A Study On Strength Properties Of Concrete Made With Waste Ready-Mix Concrete As Coarse Aggregate And Partial Replacement Of Cement By Ggbs

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Abstract: Using waste materials for new products is a global trend undergoing rapid development. Recycling materials allows for a more efficient life cycle and contributes to environmental protection. In the construction field, this trend has gained importance because of the shortage of natural resources and because of environmental problems caused by storing building-demolition wastes and concrete wastes. This situation has led to the search for new applications for these wastes, and their use as aggregates in concrete is an interesting alternative. In this paper, some characteristics of recycled coarse aggregates obtained by crushing waste ready-mix concrete, as well as the mechanical properties of recycled concretes made by using various aggregates percentages and also with GGBS with various proportions, are presented.

Keywords: Recycling; Concrete aggregates; Compressive strength; Split Tensile strength; Fineness modulus; Shear strength;

1. INTRODUCTION

Concrete is a composite material, basically consisting of different constituents such as binding materials, water, aggregates and admixtures. Among these ingredients, aggregate plays a very crucial role in concrete which occupy the largest volume of about 60–75% of total concrete volume. In recent years, the accelerating urbanization has led to excessive demolition work and construction activities, which leads to the production of large quantities of construction and demolition waste, especially concrete-waste. More than 10 billion tons of construction and demolition waste are produced every year. on a large portion cases, this sort for waste will be erroneously figured out how through unlawful deposits, which making landfill space exhaustion.. The large-scale depletion of natural aggregate and the increased amounts of C&DW going to landfill sites are causing significant damage to the environment and developing serious problems, denting the public and the environmentalist's aspirations for a waste-free society. The use of the recycled aggregates created from processing construction and demolition waste in new construction has become more important over the last two decades. There are many factors contributing to this, from the availability of new material and the damage caused by the quarrying of natural aggregate to the increased disposal costs of waste materials. Recently, these aggregates started to be used for intermediate utility applications, such as foundations for buildings and roads. The advantages of recycling construction and demolition waste are (1) it reduces the amount of construction and demolition waste entering landfill sites; and (2) it reduces the use of natural resources.

1. Materials and Methodology

1.1 Cement:

Ordinary Portland Cement (OPC) of 43 grade with brand name Ultra-Tech confirming to (IS 8112-1989) standards were used to cast the specimens. To know the quality of selected cement, few tests have been conducted in the laboratory.

***Table 1:** Test results on cement*

Sl.No.	Name	Experimental value	IS 8112-1989 specified limits
1	Fineness of cement	5.67%	!> 10%
2	Normal Consistency	29%	--
3	Initial Setting Time	58 mins	!< 30mins
4	Final Setting Time	270 mins	!>600mins
5	Soundness	3 mm	Maximum of 10mm
6	Specific Gravity	3.12	3.1 to 3.25
7	Compressive Strength 3days strength 7days strength 28days strength	 28.23MPa 37.23MPa 46.93MPa	 Minimum 16MPa Minimum 22MPa Minimum 43MPa

1.2 Fine Aggregate (FA):
Nearby available sand from Tungabhadra River confirming to a zone II from Table 4 of IS code 383-1970 has been used as FA. The tests conducted are specific gravity, water absorption and fineness modulus tests. The test results on fine aggregate and sieve analysis values are placed in the Table 2

Table 2: Test results of Fine Aggregate

Sl .No.	Test	Value
1	Specific Gravity	2.58
2	Water Absorption	1%
3	Fineness Modulus	2.92

1.2 NaturalCoarseAggregat (NCA):
Crushed natural-granite aggregate from local crusher has been used and which has maximum size of 20mm. The tests for natural granite aggregate are conducted as per IS 383-1970 procedure and the obtained results are presented in Table 3, from sieve analysis test.

Table 3: Test results of Natural Coarse Aggregate

Sl. No.	Test	Experimental Value
1	Impact value	6.97% (exceptionally strong)
2	Specific gravity	2.64
3	FM	6.88
4	Water absorption	0.55%
5	Flakiness index	8.32%
6	Elongation index	9.23%

1.3 Recycled Coarse Aggregate (RCA):
The recycled a coarse aggregate was obtained from ready-mix concrete wastes. In order to use as graded aggregate, the waste material was crushed by hammer and made as 12.5mm and 20mm aggregate. The tests conducted as similar as natural granite aggregate. The obtained results are presented in Table 4

Table 4: Test results of Recycled Aggregate

Sl. No.	Test	Recycled Coarse Aggregate
1	Impact value	11.3% (strong)
2	Specific gravity	2.5
3	Water absorption	2.7%
4	Flakiness index	10.3%
5	Elongation index	11.5%
6	FM	6.7

1.4 Water:
Clean fresh water is used for mixing and curing the specimens.

1.5 Conplast SP-430:
To obtain better workability (slump 50mm) Conplast SP-430, superplasticising admixture used in the work. It is a brown solution which disperses in water instantly. It reduces water to higher levels thus increasing the strength. The specific gravity of this admixture is 1.18. For the present experimental design work the dosage is varied from 0.9 to 0.98% by weight of cement to achieve the slump value (50mm).

1.6 GGBS (GGBFS):
Ground Granulated Blast furnace Slag consist essentially silicates & alumina silicates of calcium. Portland cement is a good catalyst for activation of slag because it contains the three main chemical components that activate slag: lime, calcium sulphate and alkalis. The material has glassy structure. and is ground to < than 45 microns. The surface area is about 350 - 450 m^2 / kg Blaine. The ground slag in presence of water and an activator which are commonly sulphates & alkalis which are supplied by ordinary Port land Cement react chemically with GGBS and hydrates and sets in a manner similar to Portland cement. Specific gravity of GGBFS = 3.11

1.7 Casting:
The cubes of inner dimensions 150X150X150mm were cast to find out the compression strength of mixes. To evaluate the split tensile strength, cylinders of 150mm diameter with 300mm height were cast. The proportions for various mixes were evaluated for 50 mm slump. The mixes are designed for M20 grade concrete as per IS Codes. All materials are weighed as in mix design separately. The cement, sand, natural-coarse aggregate and recycled-coarse aggregate were dry mixed in pan mixer thoroughly till uniform mix is achieved. Required a quantity of water is added to the dry-mix along with super plasticizer. The fresh concrete was placed in the mould and the compaction was adopted by mechanical vibrator. The specimens were removed from moulds after 24 hours & placed in water pound for 28 days curing. After a period of 28 days the specimens were taken out & allowed to dry under shade, later the specimens are allowed for testing.

Table 5: Mix proportions per cubic meter of concrete (W/c = 0.5)

Mix	Cement	FA (kg)	NCA (kg)	RCA (kg)	Water (Liters)	SP (%)	Mixing ratio
NAC	372	681	1137	---	186	0.000	1 : 1.8 : 3.0
RAC-20	316	762.7	904.6	226.1	158	0.092	1 : 2.4 : 3.5
RAC-40	334.3	747	651	434	167	0.093	1 : 2.3 : 3.2
RAC-60	334	747.4	443.2	664.9	167	0.095	1 : 2.3 : 3.3

2. Tests for Specimens

2.1 Compressive Strength Test:
This test is conducted by using 3000kN (CTM). The cube was kept in the CTM & the load is given at a constant rate of 140kg/cm^2, till the specimen fails and the corresponding load noted as ultimate load. The cube compressive strength is computed by using standard formula. The obtained results are presented in the next chapter

2.2 Split Tensile Test:
This test is conducted by using 3000kN compression testing machine (CTM). The cylinder is placed at the bottom compression plate and is aligned in such a way that center lines marked on the ends. of the specimen are a vertical. Then the top plate of the CTM is brought in contact at the top the cylinder. The load applied at the uniform rate of 140kg/cm2 and the failure load is noted. Strength is calculated by The splitting tensile the formula of 2P/πdl and results are presented in the next chapter.

2.3 Finite Element Analysis:
Analytical methods furnish precise options with applications a fan of simple geometrics. Experimental ways are used to test models. Considering that they're costly, numerical methods are probably the most sought after method for engineering evaluation. Ansys software is used to evaluate the experimental results with Analytical results.

3. Results and discussion

3.1 Compressive strength:
For every concrete mix, the compressive strength is determined on three 150×150×150mm cubes at 28 days of curing. Following table give the compressive Strength test results of concrete with 20, 40, & 60% of recycled aggregates and 10, 20 and 30 % of GGBS. The test results of the cube compressive strength are presented in Table 6 to 8 and Figure 1 to 3. In this work mineral admixture are used to compensate the Compressive strength loss of concrete made with RCA. The compressive strength of recycled aggregate concrete made with 10, 20 and 30% GGBS ranges from 41.77 to 34.37 MPa. From the Experimental Results it is clear that the compressive strength of concrete made with 40% RCA and 20% GGBS shows higher compressive strength value than natural aggregate concrete mix. From the results it is concluded that the GGBS can lightly improve the Compressive strength of recycled aggregates concrete. Hence it is viable to use RCA up to40% replacement and GGBS up to 20% replacement without affecting the required strength.

Table 6: Compressive Strength of Reference mix

Sl. NO.	Mix	Average. Ultimate Load(KN)	Compressive Strength (N/mm^2)
1	NAC	913	40.5
2	RAC-20	826	36.7
3	RAC-40	880	39.1
4	RAC-60	800	35.5

Table 7: Compressive Strength of 10%, 20% &30% GGBS

Sl.No.	Mix	Average. Ultimate Load(KN)	Compressive Strength (N/mm^2)
1	NACG1	936	41.6
2	NACG2	953	42.3
3	NACG3	903	40.1

Table 8: Compressive Strength (RCA) of 10%, 20% &30% GGBS

Sl.N0	Mix	Average Ultimate L0ad(KN)	Compressive Strength (N/mm^2)
1	RACG1-20	833	37.0
2	RACG2-20	856	38.0
3	RACG3-20	840	37.3
4	RACG1-40	863	38.3
5	RACG2-40	941	41.7
6	RACG3-40	826	36.7
7	RACG1-60	810	36.6
8	RACG2-60	780	34.6
9	RACG3-60	773	34.3

Fig 1: Compressive Strength of Reference Concrete

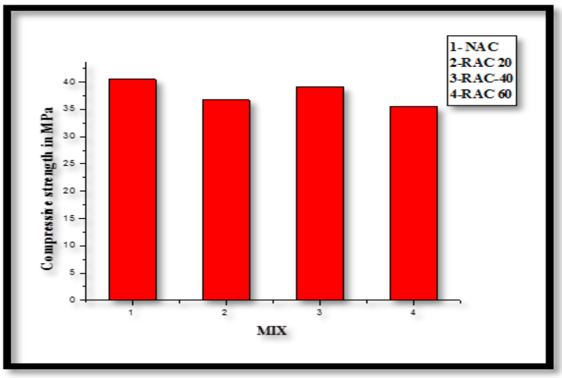


Fig 2: Compressive Strength of NAC with GGBS

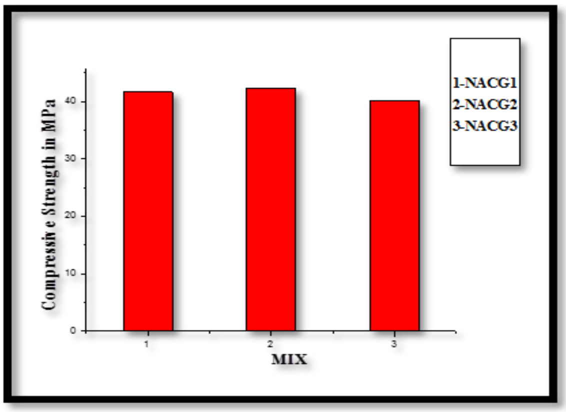
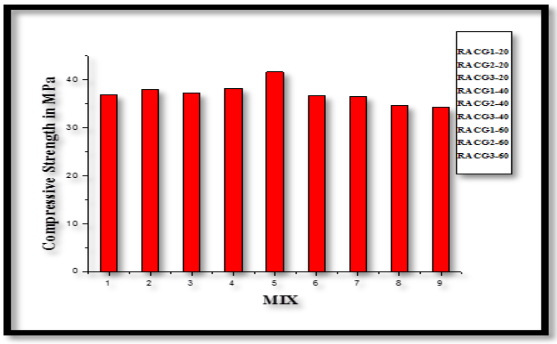


Fig 3: Compressive Strength of RAC with GGBS



3.2 Split Tensile Strength Test Result

Test has been conducted after 28 days of curing. Split-tensile is conducted on 150 mm diameter & 300 mm length cylinders bas per IS 5816 – 1999. Following tables from 9 to 11 & figure 4 to 6 give the split tensile strength results of concrete made with 0, 20, 40, and 60% of recycled aggregates and 10, 20 and 30 % of GGBS. In general the natural aggregate concrete shows more results than the RAC. But here it shows almost near value, it may be due to super plasticizer effect. In this work for NAC super plasticizer is not used. From experimental investigation it is clear that split tensile strength values of RAC with 10, 20 and 30% GGBS shows greater results than the natural concrete results. From experimental investigation it is clear that 20% replacement of RCA with 20% GGBS shows greater results than reference concrete. Hence it is viable to use RCA up to 20% and GGBS up to 20% replacement without affecting the required strength.

Table 9: Split Tensile strength of reference mix

Sl. N0.	Mix	Average Ultimate L0ad.(kN)	Split tensile strength (N/mm^2)
1	NAC-100	190	2.6
2	RAC-20	173.	2.4
3	RAC-40	163.	2.2
4	RAC-60	176.	2.4

Table 10: Split Tensile Strength (NA) of 10%, 20% &30% GGBS

Sl. N0	Mix	Average Ultimate Load(KN)	Split tensile strength (N/mm^2)
1	NACG1	220	3.0
2	NACG2	206	2.8
3	NACG3	193	2.7

Table 11: Split Tensile Strength (RCA) of 10%,20% &30% GGBS

l. N0	Mix	Average Ultimate L0ad(KN)	Split tensile strength (N/mm^2)
1	RACG1-20	223	3.1
2	RACG2-20	233	3.2
3	RACG3-20	180	2.5
4	RACG1-40	166	2.3
5	RACG2-40	176	2.4
6	RACG3-40	165	2.2
7	RACG1-60	170	2.3
8	RACG2-60	170	2.3
9	RACG3-60	173	2.4

Fig 4: Split tensile Strength of Reference Concrete

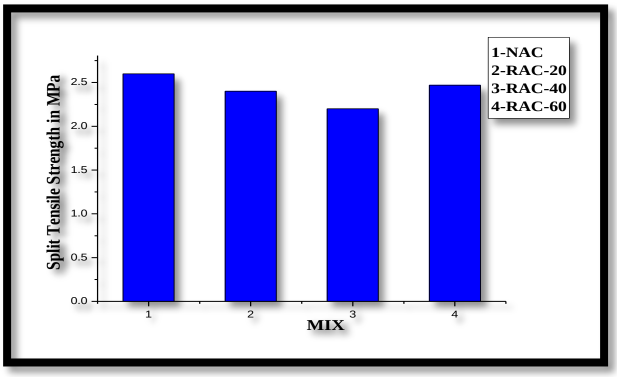


Fig 5: Split tensile Strength of NAC with GGBS

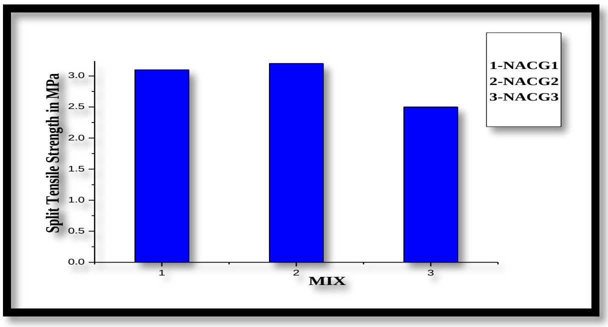
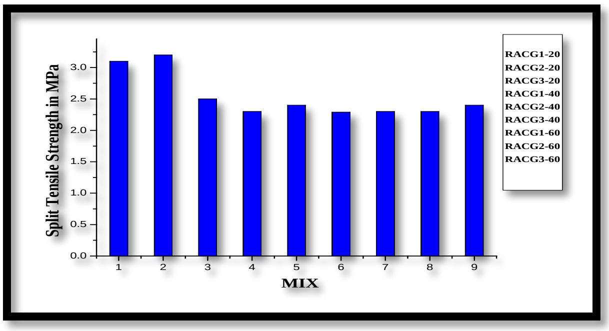


Fig 6: Split tensile Strength of RAC with GGBS



3.3 Finite Element Analysis:

3.3.1 Compressive Strength:

The variation of stress is as shown in the Figure 7. In the figure both maximum and minimum stresses are displayed. Average of these two values is taken as the average compressive strength of the cube and is compared with the experimental values in the Table 12 and Figure 9. From the Table 12 and Figure 9 shows the average experimental compressive strength results and ANSYS average Analytical compressive strength results. From the results it is observed that the ratio EXP/ANSYS result is about 0.92. The variation is about 0.92 it is small. This variation is due to the non-uniform distribution of load by compressive testing machine applied during experiment in the laboratory and here an FEM analysis was carried using ANSYS software in this software the model undergoes for meshing, this is also one of the reasons to get the accurate results. From the analytical investigation it is clear that the obtained experimental values satisfied with analytical results.

Fig 7: Variation of compressive strength

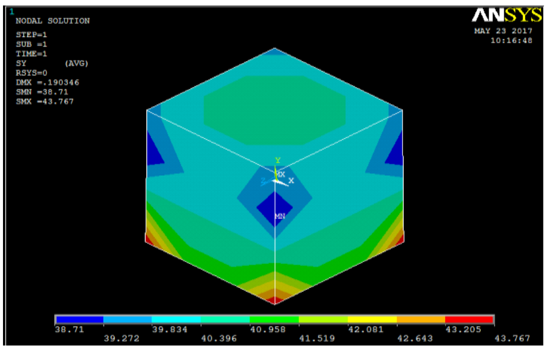


Fig 8: Variation of split tensile strength of NAC

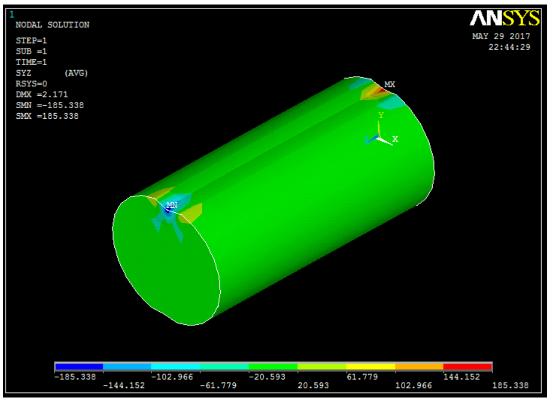


Table 12: Comparison of Experimental and ANSYS Compressive Strength Results

Sl. No.	Mix	Experimental value	ANSYS value	EXP/ANSYS
1	NAC-0	40.40	43.70	0.92
2	RAC-20	36.74	39.80	0.92
3	RAC-40	39.69	42.99	0.92
4	RAC-60	35.55	38.51	0.92
5	NACG1	41.62	45.08	0.92
6	RACG2	42.37	45.90	0.92
7	RACG3	40.14	43.48	0.92
8	RACG1-20	37.03	40.11	0.92
9	RACG2-20	38.07	41.24	0.92
10	RACG3-20	37.33	40.44	0.92
11	RACG1-40	38.37	41.56	0.92
12	RACG2-40	41.7	43.68	0.92
13	RACG3-40	36.74	39.80	0.92
14	RACG1-60	36.60	39.61	0.92
15	RACG2-60	34.60	37.4	0.92
16	RACG3-60	34.37	37.2	0.92

3.3.2 Split Tensile strength:

The variation of stress is as shown in the Figure 8. In the figure both maximum and minimum stresses are displayed. Average of these two values is taken as the average compressive strength of the cube and is compared with the experimental values in the Table 13 and Figure 10. From the Table 13 and Figure 10 shows the average experimental compressive strength results and ANSYS average Analytical compressive strength results. From the results it is observed that the ratio EXP/ANSYS results are about 0.9 to 1.04. The variation is about ten percent which is small. This variation is due to the non-uniform distribution of load by compressive testing machine applied during experiment in the laboratory and here an FEM analysis was carried using ANSYS software in this software the model undergoes for meshing, this is also one of the reasons to get the accurate results. From the analytical investigation it is clear that the variation b/w EXP and ANSYS results are small so that the obtained experimental values satisfied with analytical results.

Table 13: Comparison of Experimental and ANSYS Split Tensile strength Results

Sl. No.	Mix	Experimental value	ANSYS value	EXP/ANSYS
1	NAC-0	2.6	2.5	1.04
2	RAC-20	2.4	2.3	1.04
3	RAC-40	2.2	2.2	1.00
4	RAC-60	2.4	2.4	1.00
5	NACG1	3.0	3.3	0.90
6	RACG2	2.8	2.6	1.07
7	RACG3	2.7	2.6	1.03
8	RACG1-20	3.1	3.0	1.03
9	RACG2-20	3.2	3.1	1.03
10	RACG3-20	2.5	2.4	1.04
11	RACG1-40	2.3	2.2	1.04
12	RACG2-40	2.4	2.3	1.04
13	RACG3-40	2.3	2.2	0.95
14	RACG1-60	2.3	2.3	1.00
15	RACG2-60	2.3	2.3	1.00
16	RACG3-60	2.4	2.3	1.04

Fig 9: Comparison of Experimental and ANSYS Compressive Strength

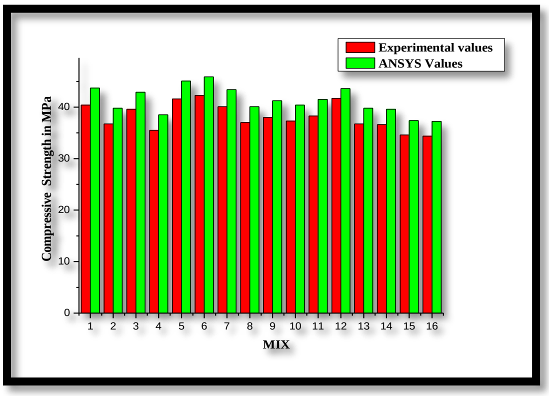
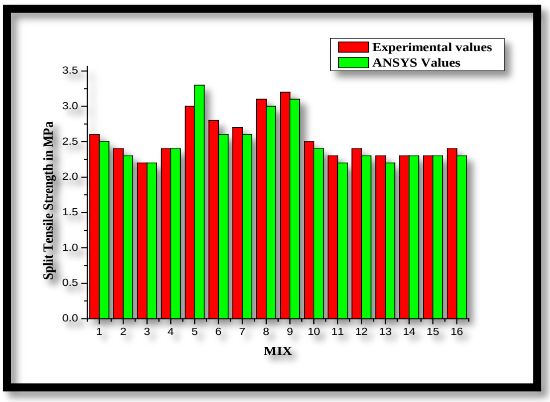


Fig 10: Comparison of Experimental and ANSYS Split Tensile Strength



4. CONCLUSIONS:

The following conclusion was made from the present experimental work.

1. The RCA obtained by crushing the remains of ready mix concrete that was deposited outdoors without adequate compaction and curing treatment was lower quality compared to with Natural Aggregates. The water absorption capacity of RCA was higher than that of the NCA
2. Quality of RCA concrete is lower than that of the NCA quality, due to the mortar that remains attached on the surface of the aggregates.
3. The compressive strength of concrete made with 40% replacement of RCA and 20% replacement of GGBS showered higher strength than reference or normal mix (0% RCA).
4. The split tensile strength of concrete made with 20% replacement of RCA and 20% replacement of GGBS showered higher strength than reference or normal mix (0% RA).
5. The compressive strength of concrete made with 40% replacement of RCA and 20% replacement of GGBS showered higher strength than reference or normal mix (0% RCA). The split tensile strength of concrete made with 20% replacement of RA and 20% replacement of GGBS showered higher strength than reference or normal mix (0% RCA). GGBS can slightly improve the compressive and split tensile strength of RAC.
6. ANSYS analysis is carried out on cubes and cylinders, to know the actual Behaviour of specimens and the results are compared with the obtained results. The compressive strength and split tensile results it is observed that the ratio EXP/Ansys is about 0.92 and 0.94-1.04. This indicates experimental values are satisfied with analytical results.

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