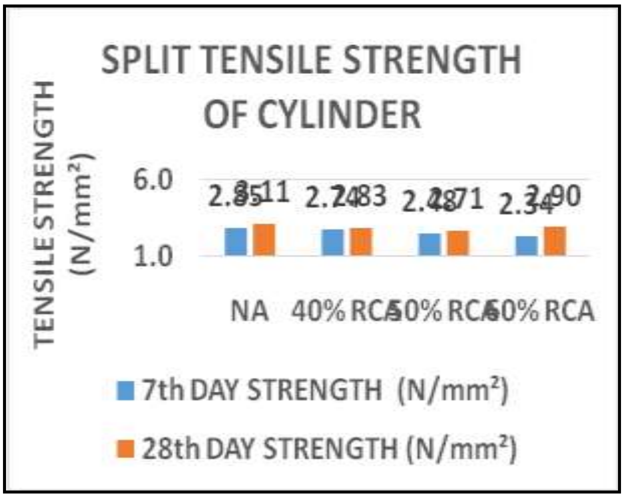
S.No	Observation	Trail 1	Trail 2	Trail 3
1	Wt. of Empty container (W1)	0.830	0.830	0.830
2	Wt. of Container + sample (W2)	2.830	2.830	2.830
3	Wt. of container+sample+water (W3)	4.410	4.425	4.415
4	Wt. of Container + water (W4)	2.175	2.170	2.180
5	Wt. of Container+Wet aggregate (W5)	2.915	3.000	3.015
6	Percentage of absorption	1.9	2	2.5

Water absorption test for RCA = × 100 = 2.5 %

Water Absorption of RCA is 1% more than the NA. Therefore RCA requires more Water Cement Ratio than the NA.







3.0 Conclusion

Generally conventional concrete is having greater strength when compared to the Recycled Concrete Aggregate. When the replacement of Recycled Concrete Aggregate increases, the improvement of Compressive strength is decreased to 23% in compression, 15% in tension and 23% in flexural strength.

However, the Compressive Strength of concrete with Recycled Concrete Aggregate replacement is 12% higher than the required target mean strength. When the Steel Fibre is added with the Recycled Concrete Aggregate, it helps to increase 25% of the Compressive Strength Specimens.

When comparing the strength of the Conventional Concrete to the 40% replacement of the Recycled Concrete Aggregate shows the small decrease of 8% in strength. Similarly the replacement of 50% and 60% Recycled Concrete Aggregate also gradually decrease in strength while comparing with the Conventional Concrete. However the Compressive Strength is mostly reduce due to the addition of Recycled Concrete Aggregate. And also the cracks occurred due to the Recycled Concrete Aggregate was slightly more while compared with the Conventional Concrete. Therefore, in order to increase the Compressive Strength the Crimped Steel Fibre in added to the concrete specimen.

While adding the Steel Fibre to the Concrete, the Compressive Strength of the Recycled Concrete Aggregate is increased. When Steel Fibre is added to the 60% replacement Compressive Strength is small increases in 20 % of the Strength. Similarly the replacement of 40% and 50% Recycled Concrete Aggregate also gradually increases in strength while comparing with the Conventional Concrete. While Adding the Steel Fibre the cracks was also reduced, Therefore Recycled Concrete Aggregate can also use in Concrete with Reinforcement for improving the tensile strength characteristics.

4.0 References

1. Chen and Kuan (2003), "Performance Of Recycled Waste Concrete And Its Applicability In Construction Industry".
2. Chetna M Vyas and Darshana R Bhatt (2014), "Evaluation Of Modulus Of Elasticity For Recycled Coarse Aggregate Concrete".
3. Kantawong and Laksana (1998), "High Strength Structural Concrete With Recycled Aggregate Concrete".
4. Limbachiya and Leelawat (2000), "Use Of Recycled Concrete Aggregate In High Strength Concrete".
5. Mandal, Chakarborty and Gupta (2002), "Environmental Suitability Of Recycled Concrete Aggregate In Highways".
6. Manjushree G.Shinde(2013), "Effect Of Physical Properties Of Recycled Aggregate On The Strength Of Concrete".
7. Neha, VikasSrivastava and V.C.Agarwal (2013), "Effect Of Demolition Waste On Compressive Strength Of Cement Matrix".
8. Poon(2002), "Compressive Strength of Recycled Aggregate Concrete With Various Percentage Of Recycled Aggregate".
9. Sagoe, Brown and Taylor (2002), "Durability And Performance Characteristics Of Recycled Aggregate Concrete".
10. Tavakoli(1996), "Effluence of Cement Content On Recycled Aggregate Concrete Properties".

*****