Use of Flyash & Lime as Partial Replacement of Cement and Partial Replacement of Fine Aggregate with Brick Kiln Dust

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Abstract— The research deals with the use of available Flyash and Lime as a partial replacement of cement and use of Brick Kiln Dust (BKD) as partial replacement of fine aggregate in concrete. The reuse of flyash and brick kiln dust is done which will reduce the amount of waste to be disposed of. As the flyash will reduce the use of cement, the pollution caused by emission of CO2 during cement manufacture will be reduced. So, the pollution caused due to both the reasons will be reduced. This paper mainly focuses on the use of waste i.e. flyash and brick kiln dust for production of eco-friendly and cost effective concrete. The objective of this paper is to find out the suitable proportions up to which cement can be replaced by flyash and lime corresponding to maximum compressive strength. Same objective goes for Brick kiln dust. The work is done for mix M25 High volume flyash concrete (HVFA) with 75% cement replacement by weight. Replaced portion contained different proportions of flyash and lime. Lime is being used in proportion from 30% to 40% by weight of replaced 75% cementitious material. The fine aggregate is being replaced with brick kiln dust in proportions from 5% to 40% by weight. Compressive strength test of cubes is tested at 7 days, 14 days & 28 days.

Key words: Flyash, HVFA, Lime, Brick Kiln Dust, Compressive strength, Pozzolana

I. INTRODUCTION

In a country like India, concrete is the major part of construction industry. Most of the structures are constructed using concrete. So, large amount of cement is being used every year and its cost is increasing day by day. The production of cement also causes air pollution and respiratory problems for workers in the cement factory. The aim of this research is to reduce the amount of cement used in concrete and further reduce the cost of concrete by using waste material. Use of waste like flyash and brick kiln dust also saves cost of disposing them. Due to some drawbacks of using high volume of flyash, we are mixing lime for binding in different ratios. Admixture is also added for enhanced strength. Cement is partly replaced by Flyash and Lime. Fine aggregate is partly replaced by Brick kiln dust. Since the amount of flyash and brick kiln dust generated annually is very high and is still increasing, this research has a high scope in future.

P. Vipul Naidu and Pawan Kumar Pandey (2014) [8] conducted a study on M40 HVFA concrete with 65% to 75% replacement by weight of cement by flyash. They also used 10% by weight of lime for binding. The 56 days' compressive strengths obtained for 65%, 70% and 75% were 58.22, 54.67 and 48.73 MPa. Their research concluded that cement can be replaced by 75% to that of cementitious material.

Rajesh Kumar Bharti, Mr. R. D. Patel (2014) [9] studied the effect of partial replacement of cement by BKD and Silica fumes on the compressive strength of concrete. They used silica fumes in proportion of 0, 5, 10, 15 % by weight and BKD in 0, 5, 10, 15 % by weight. This study concluded that maximum strength of 33.56 MPa is obtained at 15% silica fumes plus 10% BKD as replacement of cement.

Srila Dey (2016) [10] made an attempt to study the effect of HVFA by replacing cement with flyash and silica fumes in proportions of 50% to 80% and 0% to 15% by weight respectively. The author got maximum strength at 10% silica fumes. The 45 day strengths obtained at 50%, 60%, 70% & 80% flyash contents (10% silica fume) were 37, 30.5, 25, 15 MPa.

II. MATERIAL USED

1) Coarse aggregate: These are crushed stones which provide rigidity to the concrete. Aggregate of size 10mm and 20 mm were used.
2) Fine aggregate: Fine aggregate/Sand extracted from river bed are crushed stones. Locally available sand of zone III as per IS 383:1970 was used. Sand passing from 2.36 IS sieve is used.
3) Cement (OPC-43): Ordinary Portland Cement is pure form of cement with no pozzolanic additives. OPC of grade 43 (manufactured by Zuari Cement) as pert IS 8112:1989 was used.
4) Flyash: Flyash is a waste material generated from thermal power plant in process of combustion of pulverized coal. It is a pozzolanic material and shows binding capability when lime is mixed. Class F flyash from Unchahar Thermal Power Plant is used which is located in Raebareli, Uttar Pradesh, India.
5) Lime: It is also known as Quicklime or Calcium Oxide. It is white substance prepared by heating naturally occurring limestone in lime kiln. Locally available Quicklime is used as a binding material.
6) Brick Kiln Dust (BKD): BKD is a waste produced from brick kilns. It is locally known as Rabbish. BKD from brick kiln located at Mati, near Deva road, Lucknow, Uttar Pradesh, India.
7) Admixture: It enhances the workability of concrete due to its dispersion effect on cement. It reduces the air voids in the concrete and gives better surface finish. Use of admixture reduces the amount of water required for concrete. Silicon PC Superplasticizer is used in this research.
8) Water: Tap water is used to make concrete.

III. METHODOLOGY

– Making of concrete: Cubes were casted in the college laboratory. Cubes of size 150mm * 150mm * 150mm were selected for casting. The material was collected and weighed according to the ratios required. All the

materials used were in dry state. After adding water, materials were thoroughly mixed for homogeneity. Then cubes were filled with concrete using tamping rod and vibration machine.

- Mix 1: Firstly, only cement was replaced by flyash and lime. Cement was kept constant at 25% by weight of total cementitious material. The content of flyash with respect remaining 75% cementitious material was 60%, 62%, 65%, 68%, 70%, 73% & 75%. Total of 42 cubes with flyash content were casted.
- Mix 2: Secondly, only sand was replaced with BKD. The proportions of BKD were 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%. Total of 48 cubes with BKD only were casted.
- Mix 3: After obtaining the optimum percentage of flyash and lime from Mix 1 and percentage of BKD from Mix 2, final cubes were casted with both optimum replacements. 6 cubes for final mix were casted.
- Cubes were tested for compressive strength at 7 day, 14 day and 28 day (2 cubes every time). The readings for each test are given below.

IV. RESULTS

S. No.	Property	Obtained Value			
		Sample 1	Sample 2	Sample 3	Average
1.	Crushing Value Test	23.6%	23.8%	23.41 %	23.6%
2.	Impact Value Test	12.32 %	13.32 %	13.09 %	12.88%
3.	Abrasion Value Test	30.17 %	32.0%	31.5%	31.22%
4.	Bulk Density	1.42	1.37	1.39	1.39
5.	Water Absorption	0.34%	0.31%	0.28%	0.32%
6.	Specific Gravity	2.92	2.84	2.80	2.88

Table 1: Properties of Coarse Aggregate

S. No.	Property	Obtained Value			
		Sample 1	Sample 2	Sample 3	Average
1.	Specific Gravity	2.54	2.62	2.64	2.60
2.	Water Absorption	2.62	2.67	2.66	2.65
3.	Bulking	5.35	3.27	4.9	4.51

Table 2: Properties of Fine Aggregate

S. No.	Property	Obtained Value			
		Sample 1	Sample 2	Sample 3	Average
1.	Initial Setting Time (min)	101	102	98	100
2.	Final Setting Time (hr)	220	217	221	219
3.	Consistency	40	41	39	40
4.	Fineness	2.8	3.2	3.0	3.0
5.	Compressive Strength: 1. 3 Days 2. 7 Days 3. 28 Days	 24.06 36.44 45.8	 22.89 35.75 44.32	 24.34 37.21 46.26	 23.76 36.47 45.46

Table 3: Properties of Cement

S. No.	Property	Obtained Value			
		Sample 1	Sample 2	Sample 3	Average
1.	Fineness	24.5	24.8	25.7	25
2.	Consistency	44	46	45	45

Table 4: Properties of Flyash

S. No.	Property	Obtained Value			
		Sample 1	Sample 2	Sample 3	Average
1.	Water Absorption	27%	29.5%	28.2%	28.2%
2.	Bulking	2.85%	4.61%	3.9%	4.12%

Table 5: Properties of BKD

Materials		For 1 cube (150mm * 150mm * 150mm)						
		60 %* Flyash	62 %* Flyash	65 %* Flyash	68 %* Flyash	70 %* Flyash	73 %* Flyash	75 %* Flyash
Cement (kg)		0.5	0.5	0.5	0.5	0.5	0.5	0.5
Flyash (kg)		0.9	0.93	0.96	1.02	1.05	1.095	1.125
Lime (kg)		0.6	0.57	0.54	0.48	0.45	0.40	0.375
Sand (kg)		2.0	2.0	2..0	2.0	2.0	2.0	2.0
10mm aggregate (kg)		1.6	1.6	1.6	1.6	1.6	1.6	1.6
20mm aggregate (kg)		2.4	2.4	2.4	2.4	2.4	2.4	2.4
w/c ratio		0.38	0.35	0.33	0.34	0.355	0.35	0.345
Admixture (gm)		16	16	16	16	16	16	16
Strength (MPa)	7 days	15.55	15.11	16.44	16.0	15.55	14.20	11.11
	14 days	22.22	22.22	24.44	24.44	24.88	21.77	18.22
	28 days	24.44	24.88	27.55	26.67	26.88	24.44	20

Table 6: Mix 1: Flyash + Lime

Cement was kept constant at 25% of cementitious material. Given percentages in the table represent flyash percent out of 75% of remaining cementitious material.

Materials		For 1 cube (150mm * 150mm * 150mm)							
		5 % Dust	10 % Dust	15 % Dust	20 % Dust	25 % Dust	30 % Dust	35 % Dust	40 % Dust
Cement (kg)		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Brick kiln Dust (kg)		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Sand (kg)		1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2
10mm aggregate (kg)		1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
20mm aggregate (kg)		2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
w/c ratio		0.35	0.36	0.40	0.40	0.42	0.47	0.50	0.56
Strength (MPa)	7 days	15.55	16.44	16.0	16.0	15.55	15.55	12.88	11.55
	14 days	24.0	25.11	24.88	24.44	23.55	24.0	19.55	16.88
	28 days	27.55	28.0	27.33	27.11	26.88	26.66	21.33	18.66

Table 7: Mix 2: BKD

Materials		For 1 cube
		MIX 3
Cement (kg)		2.0
Brick kiln Dust (kg)		0.1
Sand (kg)		1.9
10mm aggregate (kg)		1.6
20mm aggregate (kg)		2.4
Flyash (kg)		0.96
Lime (kg)		0.54
Admixture (gm)		16.0
w/c ratio		0.35
Strength (MPa)	7 days	16.7
	14 days	25.2
	28 days	27.9

Table 8: Mix 3: Flyash + Lime + BKD

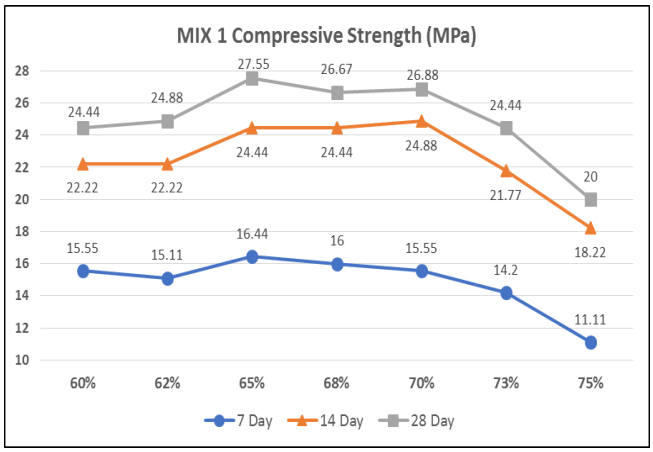

Fig. 1: Compressive Strength of Mix 1 (Flyash + Lime)

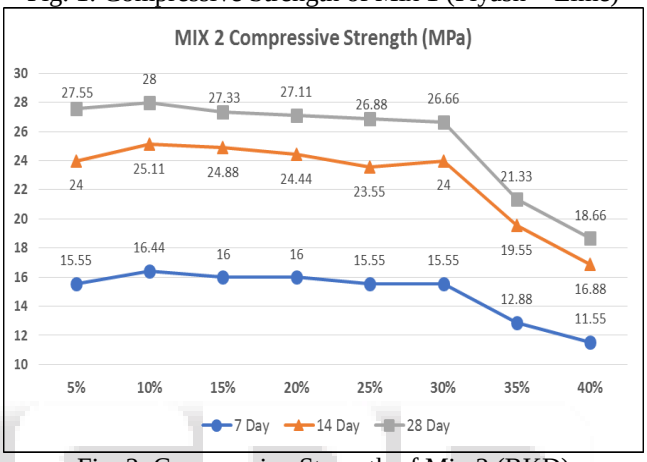

Fig. 2: Compressive Strength of Mix 2 (BKD)

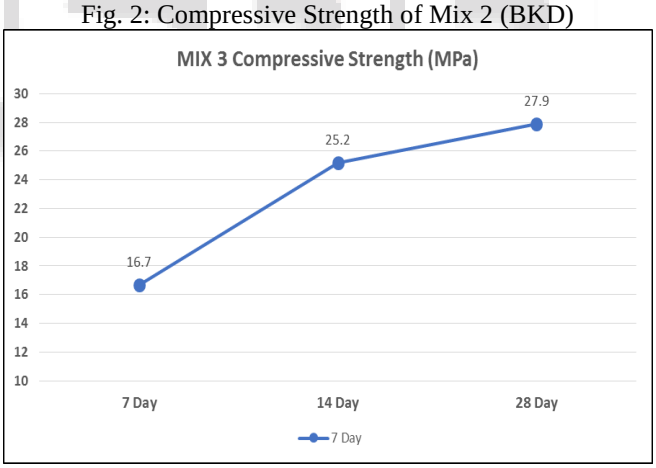

Fig. 3: Compressive Strength of Mix 3 (Flyash + Lime + BKD)

V. CONCLUSIONS

1) Cost Analysis:

Cost of materials per unit:

- Cement: Rs. 8 /kg
- Sand: Rs. 70 /cubic ft.
- Aggregate: Rs. 50 /cubic ft.
- Lime: Rs. 10 /kg
- Flyash: Rs. 1 /kg
- Brick Kiln Dust: Rs. 0
- Admixture: Rs. 140 /litre

Aggregate	Sand	Cement	Total
1015	775.5	4740.8	6531.3

Table 9: Cost of Conventional concrete

Aggregate	Sand	Cement	Fly ash	Brick kiln dust	Lime	Admixture	Total
1015	775.5	1185.3	144.4	0.0	1555.6	663.7	5339.5

Table 10: Cost of Mix 3

Total reduction in cost: Rs. 1191.8 ≈ Rs. 1200.

2) Cement can be replaced up to 75% by combination of fly ash, lime & sand can be replaced 10% by BKD along with admixture.
3) Maximum strength of 27.55 MPa was obtained at 65% flyash and 35% lime content by weight of 75% replacement for Mix 1.
4) Maximum strength of 28 MPa was obtained at 10% BKD content by weight of sand for Mix 2.
5) Strength of Mix 3 at 28 day was found to be 27.9 MPa.
6) The cost of new concrete with respect to conventional concrete was reduced by 18.25%.
7) This concrete can be used up to 3 floor houses/buildings, surface water tanks and for structures of aesthetic value.
8) High quality control with respect to material and casting is required for this type of concrete manufacture.
9) The water requirement of this concrete is low.
10) Since huge amount of waste is utilized, this concrete is eco-friendly and cost efficient.
11) Better finish is obtained in this concrete with lesser air voids.

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