EXPERIMENTAL STUDY OF CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT WITH RICE HUSK ASH AND FINE AGGREGATE WITH GRANITE DUST

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Abstract— **Sustainable construction development require efficient use of natural resources by recycling the waste products . The production of concrete is not eco friendly and therefore in alternate, environmentally sensitive materials are identified for use in concrete. The waste products generated by industries in various forms like rice husk , rice husk ash , granite fines , quarry dust , fly ash , copper slag , steel slag etc. can be used as resource saving concrete structures and also will contribute a solution to the growing problem of waste disposal. There are some projects which uses either rice husk or granite fines as partial replacement in concrete. In this project we use both rice husk ash (RHA) and granite fines(GF) as partial replacement of cement and fine aggregate respectively in concrete to assess its mechanical properties. The percentage replacement of cement with RHA is 5% , 10% & 15% and the percentage replacement of GF is 30% & 50%. As RHA is used in greater percentages , the slump value was found to be less and hence super plasticizer has been used to enhance the workability of concrete. The concrete has been tested for compressive strength , split tensile strength and flexural strength of concrete with various mix proportions of RHA and GF as mentioned earlier. Reinforced concrete beam has been casted and tested for control concrete and optimum concrete and has been compared with their load deflection behavior. All the test results has been discussed and concluded.**

Keywords- ***Rice husk ash, Granite fines, Slump, compression test, Split tensile test, Flexural test, Load - Deflection behavior*.**

I. INTRODUCTION

Green concrete can be defined as the concrete with substitution material as a partial or complete replacement for cement or fine or coarse aggregates. The substitution material can be of waste or residual product in the manufacturing process. The substituted materials could be a waste material that remain unused, that may be harmful (material that contains radioactive elements). The three major objective behind green concept in concrete is

To reduce green house gas emission (carbon dioxide emission from cement industry, as one ton of cement manufacturing process emits one ton of carbon dioxide),

Secondly to reduce the use of natural resources such as limestone, shale, clay, natural river sand, natural rocks that are being consumed for the development of human mankind that are not given back to the earth,

Thirdly use of waste materials in concrete that also prevents the large area of land that is used for the storage of waste materials that results in the air, land and water pollution.

This objective behind green concrete will result in the sustainable development without destructing natural resources.

II. AIM OF INVESTIGATION

The aim of the investigation to study the mechanical strength of concrete using Rice Husk Ash and Granite fines that are partially replaced with cement and fine aggregate respectively by checking the compressive strength , split tensile strength and flexural strength for M30 concrete and thus optimizing the proportions. Load deflection behavior is compared between control and optimized concrete Also comparison has been made between control concrete and concrete with various mix proportions.

III. MATERIAL PROPERTIES

A. Cement

In this project , chettinadu 53 grade ordinary portland cement was used confirming to IS 12269:1987. Tests were conducted to find the specific gravity , consistency and setting time of OPC and the results are tabulated in the table 1.

TABLE 1 PROPERTIES OF CEMENT

S.no	Description	Test result
1	Fineness	2.1%
2	Consistency	31.25%
3	Initial setting time	36 minutes
4	Final setting time	390 minutes
5	Specific gravity	3.2

B. Fine aggregate

River sand passing through 4.75mm sieve was used. The physical properties of fine aggregates are determined as per IS 2386-1968 . Tests were conducted to obtain the specific gravity , fineness modulus, moisture content and water absorption. The test results are tabulated in table 2.

TABLE 2 PROPERTIES OF FINE AGGREGATE

S.no	Description	Test result
1	Fineness modulus	3.09
2	Sand conforming zone	II
3	Specific gravity	2.66
4	Moisture content	2.4%
5	Water absorption	0.80%

C. Coarse aggregate

Coarse aggregates were collected from approved quarry and the aggregates used were in the size ranging from 10mm to 20mm. The tests are carried out on coarse aggregate as per IS 2386-1968. Tests were conducted to obtain specific gravity , water absorption, fineness modulus and bulk density. The results obtained are tabulated in table 3.

TABLE 3 PROPERTIES OF COARSE AGGREGATE

S.no	Description	Test result
1	Fineness modulus	6.04
2	Nominal size of CA	20
3	Specific gravity	2.81
4	Bulk density	1633Kg/m^3
5	Water absorption	0.339%

D. Rice husk ash

Rice husk was collected from a locally recognized rice mill and was burnt for approximately 48 hrs to get rice husk ash. This rice husk ash was sieved through a standard sieve of 75 µm size and was tested for fineness and specific gravity. The test results are tabulated in table 4.

TABLE 4 PROPERTIES OF RICE HUSK ASH

S.no	Description	Test result
1.	Fineness modulus	8%
2.	Specific gravity	2.23

E. Granite fines

Moist granite fines were collected from locally recognized granite factory and was sun dried , and the lumps were fragmented to bring it into dust form. This granite dust was tested for fineness modulus and specific gravity . The results obtained are tabulated in table 5.

TABLE 5 PROPERTIES OF GRANITE FINES

S.no	Description	Test result
1.	Fineness modulus	3.06
2.	Specific gravity	2.4
3.	Sand conforming zone	II

F. Super plasticizers

The Super plasticizer used in concrete is Conplast SP430. It is based on Sulphonated Napthalene Polymers and supplied as a brown liquid instantly dispersible in water. Conplast SP430 has been specially formulated to give high water reductions up to 25% without loss of workability or to produce high quality concrete of reduced permeability. The dosage of Super plasticizer was 0.5 to 1.5 litres per 100kg of cement. The properties of super plasticizer are tabulated in table 6.

TABLE 6 PROPERTIES OF SUPER PLASTICIZER

S.no	Description	Test result
1	Type	CONPLAST SP430
2	Appearance	Brown liquid
3	Specific gravity	1.18
4	Dosage	0.5 – 1.5L/100 Kg

IV. CONCRETE MIX PROPORTIONS

The design of M-30 grade concrete is done by using the IS 10262 -2009 codal provision and is as follows:

TABLE 7 MIX RATIO OF CONCRETE

Materials	Quantity	Ratio
Cement	400.00	1
Fine aggregate	640	1.6
Coarse aggregate	1105	2.8
Water	175.33	0.42
Super plasticizers	8	0.02

V. DETAILS ON MIX SPECIMEN

TABLE 8 SPECIMEN DETAILS

S.no	% of RHA	% of GF	Mix name
1	0	0	N1
2	5	30	N2
3	5	50	N3
4	10	30	N4
5	10	50	N5
6	15	30	N6
7	15	30	N7
RHA - Rice husk ash, GF - Granite fines FA - Fine aggregate, CA - Coarse aggregate			

VI. METHODOLOGY AND EXPERIMENTAL RESULTS

A total number of 63 cubes, 42 cylinders and 42 prisms were casted. RHA were added in concrete at 5% , 10% and 15%. replacement with cement. GF were added in concrete at 30% and 50% replacement with fine aggregate. Seven various mix proportions were arrived namely N1, N2, N3, N4, N5, N6 & N7. The mix proportion details are tabulated in table. Cubes, cylinders and prism are casted in respective moulds and are de-moulded after 1 day interval. The de-moulded specimens are put in water tank for curing. Final strength of cube, cylinder and prism are tested after 28 days. compressive strength test and split tensile test are tested using compression testing machine. The crushing loads were noted and average compressive strength and tensile strength for three specimens is determined respectively. The flexural strength test has been done on prisms of size 150 x 150 x 500mm by flexural testing machine. This was done by single point load test having an end bearing of 50mm from each support.

A. *Workability test*

To determine the workability of fresh concrete, slump test as per IS:1199-1959 is followed. The apparatus used for doing slump are slump cone and tamping rod. Figure 1 shows the slump value of different mixes.

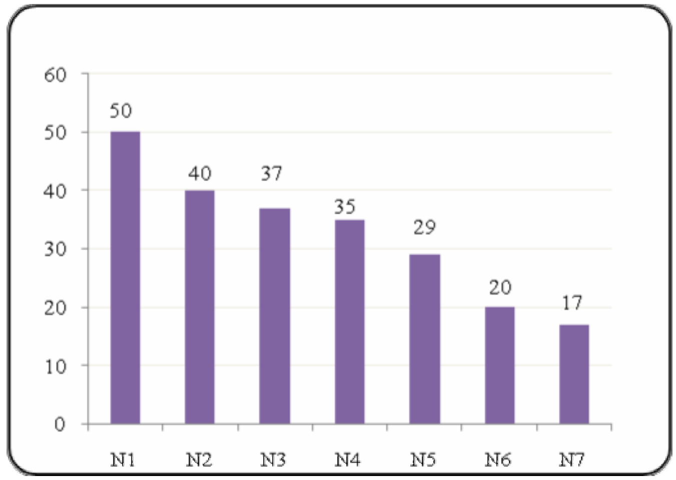

Figure 1 Variation of slump on different mix

It is observed that from N2,N3,N4,N5,N6 and N7 the slump value gradually decreases with respect to percentage of replacement of cement with RHA and fine aggregates with GF. The reason for decrease in slump is that RHA and GF has more water absorption when compared with cement and fine aggregate. Hence super plasticizers are used in the concrete to enhance the workability.

B. *Compressive strength test*

The compressive strength of concrete is tested using compression testing machine. The experimental results are compared with standard control concrete designed to yield an average compressive strength of 30MPa at 28 days. Cubes were casted for the mixes namely N1, N2, N3, N4, N5, N6 & N7. These casted cubes are tested for its compressive strength after 7, 14 & 28 days curing period. The test results are tabulated in table 9 and plotted in figure 3 . Compressive strength (MPa) = Failure load / cross sectional area.

Figure 2 Compression test of concrete

TABLE 9 COMPRESSIVE STRENGTH TEST RESULT

S.no	Name of mix	Compressive strength (N/mm^2)		
		7 days	14 days	28 days
1	N1	21.42	25.1	33.3
2	N2	23.7	28.3	36.1
3	N3	23.02	29.9	35.6
4	N4	28.3	31.5	40.2
5	N5	26.1	28.9	38
6	N6	22.4	25.3	32.7
7	N7	20	21.42	28.9

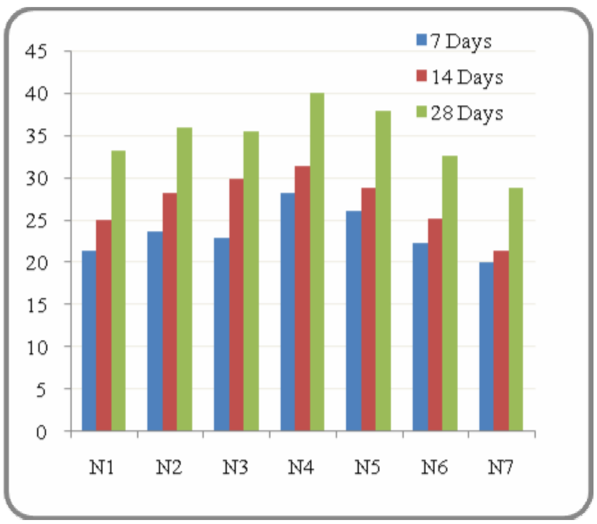

Figure 3 Variation of compressive strength on different mix

C. *Split tensile strength test*

Cylinders were casted for the specimens N1, N2, N3, N4, N5, N6 & N7 and were tested after 7 and 14 days curing. The load is applied uniformly along the length of the cylinder and the load is applied until failure of the cylinder, along the vertical diameter. The test results are tabulated in table 10 and plotted in figure 5. Split tensile strength was calculated as follows:

Spilt Tensile strength (MPa) = $2P / \pi DL$

Where, P = Failure Load (KN)

D = Diameter of Specimen (150 mm)

L = Length of Specimen (300 mm)

Figure 4 Split tensile test of concrete

TABLE 10 SPLIT TENSILE STRENGTH TEST RESULT

S.no	Name of mix	Split tensile strength (N/mm^2)	
		7 days	28 days
1	N1	1.7	2.4
2	N2	2.2	2.6
3	N3	2.3	2.54
4	N4	2.9	3.2
5	N5	2.6	3
6	N6	2.3	2.5
7	N7	1.4	1.97

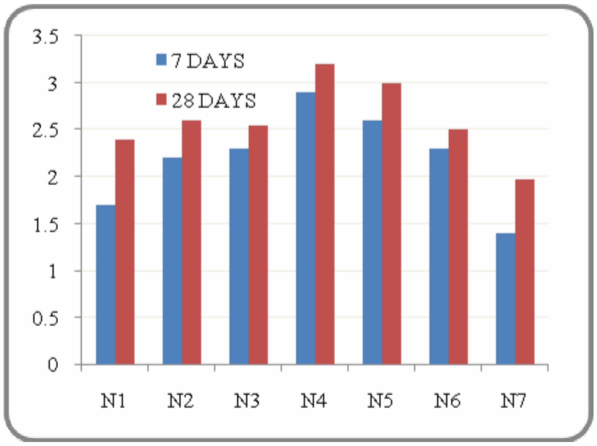

Figure 5 Variation of split strength on different mix

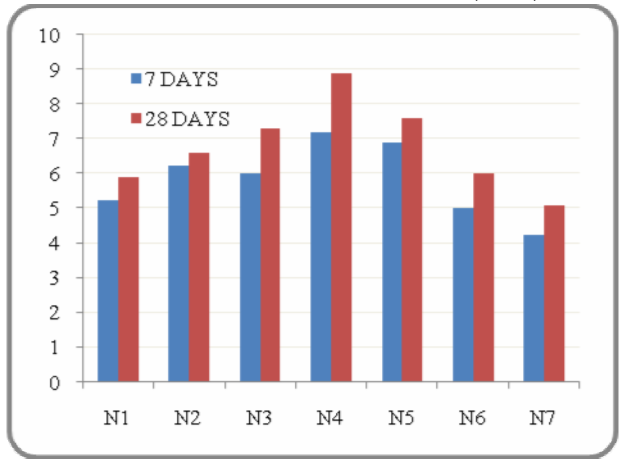

Figure 6 Variation of flexural strength on different mix

D. Flexural strength test

The prism of size 100mm x 100mm x 500mm is used for determining the flexural strength. The specimens are tested at the end of 7 & 28 days curing using flexural testing machine Prisms were casted for all the specimens from N1 to N7. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded. The test results are tabulated in table 11 and plotted in figure 6. The Flexural strength is calculated by using the formula

$\sigma = P\, l / bh^2$

Where,

P = load in Newton

l = length of rectangular prism in mm

b = breadth of rectangular prism

h = height of rectangular prism

TABLE 11 FLEXURAL STRENGTH TEST RESULT

S.no	**Name of mix**	**Flexural strength (N/mm²)**	
		7 days	**28 days**
1	N1	5.25	5.9
2	N2	6.25	6.6
3	N3	6	7.3
4	N4	7.2	8.9
5	N5	6.9	7.6
6	N6	5	6
7	N7	4.25	5.1

VII. LOAD DEFLECTION BEHAVIOR OF RCC BEAM

Flexural strength of reinforced concrete beam is determined to find out the load at which the concrete member may crack From the results of compression test ,N4 specimen has achieved a higher compressive strength of 40.2 N/mm² and has been identified as optimized concrete.

Reinforced concrete beams were casted for N1(control concrete) specimen and N4 (RHA 10% & GF 30%) specimen. Standard specimen of size 150 X 200 X 1500 mm were used. The beams were reinforced with 2 Nos of 10 mm dia bars in tension zone and 2 Nos of 10 mm dia bars in compression zone. 8 mm dia 2 legged stirrups with a spacing of 150 mm C/C were used as shear reinforcement. Two point load was applied on the beam and was loaded continuously at a constant rate until failure. Yield load, ultimate load , ultimate deflection were observed. The results are tabulated in table 12 and plotted in figure 7.

TABLE 12 RCC BEAM RESULTS OF MIX N1 & N4

S.no	**Description**	**N1 Beam**	**N4 Beam**
1	Yield load	18kn	20kn
2	Ultimate Load	42kn	46kn
3	Initial crack	18kn	20kn
4	Ultimate deflection	19.22	16.19
5	Ductility ratio	3.86	4.64
6	Initial crack width	0.09	0.07

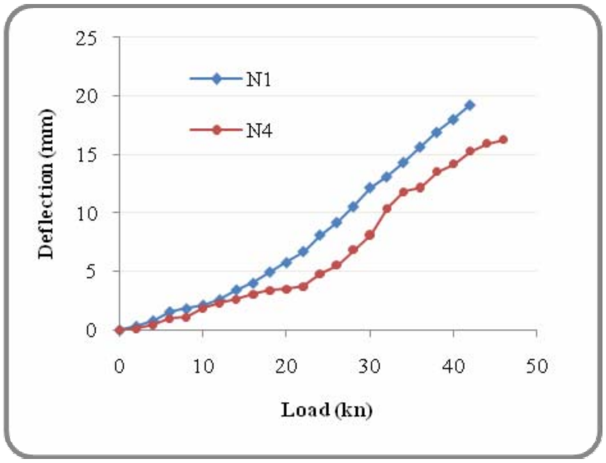

Figure 7 Comparison of load - deflection behavior of N1 and N4 mix beam

Figure 8 RCC beam set up

VIII. CONCLUSION

From the test results the following conclusions are made

- As the percentage of RHA and Granite fines are increased, the slump value decreased. Hence super plasticizer had been used to enhance the workability
- From the compressive strength , split tensile strength and flexural strength test results , N4 (RHA 10% & GF 30%) mix is identified as optimized concrete.
- The compressive strength test result of mix N4 on 28th day showed 32% increase in strength when compared with control mix (N1) .
- The split tensile strength test result of mix N4 on 28th day showed 33% increase in strength when compared with control mix.
- The flexural strength test result of mix N4 on 28th day showed 50% increase in strength when compared with control mix.
- In RCC beams , when compared to N1, mix N4 gives lesser deflection. The ultimate load of mix N4 is 46 kn which is 10% higher than N1 mix. Ductility ratio of mix N4 shows 20% increase than mix N1.
- On Whole it is concluded that both RHA and GF can be utilized in concrete at 10% replacement of RHA with cement and 30% replacement of GF with fine aggregate.
- Effective utilization of RHA and GF in concrete can save natural resources and hence can help to keep our environment safe.

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