Experimental study on Fly Ash, Wheat Straw Ash, Rice Husk Ash, Saw Dust Ash and Glass powder as a partial replacement of cement in Concrete and their Cost Analysis

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Abstract— Different materials with pozzolanic properties such as fly ash. Condensed silica fume, blast furnace slag and rice husk ash have played an important part in the production of high performance concrete. During the late 20th century, three has been an increase in the consumption of mineral admixture by the cement and concrete industries[4]. The increasing demand for cement and concrete is met by the partial replacement for energy intensive Portland cement. Pozzolanic materials have long demonstration their effectiveness in producing high performance concrete. Artificial pozzolanas such as supplementary cementing material in many part of the world[2]. This work evaluates the compressive strength of rice husk ash (RHA, Wheat Straw Ash (WSA), Fly Ash, (FA), Glass powder (GP)as a partial replacement for OPC in concrete[1]. The main aim of this work is to determine the optimum %(10, 20, 30) of Rice husk ash (RHA), Wheat Straw Ash (WSA), Fly Ash, (FA), Glass powder (GP) as partial replacement of cement for M40 grade of concrete[3]. In addition, results show that Rice husk ash(RHA), Wheat Straw Ash (WSA), Fly Ash, (FA), Glass powder (GP) as an artificial pozzolanic material has enhanced the durability of concrete..

Key words: Rice husk ash(RHA), Wheat Straw Ash (WSA), Fly Ash, (FA), Glass powder (GP), cement replacement, concrete, Compressive strength.

I. INTRODUCTION

There has been alarming rate of increase in the price of building materials in the recent past. This has necessitated government, private and individuals to go in research for locally sourced materials to supplement (replace-fully or partially) the conventional materials[1]. The increasing demand for cement and concrete is met by the partial replacement of cement[4]. Concrete is a composite material which consists eccentrically of a binding medium[1]. Concrete is no longer made of aggregate Portland cement and water only. Often but not always it has to incorporate at least one of the additional ingredients such as admixture or cementitious material to enhance its strength and durability[4].This investigation target to determine the optimum percentage (10, 20, 30%) of Rice husk ash(RHA), Wheat Straw Ash (WSA), Fly Ash, (FA), Glass powder (GP) as a partial replacement of cement for M40 grade of concrete, and to determine its compressive strength.

II. METHODOLOGY

In this project Rice husk ash, wheat straw ash, Saw Dust ash, Fly ash and glass powder are partially replaced by cement in concrete. Concrete of M40 grade is prepared according IS 10262 : 2009 specification; 15 mix are prepared containing different waste material with different proportions; with Rice husk ash RHA10, RHA20 and RHA30 mix are prepared in which RHA shows Rice husk ash and 10,20,30 shows their replacement percentage; with Wheat straw ash WSA10 WSA20 WSA30 mix are prepared; with Saw dust ash SWA10, SWA20, SWA30; with Fly ash FA10, FA20, FA30; with Glass powder GP10, GP20, GP30 mix are prepared. 15 * 15 * 15 cm cube was casted for each mix containing different waste materials; for each mix 9 cubes was casted for 7, 14 and 28 days of curing. Each cube of different mixes are goes for compression strength test and average of three cubes are taken as compression strength of concrete. For mix design materials are tested for their physical properties. Results of specific gravity of materials are given in table 1; fineness modulus are in table 2; Fineness Modulus of Aggregates (Sieve Analysis) are given in table 3; water absorption of aggregates are given in table 4.

S. No.	Material	Specific Gravity
1.	Cement	3.14
2.	Fine Aggregate	2.24
3.	Coarse Aggregate	2.52
4.	Fly Ash	2.56
5.	Glass Powder	2.20
6.	Rice husk Ash	2.01
7.	Wheat Straw Ash	2.10
8.	Saw Dust Ash	2.12

Table 1 Results of Specific Gravity Test

S. No	Material	Fineness modulus
1.	Cement	4
2.	Glass powder	6
3.	Fly ash	4.5
4.	Rice hus ash	5.2
5.	Wheat straw ash	4.9
6.	Saw Dust ash	6.2

Table 2: Fineness Modulus of Materials

Sieve Sizes	Total Percentage Retained		
	Fine Aggregate	Coarse Aggregate	Combined coarse and fine (65:35)
1-1/2-in. (38.1-mm)	0	4	3
¾ in (19.00 mm)	0	49	32

3/8 in. (9.5 mm)	0	91	59
No. 4 (4.75 mm)	4	100	66
No. 8 (2.36 mm)	21	100	72
No. 16 (1.18 mm)	46	100	81
No. 30 (600 µm)	74	100	91
No. 50 (300 µm)	89	100	96
No. 100 (150 µm)	95	100	98
Total %	329	744	598

Fineness modulus = Total percentage/100
Fine aggregate = 329/100 = 3.29
Coarse aggregate = 744/100 = 7.44
Combined = 598/100 = 5.98

Table 3 Fineness Modulus of Aggregates(Sieve Analysis)

S. No.	Determination No.	Fine Aggregates			Coarse		
		I	II	III	I	II	III
1	Weight of saturated surface dried sample in grams (A)	2409	2380	2491	2409	2380	2491
2	Weight of Oven Dried sample in grams (B)	2404	2375	2486	2385	2356	2466
3	$\frac{A-B}{B} \times 100\%$	0.208%	0.210%	0.201%	1.05%	1.01%	1.01%
Average		0.206%			1.023%		

Table 4 Water Absorption test of Fine aggregates

III. RESULT AND DISCUSSION

A. Compression Strength Test

When concrete cubes of different mixes go through the Compression Strength Test it was analyzed that, all material are useable because they gives better results by replacing cement but if we see FA10, FA20, FA30, GP20 and SDA 30 mix gives best result in compressive strength. Results of all mix are given in table 5.

S. No.	Mix	Compressive Strength		
		7 Days	14 Days	28 Days
1.	FA10	40.16	42.71	47.23
2.	FA20	38.46	42.14	46.92
3.	FA30	37.22	41.54	47.12
4.	RHA10	34.32	38.77	48.42
5.	RHA20	29.34	34.56	40.86
6.	RHA30	27.42	31.95	37.05
7.	WSA10	32.32	36.77	41.42
8.	WSA20	26.34	31.56	38.92
9.	WSA30	25.42	27.95	35.05
10.	GP10	27.94	32.67	42.43
11.	GP20	29.28	34.36	44.33
12.	GP30	26.64	31.82	41.52
13.	SDA10	36.12	37.85	39.66
14.	SDA20	35.64	37.36	38.21
15.	SDA30	36.98	40.22	44.21

Table:5 Compressive strength of concrete **cube with**

Compressive strength of concrete cube is determined and it is found that all material at any percentage of mixing upto 30% gives satisfactory results where fly ash (FA) gives 47.23 N/mm^2, 46.92 N/mm^2, 47.12 N/mm^2 at 10,20 and 30% replacement respectively, which is more than design strength where Rice husk Ash (RHA) gives 48.42, 40.86 and 37.05 for 10,20 and 30% replacement respectively, which is more than 85% of designed Fck. Where Wheat Straw Ash (WSA)does not gives excellent result but it is satisfactory, it gives 41.42, 38.92 and 35.05 N/mm^2 at 10,20 and 30% replacement respectively. Glass powder (GP) gives better result i.e. 42.44, 44.37, 41.52 N/mm^2 at 10,20 and 30% replacement respectively and Saw Dust ash (SWA) gives average result as compare to above materials it possess 39.66, 38.21,44.21 N/mm^2 at 10,20 and 30% replacement respectively. All these results are of 28 of curing. Compression strength test is carried out after at 7th and 14th days of curing, it has been observed that 60% strength is gained by concrete cube at 7th day of curing and 80% strength is gain at 14 days of curing.

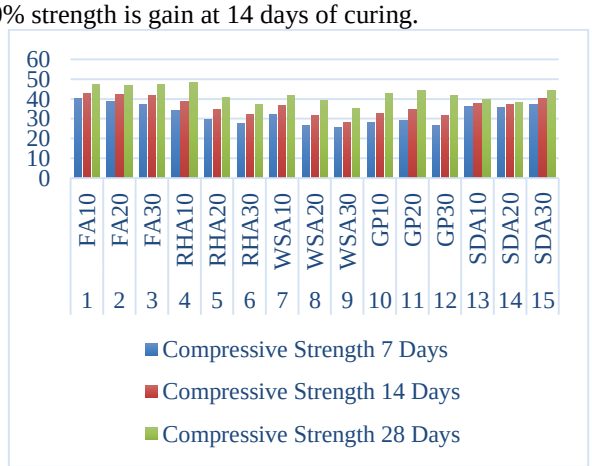

Figure 1: Bar Chart for Compressive strength of Concrete cube

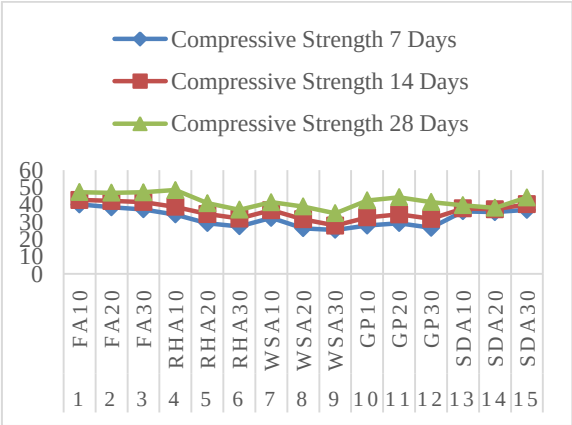

Fig. 2: Line Chart for Compressive Strength of Concrete cube

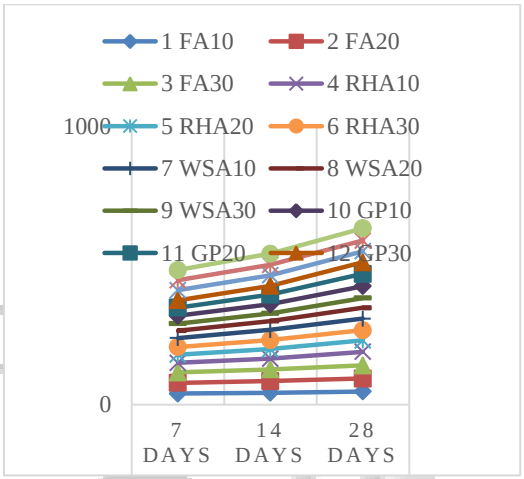

Figure 3: Line Chart for Compressive Strength of Concrete cube According to curing time Cost Analysis and Cost Comparison

Concrete is a versatile material and largely used in construction. The raw materials required for manufacture of the product are Portland cement and aggregates which are available locally in every part of the country. In this chapter we determine cost of a 1 m^3. Here general cost of concrete is determined by simply calculating aggregates and cement content by its present rate. The main aim of this chapter is to calculate how much money can be saved by replacing cement by these waste materials, cement is a very costly building material and if we save cement so some amount of money can be saved.

B. Cost analysis of a Concrete

Cost of concrete is contains many aspects like rate of cement, aggregates and it also includes transportation charges of materials, different expenditures of plants, labour charges, owners profit etc. but here cost of a concrete is calculated simply by calculating its aggregate and cement requirements other aspects is calculated here because we want compares its rate when cement is replaced by waste materials upto 30%.

Cost analysis of 1 m^3, M40 grade of concrete as per mix design is given below:

S. No.	Material	Rate	Cost
1.	Cement	Rs.315/ bag *Bag contain 50 kg cement 6.3/ kg	Rs 3413.00/-
2.	Fine Aggregate (Sand)	Rs. 1620/ m^3 Rs. 0.72/ kg	Rs. 1620/-
3.	Coarse Aggregates (Crushed Stone of 10 mm)	Rs. 1800/ m^3 Rs. 71/ Kg	Rs. 1800/-
Total Cost of a paver block =			Rs. 6833.00/-

Table 6: Cost Analysis of Concrete

Rate of 1 m^3 is Rs. 6833.00/-

C. Cost Comparison

It is calculated that cost of 1 m^3 concrete is Rs.6833/-, so if we replace cement upto 30% by waste material and its cost comparison with conventional one is given below:

S. No.	Replacement Percentage of waste material	Maas of Cement Reduced (Kg)	Mass of Cement Mixed (Kg)	Cost of cement	Cost of One Concrete cube	Cost Save in one Concrete cube
1.	10	54.176	487.584	Rs. 3071.77/-	Rs. 6491.77/-	Rs. 341.23/-
2.	20	108.352	433.408	Rs. 2730.40/-	Rs. 6150.47/-	Rs. 683/-
3.	30	162.528	379.23	Rs. 2389.14/-	Rs. 5809.14/-	Rs. 1024/-

Table 7: Cost comparison of concrete

Let suppose if we required 1000 m^3 concrete for a building work.

- If we provide general concrete which costs 6833 × 1000 = Rs. 6833000/-
- If we provide 10% replacement blocks then it costs total 6491.77 × 1000 = Rs.6491770 /- which saves Rs. 341230/- it means approx 5% money is saved.
- If we provide 20% replacement blocks then it costs total 6150.47 × 1000 = Rs. 6150470/- which saves Rs. 683000/- it means approx 10% money is saved.
- If we provide 30% replacement blocks then it costs total 5809.14 × 1000 = Rs.5809140/- which saves Rs. 1024000/- it means approx 15% money is saved.

It has been observed that 5%, 10%, 15% money is saved when we use 10%, 20%, 30% cement replacement mix respectively.

IV. CONCLUSION

A. On the basis of strength

The result of study shows that there are good prospects of using Rice husk Ash (RHA), Fly Ash (FA), Wheat Straw

Ash (WSA), Saw Dust Ash (SWA) and Glass Powder (GP) as a pozzolana combination with ordinary Portland cement (OPC) in the Concrete Blocks.15*15*15cm concrete cubes are casted and its compressive is determined. The combination of 10%, 20% and 30% cement replacement Mix is prepared by using all WSA, RHA, FA, GP, and SWA for 0.4 water cement ratio. It shows that compressive increase with curing time.

The compressive strength of paver blocks with fly ash gives tremendous results. Its FA10 and FA30 mix gives 52.9 and 52.77 N/mm^2 compressive strength respectively which is awesome. Where Rice Husk Ash RHA10 mix gives excellent compressive strength i.e. 54.2 N/mm^2. Wheat straw ash gives average results, their all mix are above 85% of specified strength as recommended by IS 15658 : 2006. Glass Powder and Saw Dust Ash GP20 and SDA30 mix posses good compressive strength i.e. 49.65 and 49.6 N/mm^2. All mix gives more than 85% compressive strength so all waste mix can be used for paver blocks. As if u want to select only one material then I will suggest fly Ash with FA30 mix on the basis of compressive strength because here 30% cement is saved and also it gives better result as compare to others, along with FA30 mix RHA30, FA20, SDA30 and GP20 Mix also gives better results and they are also applicable.

*All result mention above are of 28 days curing.

If any mix we want to select on the basis of compressive and there are some aspect on which we have to select mix and they are

(1) Percentage replacement: we have taken maximum percentage replacement so that maximum cement can be saved and also prevent environment.
(2) Compressive Strength: after percentage replacement we have look its compressive strength.

On the basis of above three points mix is ranked in table below:

S. No.	Mix	Compressive Strength N/mm2 (28 days Curing)
1	**FA30**	**52.77**
2	**SDA30**	**49.52**
3	**GP30**	**46.5**
4	**RHA30**	**41.5**
5	**WSA30**	**39.26**
6	**FA20**	**52.55**
7	**GP20**	**49.65**
8	**RHA20**	**45.76**
9	**WSA20**	**43.59**
10	**SDA20**	**42.8**
11	**RHA10**	**54.23**
12	**FA10**	**52.9**
13	**GP10**	**47.52**
14	**WSA10**	**46.39**
15	**SDA10**	**44.42**

Rank 1	
Rank 2	
Rank 3	
Rank 4	
Rank 5	
Rank 6	

Table 8: Suggested Rank for Paver Blocks of different Material

From the study conducted, it was clearly shown that Rice husk ash(RHA), Wheat Straw Ash (WSA), Fly Ash, (FA), Glass powder (GP) are pozzolanic material and can contribute to the sustainability to the construction material.

B. On basis of cost

When cement is replaced by cement in paver block, It has been observed that 4%, 16%, 25% money is saved when we use 10%, 20%, 30% money respectively.

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