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Comparative study on partial replacement of cement with Hospital waste ash Coal dust and Rice husk ash

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Abstract : The use of Portland cement in concrete construction is under critical review due to high amount of carbon dioxide gas released to the atmosphere during the production of cement. In recent years, attempts to increase the utilization of waste materials to partially replace the use of Portland cement in concrete are gathering momentum. Most of this by-product material is currently dumped in landfills, creating a threat to the environment.M25 grades of concrete has been chosen as the reference concrete specimen. This project deals with partial replacement of cement with coal dust, Hospital waste ash and rice husk ash varies with percentages of 0%, 5%, 10%, 15% &20%. In this study, workability, compressive strength, Flexural strength and Tensile strength of concrete was evaluated to investigate the optimal use of coal dust, Rice husk ash and hospital waste ash as cement in concrete.

Keywords *-coal dust, Rice husk ash, hospital waste ash, workability, compressive strength, Flexural strength and Tensile strength*

1.INTRODUCTION

In Civil Engineering "Cement" plays an important role as it is impossible to produce any sustainable infrastructure without use of cement. We can say everything is incomplete without "Cement", as construction industries rapidly growing with new innovations and ideas. Leaving waste materials in to environment directly results to damage of natural climatic conditions, hence use of waste materials is made at most importance in present study. Coal dust a waste obtained from mining process is used as partial replacement to cement a pozzolonic material also used after identifying the optimum usage of coal dust in partial replacement of cement. Cement, at the time of production produces equal amounts of Co_2. Hence the partial replacement of cement can be made practice to optimize the cement content effects the production of cement and CO_2 content production. The demand for construction material is also increasing, at the same time the cost of the construction material is also increasing, To overcome these type of problems are want to found the new composition with low cost is the ultimate aim of our project.

A. Hospital waste ash

Hospital waste ash is a special type of waste. All human activities producing waste. We all know that such waste may be dangerous and needs safe disposal. Industrial waste, sewage and agricultural waste pollute water,

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soil and air. It can also be dangerous to human beings and environment. Similarly hospitals and other health care facilities generate lot of waste. Cotton dressing and bandages with blood, used needles, used syringes, bottles, plastic bags etc., mostly glass or plastic. Operation theater waste like tissues, blood, and flesh etc., the hospital waste is highly pathogenic like bacteria, fungi and virus. This can transmit infections to the people. These wastes need proper collection, transportation and management. India generates around three million tons of hospital waste every year and the amount is expected to grow at eight percent annually.
Hospital waste ash may sometimes toxic or non-toxic. Non-toxic waste is usually utilized for the partial replacement of cement in concrete. These non-toxic waste is generated in incinerator. This waste which consist of broken glass bottles, paper wastes, syringes, tablet packets etc.

The idea of using this ash as cement replacement has been made because of the over dumping of Hospital wastes. The consequences of dumping HWA creates pathogenic and environmental diseases. The HWA is main content in this investigation.

B. Coal dust

Coal Dust is a fine powdered form of coal, which is created by the crushing, grinding, or pulverizing of coal. Because of the brittle nature of coal, coal dust can be created during mining, transportation, or by mechanically handling coal. Coal is defined as a readily combustible rock containing more than 50% by weight of carbon. Coals other constituents include hydrogen, oxygen, nitrogen, ash, and sulfur. Some of the undesirable chemical constituents include chorine and sodium.

C. Rice husk ash

Rich husk ash is an agricultural by product which is obtained from rice mill and then burned and very high temperature as fuel .which gives some extra advantages when utilized in cement. Rice husk can be burnt into ash that fulfills the physical characteristics and chemical composition of mineral admixtures. Pozzolanic activity of rice husk ash (RHA) depends on (i) silica content, (ii) silica crystallization phase, and (iii) size and surface area of ash particles. In addition, ash must contain only a small amount of carbon.The optimized RHA, by controlled burn and/or grinding, has been used as a pozzolanic material in cement and concrete. Using it provides several advantages, such as improved strength and durability properties, and environmental benefits related to the disposal of waste materials and to reduced carbon dioxide emissions.

Rice husk is generated from the rice processing industries as a major agricultural by product in many parts of the world especially in developing countries. About 500 million tons of paddies are produced in the world annually after incineration only about 20% of rice husk is transformed to RHA. Still now there is no useful application of RHA and is usually dumped into water streams or as landfills causing environmental pollution of air, water and soil. RHA consists of non-crystalline silicon dioxide with high specific Surface area and high pozzolanic reactivity, thus due to growing environmental concern and the need to conserve energy and resources, utilization of industrial and biogenic waste as supplementary cementing material has become an integral part of concrete construction. Pozzolonas improve strength

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because they are smaller than the cement particles, and can pack in between the cement particles and provide a finer pore structure. RHA has two roles in concrete manufacture, as a substitute for Portland cement, reducing the cost of concrete in the production of low cost building blocks, and as an admixture in the production of high strength concrete.

2. OBJECTIVE

i) To develop mix design methodology for mix 25MPa
ii) To study the effect of adding different percentages (0% - 20%) of Hospital waste ash, rice husk ash and coal dust by the weight of cement in the preparation of concrete mix.
iii) To determine the workability of freshly prepared concrete by Slump test.
iv) To determine the compressive strength of cubes at 7, 14, 28 days.
v) To determine the Flexural strength of beams at 28 days.
vi) To determine the Tensile strength of beams at 28 days.

3.MATERIALS USED

Cement:

Cement used in the investigation was found to be Ordinary Portland Cement(53 grade) confirming to IS : 12269 – 1987.

Fine Aggregate:

The fine aggregate used was obtained from a near by river course. The fine aggregate confirming to zone – II according to Is 383-1970 was used..

Coarse aggregate:

The coarse aggregate used is from a local crushing unit having 20mm nominal size. The coarse aggregate confirming to 20mm well-graded according to IS:383-1970 is used in this investigation.

Hospital waste ash:
Non-toxic waste is generated in incinerator. This waste which consist of broken glass bottles, paper wastes, syringes, tablet packets etc. HWA size was finer then cement.

Figure.1:Hospital waste ash

Coal dust:

Coal dust size was finer then cement. I t was collected from local coal factory.

Figure.2: Coal Dust Powder

Rice husk ash:

Rice husk collected from near by rice mill and its burnt upto converting ash form. Its size similar to cement.

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Figure.3: Rice husk ash

4. EXPERIMENTAL WORK

AdoptedMix design - M25

S.No	Item name	As per mixed design(kg/m3)	Per unit
1	Cement	448.6	1
2	Fine aggregates	752.71	1.432
3	Coarse aggregates	1064.65	2.568
4	water	197.4	0.44
Ratio of M25 Designed Mix=1:1.432:2.568 with water/binder ratio=0.44			

Table.1: Designed Values of Materials

A. Mixed design proportions for HWA , RHA and Coal dust Concrete

a. In this research work 15 Standard cubic specimens of size(nine sample for each percentage of HWA, RHA & COAL DUST) were casted for the compressive strength of concrete and it was kept under curing for 7, 14 days & 28 days of age.

b. Total cubes for compressive strength testing of individual waste (hwa, rha & coal dust) replacement 45 (9 cubes * 5 proportions).

c. In this research work 10 standard beams of size (three sample for each percentage of HWA, RHA & COAL DUST) were casted for flexural strength of concrete and it was kept under curing for 28 days of age. Total beams for flexural strength testing was 15(3beams * 5 proportions).

d. In this research work 15 standard cylinder of size (three sample for each percentage of HWA, RHA & COAL DUST) were casted for tensile strength of concrete and it was kept under curing for 28 days of age. Total cylinders for flexural strength testing was 15 (3cylinders * 5 proportions).

e. Mass of ingredients required will be calculated for 9 no's cubes assuming 10% wastage

f. Volume of the Cube = $9*1.10*(0.15)^3$ $=0.0334125\ m^3$

g. Mass of ingredients required will be calculated for 3 no's beams assuming 10% wastage

h. Volume of the Beam = $3*1.10*((0.10)^2*(0.50)) = 0.0165\ m^3$

i. Mass of ingredients required will be calculated for 3 no's cylinders assuming 10% wastage

j. Volume of the cylinders = $3*1.10*(3.14*\ (0.15\ /\ 2)^2*(0.30)) = 0.01748m^3$

B. Sample Production

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The cement, fine and coarse aggregates were weighted according to mix proportion of M_{25}. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.44. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

For the second series of the mixture, the waste material was added at 5%, 10%,15% and 20% by weight of Cement. Immediately after mixing, slump test was carried out for all the concrete series mixture. A standard 150×150×150mm cube specimens 300 mm height X 150mm diameter cylinder specimen and 100×100×500mm beam specimen were casted.

The samples were then stripped after 24hours of casting and are then be ponded in a water curing. As casted, a total of 180 (5proportions * 4materilas * 9cubes) 150×150×150mm cubes, 60 (5proportions * 4materilas * 3cubes) 300 mm X 150mm diameter cylinders and 60 (5proportions * 4materilas * 3cubes) 100×100×500mm beams specimens were produced.

The method of curing adopted was the ponding method of curing and produced samples werecured for 7days, 14days, and 28 days.

C. Test For Fresh Properties of Concrete (Workability Test)

a. Slump Test:

which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor is it always representative of the placability of the concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factor contributing to workability. The slump test was carried in accordance with B.S:1882 PART2:1970.

b. Compacting Factor

The compacting factor test was conducted in accordance with B.S 1881: PART 2:1970. The

compacting factor was computed using:-

$$\text{Compacting factor} = \frac{\text{Weight of freely fall of sample}}{weight of compacted sample}$$

D. Test For Harden Properties of Concrete

a. Compressive Strength of Concrete

The compression test was conducted according to IS 516-1959.This test helps us in determining the compressive strength of the concrete cubes. The obtained value of compressive strength can then be used to assess whether the given batch of that concrete cube will meet the required compressive strength requirements or not. For the compression test, the specimen's cubes of 15 cm x 15 cm x 15 cm were prepared by using hwa concrete as explained earlier. These specimens were tested under universal testing machine after 7 days, 14 days and 28 days of curing. Load was applied gradually at the rate of 140kg/cm^2 per minute till the specimens failed. Load at the failure was divided by area of specimen and this gave us the compressive strength of concrete for the given sample.

b. Flexural Strength of Concrete (IS:516-1959)

The beam specimens were tested on universal testing machine for two-point loading to create a pure bending. The bearing surface of machine was wiped off clean and sand or other material is removed from the surface of the specimen. The two point bending load applied was increased continuously at a constant rate until the specimen breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. The modulus of rupture depends on where the specimen breaks along the span. Beam dimensions are 500mm×100mm×100mm. if the specimen breaks at the middle third of the span then the modulus of rupture is given by,

$$f_{rup} = \frac{Pl}{bd^2}$$

Where; P = load, d = depth of the beam, b = width of the beam.

c. Split-Tensile Test

It is the standard test, to determine the tensile strength of concrete in an indirect way. This test could be performed in accordance with IS : 5816-1970.

Astandard test cylinder of concrete specimen (300 mm X 150mm diameter) is placed horizontally between the loading surfaces of Compression Testing Machine (Fig-4). The compression load is applied diametrically and uniformly along the length of cylinder until the failure of the cylinder along the vertical diameter. To allow the uniform distribution of this applied load and to reduce the magnitude of the high compressive stresses near the points of application of this load, strips of plywood are placed between the specimen and loading platens of the testing machine. Concrete cylinders split into two halves along this vertical plane due to indirect tensile stress generated by poison’s effect.

5. RESULTS & DISCUSSIONS

A. Results for Cement, HWA, RHA & Coal dust

Properties	Results
Specific gravity	3.15
Standard consistency	31%
Initial setting time	38minutes
Final setting time	560minutes
Fineness	7%

Table .2: Properties of cement

Material	Fineness	Specific gravity
Cement	6	3.07
HWA	4	1.096
RHA	6	2.21
Coal dust	5	2.87

Table .3: Properties of materials

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B. Workability of the concrete

a. Slump test

The Slump test was performed on the hwa, rha and coal dust concrete to check the workability of it at different replacements viz. 5 %, 10 %, 15%, 20% and the following results were obtained, according to which it can be concluded that with the increase in % of hwa, rha and coal dust from 0 to 20 % , workability decreases. The results obtained for Slump test are shown below in Tables.

Material	0%	5%	10%	15 %	20 %
HWA	15	11. 5	11	10. 5	8.5
RHA	15	13	11	9.8	7
Coal dust	15	14	12	10	9

Table.4: Slump cone results

b. Compaction factor test

The compaction factor test was performed on the concrete with cemnet replacement to check the workability of it at different replacements viz. 5 % , 10 % , 15%, 20% and the following results were obtained, according to which it can be concluded that with the increase in % of HWA, RHA & Coal dust from 0 to 20 % , workability decreases. Theoretical maximum value of compaction factor can be .96 to 1.0. The results obtained for compaction factor test are shown below in Tables.

%	HWA	RHA	Coal dust
0%	0.91	0.91	0.91
5%	0.87	0.85	0.87
10%	0.84	0.84	0.86
15%	0.82	0.83	0.84
20%	0.80	0.80	0.81

Table.5: Results of compaction factor test

C. COMPRESSIVE STRENGTH

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of concrete with replacing of HWA, RHA & COAL DUST in Cement and the results obtained are given in below Tables.

% HWA	Compressive strength of cubes (Average results)(N/mm^2)		
	7 days	14 days	28 days
0	15.8	22.9	27.2
5	18.9	26.26	32.9
10	17.2	24.06	29.13
15	16.23	22	26
20	15	20	23.2

Table.6: Results of compressive strength test for HWA

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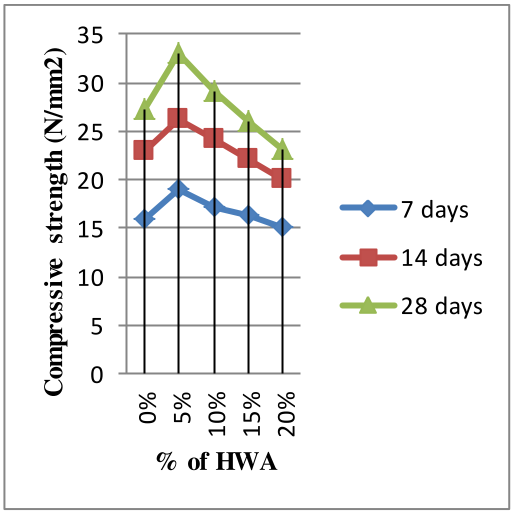

Figure.4: Compressive strength v/s % of HWA

From the above graph it was observed that with the increase in percentage of HWA from 0% to 20% in concrete the compressive strength decreased.

% RHA	Compressive strength of cubes (Average results)(N/mm^2)		
	7 days	14 days	28 days
0	15.8	22.9	27.2
5	17.34	24.51	33.92
10	15.25	22.56	32.43
15	10.01	19.75	28.04
20	9.32	17.42	20.23

Table.7: Results of compressive strength test for RHA

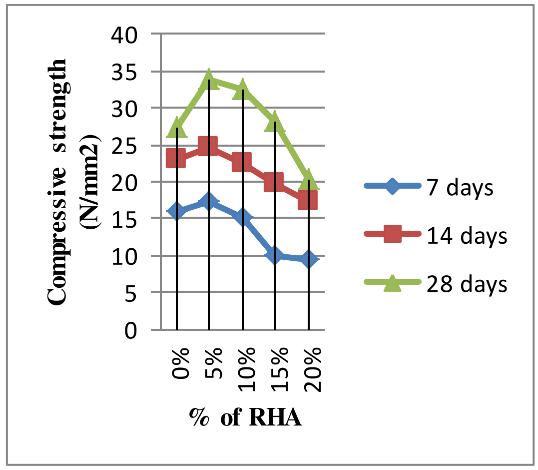

Figure.5: Compressive strength v/s % of RHA

From the above graph it was observed that with the increase in percentage of RHA from 0% to 20% in concrete the compressive strength decreased.

% Coal dust	Compressive strength of cubes (Average results)(N/mm^2)		
	7 days	14 days	28 days
0	15.8	22.9	27.2
5	16.23	23	28.32
10	17.21	23.84	32.15
15	17.96	24.32	33.61
20	15.9	22.34	30.45

Table.8: Results of compressive strength test for Coal dust

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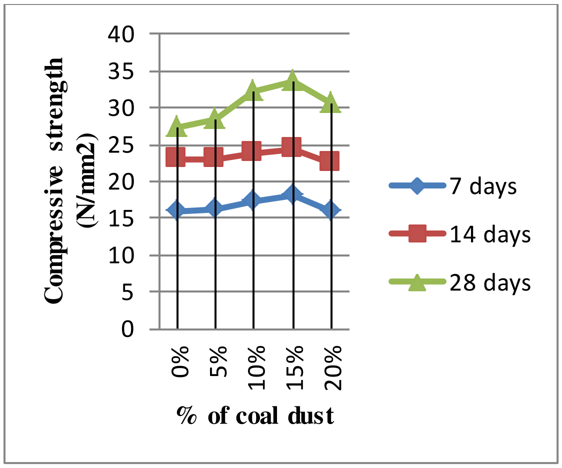

Figure.6: Compressive strength v/s % of coal dust

From the above graph it was observed that with the increase in percentage of COAL DUST from 0% to 15% in concrete the compressive strength increases after that decresing.

D. FLEXURAL STRENGTH TEST

The Flexural test was performed on the beams of size 50 x 10 x 10 cm to check the flexural strength of theconcrete with replacing of HWA, RHA & COAL DUST in Cement and the results obtained while performing the flexural test on UTM are given in below Tables.

Material	Flexural strength (N/mm^2)				
	0%	5%	10%	15%	20%
HWA	6.26	6.56	5.48	5.16	4.72
RHA	6.26	6.61	5.83	5.26	4.75
Coal dust	6.26	5.86	6.1	6.34	5.04

Table.9: Result of flexural strength for HWA,RHA & Coal dust

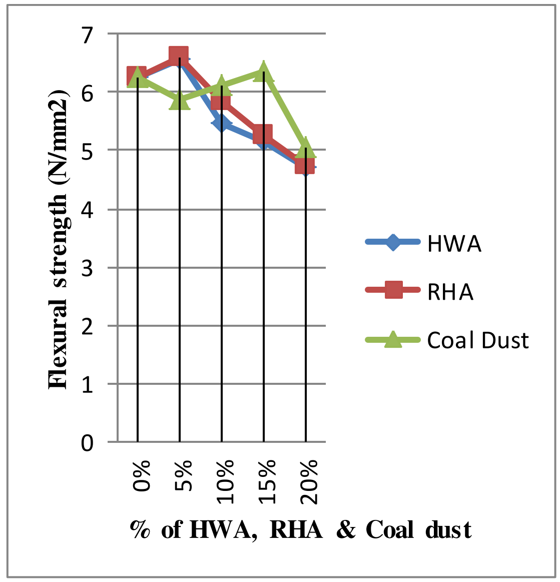

Figure.7: Flexural strength v/s % of HWA

E. SPLIT TESNSILE TEST

The tensile test was performed on the beams of size (300 mm X 150mm diameter) to check the tensile strength of theconcrete with replacing of HWA, RHA & COAL DUST in Cement and the results obtained while performing the tensile test on UTM are given in below Tables.

Material	Tensile strength (N/mm^2)				
	0%	5%	10%	15%	20%
HWA	3.32	4.31	3.89	3.64	3.29
RHA	3.32	4.25	4.1	3.57	3.19
Coal dust	3.32	3.86	3.90	4.15	3.8

Table.10: Result of Split tensile strength for HWA,RHA & Coal dust

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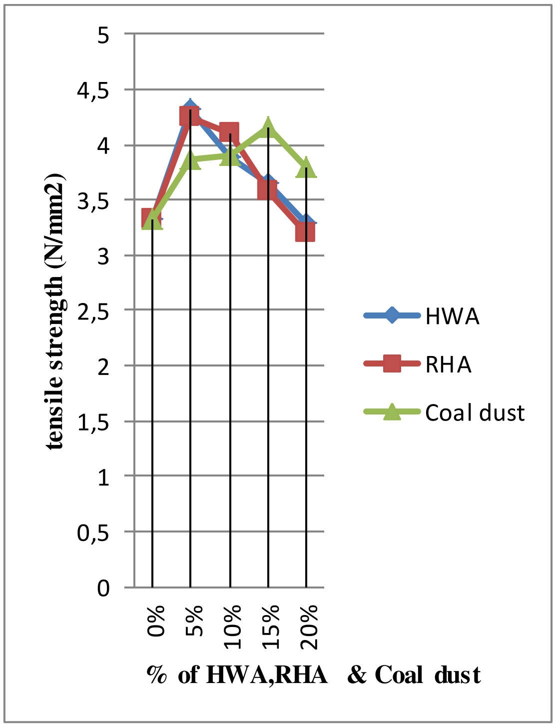

Figure.8: Tensile strength v/s % of HWA

6. CONCLUSION

a. Based on the result that have carried out here as part of this research, I concluded that the replacement of HWA, RHA & Coal dust wastes can be used for the preparation of concrete. The best advantage of this partial replacement is reducing the over dumping of wastes to public.

b. In this research the workability decreased with increasing percentage of proportion of HWA, RHA & Coal dust.

c. The compressive strength of specimen with 5% HWA, 5% RHA & 15% Coal dust were partial replacing with cement in concrete shows higher than that of control mix.

d. The flexural strength of specimen with 5% HWA, 5% RHA & 15% Coal dust were partial replacing with cement in concrete shows higher than that of control mix.

e. The tensile strength of specimen with 5% HWA, 5% RHA & 15% Coal dust were partial replacing with cement in concrete shows higher than that of control mix.

f. The compressive, flexural & tensile strength with 5% RHA, 5% HWA & 15% Coal dustshows higher than that of control mix.

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