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Performance of Fly Ash Bricks with Differential Composition

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Abstract: ***Flyash is one of the largest emerging products in the construction industry. The fly ash is the by-product which is widely used in brick manufacturing plant. The flyash reduces the cement content and also overcomes several disadvantages. Simply, it is a step towards eco-friendly environment. Though the flyash brick has many advantages, it has lower strength at initial stages due to low hydration. In this study, the experimental investigation was carried out to find the optimum mix ratio of various compositions of fly ash bricks. The brick specimens were casted on different compositions of cement, flyash, eco-sand and various other admixtures. On addition of these admixtures the early compressive strength was also high and a quick hydration was observed. The tests were conducted on 3rd, 5th, 7th and 28th day. The results suggest that the maximum strength was obtained for the composition of fly ash, ecosand, cement and silica fume.***

Keywords: Flyash, Cement, Eco-sand, Silica Fume, Admixtures, Compressive strength

I. INTRODUCTION

The present scenario of our construction industries is to use environmental friendly and eco-friendly materials to a larger extent. The use of fly ash bricks greatly replaces the disadvantages of clay burnt bricks but the only concern is about the usage of cement. The cement manufacturing industries greatly accounts for the emission of carbon-di-oxide into the atmosphere which results in global warming. They also consume high amount of energy for the manufacturing process. In order to overcome this environmental pollution, the researchers are working on replacement of cement with other materials in fly ash bricks, thereby reducing the content of cement.

Kumar and Gomathi [1] analysed the compressive strength of bricks manufactured using fly ash, sludge lime, gupsum, sand and plastic waste materials. They used plastics such as high density polyethylene (HDPE) and polyethylene (PE) bottles and bags for the manufacturing process. Prasanth et al. [2] used waste plastics in the manufacturing of fly ash bricks. They investigated the compressive strength, water absorption and efflorescence with addition of plastics upto 20% with an interval of 5%. Kanchidurai et al. [3] analyzed the compressive strength and impact resistance of fly ash bricks with the addition of least expensive plastic waste materials. They found that the compressive strength of plastics mixed fly ash bricks improved gradually upto 40% of addition of plastic material. Similar studies were conducted by Thirugnanasambantham et al. [4] and Bhushaiah et al. [5]. Meenaabhavani [6] conducted a study on the brick manufacturing process by using fly ash, pond ash, lime, gypsum, and quarry dust. She performed the compression, water absorption, durability and soundness tests at the end of 7, 14, and 28 days.

It is evident from the above literature review that several studies on manufacture of bricks using plastic waste have been conducted in the past but none of studies have compared the compressive strength of fly ash bricks with differential compositions. In this study, we have made used ecosand instead of conventional sand as fine aggregate. Moreover, the effect of addition of admixtures, silica fume, plastic wastes and hot water on the strength of fly ash bricks has been analysed. The optimum mix proportion of flyash, ecosand, cement and admixtures were used. The flyash is used as a main ingredient, ecosand as a by-product of cement industry and cement in little proportions as a binder and admixtures were used to increase the strength and fasten the rate of hydration in optimum ratio. Efflorescence and water absorption of the bricks formed under room temperature conditions were also investigated. The main objective of this paper is to determine the compressive strength of fly ash bricks with different compositions of fly ash, cement, ecosand and various other compounds like plastics, hot water, silica fume and admixtures.

II. MIX PROPORTIONS

Casting of bricks is done by machine moulding with an appropriate size of 230mm x 110mmx90mm.They were cast according to the standard procedure with various mix proportions. Table I shows the compressive strength of bricks with composition of flyash, ecosand, cement and BASF 1162 (0.120 ml) at 3, 5, 7, 28days.

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Table II shows the compressive strength of bricks with composition of flyash, ecosand, cement and BASF 1162 (0.180 ml) at 3, 5, 7, 28days. Table III shows the compressive strength of bricks with composition of flyash, ecosand, cement and BASF 1162 (0.680 ml) at 3, 5, 7, 28days. Table IV shows the compressive strength of bricks with composition of flyash, ecosand, cement, conplast SD110 (0.120ml) at 3, 5, 7, 28days.

Table V shows the compressive strength of bricks with composition of flyash, ecosand, cement, and karur plastic waste\caustic waste (10 kg) at 3, 5, 7, 28days. Table VI shows the compressive strength of bricks with composition of flyash, ecosand, cement, and karur plastic waste\caustic waste (20 kg) at 3, 5, 7, 28days. Table VII shows the compressive strength of bricks with composition of flyash, ecosand, cement, and karur plastic waste\caustic waste (30 kg) at 3, 5, 7, 28days. Table VIII shows the compressive strength of bricks with composition of flyash, ecosand, cement, and silica fume (5 kg) at 3, 5, 7, 28days. Table IX shows the compressive strength of bricks with composition of Flyash, ecosand, cement, and silica fume (10 kg) at 3, 5, 7, 28days. Table X shows the compressive strength of bricks with composition of flyash, ecosand, cement, and hot water at 3, 5, 7, 28days.

Table- I: M1- Flyash bricks with composition of Flyash, ecosand, cement and BASF 1162 (0.120 ml)

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight (Kg)	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	Weight(Kg)	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
1	Flyash	140	35	1.45	1.45	2.675	37	1.53	1.67	2.700	72	2.98	2.71	2.415	60	6.90	6.97
	Ecosand	160	37	1.53		2.785	47	1.95		2.420	62	2.57		2.420	75	7.20	
	Cement	30	33	1.37		2.75	37	1.53		2.680	62	2.57		2.400	60	6.80	
	BASF 1162	0.120 ML															
	Total	330															

Table-II: M2- Flyash bricks with composition of Flyash, ecosand, cement and BASF 1162 (0.180ml)

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight (Kg)	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	Weight(Kg)	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
2	Flyash	140	30	1.24	1.26	2.8	54	2.24	2.02	2.470	55	2.28	2.42	2.640	70	7.10	6.63
	Ecosand	160	28	1.16		2.65	37	1.53		2.575	55	2.28		2.710	65	6.60	
	Cement	30	33	1.37		2.855	55	2.28		2.450	65	2.69		2.610	50	6.20	
	BASF 1162	0.180 ML															
	Total	330															

Table-III: M3- Flyash bricks with composition of Flyash, ecosand, cement and BASF 1162 (0.680ml)

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight (Kg)	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	Weight(Kg)	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
3	Flyash	140	37	1.53	1.57	2.79	43	1.78	1.82	2.755	75	3.11	2.62	2.510	80	7.70	6.83
	Ecosand	160	42	1.74		2.725	39	1.61		2.625	58	2.40		2.470	55	6.90	
	Cement	30	35	1.45		2.895	50	2.07		2.570	57	2.36		2.535	65	5.90	
	BASF 1162	0.680 ML															
	Total	330															

Table-IV: M4- Flyash bricks with composition of Flyash, ecosand, cement and conplast SD110

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight (Kg)	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	Weight(Kg)	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
4	Flyash	140	25	1.04	1.10	2.72	43	1.78	1.82	2.755	72	2.98	2.36	2.365	55	6.70	6.47
	Ecosand	160	30	1.24		2.6	42	1.74		2.585	52	2.15		2.415	55	6.40	
	Cement	30	25	1.04		2.68	47	1.95		2.440	47	1.95		2.440	50	6.30	
	Canplast SD110	0.120ML															
	Total	330															

Table-V: M5- Flyash bricks with composition of Flyash, ecosand, cement and karur plastic waste\caustic waste (10 kg)

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight Kg	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	WeightKg	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
5	Flyash	130	42	1.74	1.68	2.79	42	1.74	1.96	2.470	69	2.86	2.77	2.450	55	7.10	7.62
	Ecosand	160	35	1.45		2.805	53	2.19		2.730	70	2.90		2.625	80	7.70	
	Cement	30	45	1.86		2.89	47	1.95		2.540	62	2.57		2.440	55	6.99	
	Karurplasticwaste	10															
	Total	330															

Table-VI: M6- Flyash bricks with composition of Flyash, ecosand, cement and karur plastic waste\caustic waste (20 kg)

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight Kg	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	WeightKg	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
6	Flyash	120	32	1.33	1.41	2.77	55	2.28	1.93	2.560	68	2.82	2.57	2.410	70	7.23	6.66
	Ecosand	160	30	1.24		2.76	43	1.78		2.640	63	2.61		2.305	80	6.77	
	Cement	30	40	1.66		2.73	42	1.74		2.670	55	2.28		2.370	70	5.99	
	Karur plastic waste	20															
	Total	330															

Table-VII: M7- Flyash bricks with composition of Flyash, ecosand, cement and karur plastic waste\caustic waste (30 kg)

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight Kg	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	WeightKg	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
7	Flyash	110	34	1.41	1.37	2.535	42	1.74	1.79	2.530	54	2.24	2.39	2.385	55	7.01	6.61
	Ecosand	160	33	1.37		2.61	43	1.78		2.550	62	2.57		2.300	55	6.73	
	Cement	30	32	1.33		2.66	45	1.86		2.580	57	2.36		2.350	70	6.08	
	Karur plastic waste	30															
	Total	330															

Table-VIII: M8- Flyash bricks with composition of Flyash, ecosand, cement and silica fume (5 kg)

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight Kg	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	WeightKg	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
	Flyash	140	37	1.53	1.68	2.88	58	2.40	2.31	2.480	67	2.77	2.82	2.425	80	6.66	6.68
	Ecosand	160	42	1.74		2.905	67	2.77		2.645	67	2.77		2.420	55	6.34	
	Cement	25	43	1.78		3.01	42	1.74		2.455	70	2.90		2.350	70	7.04	

8	slica fume	5															
	Total	330															

Table-IX: M9- Flyash bricks with composition of Flyash, ecosand, cement and silica fume (10 kg)

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight (Kg)	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	Weight(Kg)	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
9	Flyash	140	47	1.95	1.86	2.86	76	3.15	3.33	2.690	90	3.73	3.51	2.620	75	7.53	7.76
	Ecosand	160	46	1.90		2.905	65	2.69		2.705	77	3.19		2.460	75	7.77	
	Cement	20	42	1.74		2.845	100	4.14		2.840	87	3.60		2.540	85	7.97	
	Slica fume	10															
	Total	330															

Table-X: M10- Flyash bricks with composition of Flyash, ecosand, cement and hot water.

S.NO	Item	Weight (Kg)	3 rd Day Testing (kN)	3 rdDay strength (N/mm^2)	3 day Avg strength (N/mm^2)	Weight(Kg)	5 th Day Testing (kN)	5th Day strength (N/mm^2)	5 day Avg strength (N/mm^2)	Weight (Kg)	7 thDay Testing (kN)	7th Day strength (N/mm^2)	7thday Avg strength (N/mm^2)	Weight(Kg)	28 th Day Testing(kN)	28thDay strength (N/mm^2)	28th day Avg strength (N/mm^2)
10	Flyash	140	28	1.16	1.09	3.435	96	3.98	2.72	2.905	33	1.37	1.89	2.285	35	5.99	6.17
	Ecosand	160	26	1.08		2.845	34	1.41		2.760	52	2.15		2.560	50	5.81	
	Cement	30	25	1.04		2.92	67	2.77		2.835	52	2.15		2.550	30	6.72	
	Hot Water	0															
	Total	330															

Table-XI: Compressive strength (N/mm2) for various mix proportions at 3rd, 5th, 7th and 28th day of testing

Day of testing	Compressive strength(N/mm^2)									
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
3^{rd} day	1.45	1.26	1.57	1.10	1.68	1.41	1.37	1.68	1.86	1.09
5^{th} day	1.67	2.02	1.82	1.82	1.96	1.93	1.79	2.31	3.33	2.72
7^{th} day	2.71	2.42	2.62	2.36	2.77	2.57	2.39	2.82	3.51	1.89
28^{th} day	6.97	6.63	6.83	6.47	7.62	6.66	6.61	6.68	7.76	6.17

III. RESULTS AND DISCUSSION

In this study, an investigation was carried out to determine the optimal mix strength of fly ash bricks with cement, ecosand, and various other mixtures in varying compositions.

A. COMPRESSION

The compressive strength of flyash brick is three times greater than the normal clay brick.

The minimum compressive strength of clay brick is 3.5 N/mm² but the flyash brick has compressive strength of 6-9 N/mm². Bricks to be used for different works should not have compressive strength less than the above value. The following table and figure indicates the compressive strength of bricks manufactured using various mix proportions at 3, 5, 7, 28days.

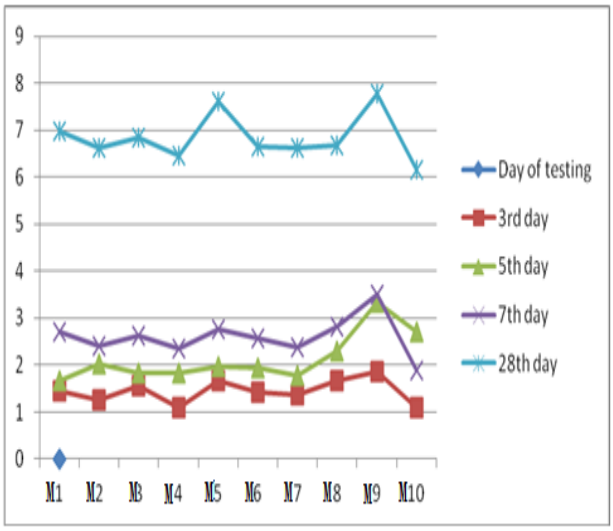

Fig. 1. Graphical representation of compressive strength for various mix proportions

It is observed from the figure that mix proportion 5 and 9 seem to provide the maximum compressive strength of 7.62 N/mm^2 and 7.76N/mm^2. Mix proportion 5 consists of fly ash, ecosand, cement and karur plastic waste (10kg) and mix proportion 9 consists of fly ash, ecosand, cement and silica fume (10kg).

B. WATER ABSORPTION

Fly ash Bricks should not absorb water more than 15%. The bricks are weighed (W1). They were then immersed completely in clean water for 24 hrs (Fig. 2). The bricks were then removed and wiped out for any traces of water and weighed as W2. Water absorption in % by weight = [(W2 – W1)/W1)] x 100. In this study, the bricks absorb 13.29% of water only and thus possesses less water absorption property. Table 12 shows the water absorption values for different mix proportion bricks.

Fig. 2. Water absorption test in the site

Table-XII: Water absorption for different mix proportions

Proportions	W1	W2	W1-W2	(W1-W2)/ W1	% absorption
M1	2.67	3.01	0.34	0.127	12.7
M2	2.8	3.23	0.43	0.153	15.3
M3	2.79	3.178	0.388	0.139	13.9
M4	2.72	3.12	0.40	0.147	14.7
M5	2.79	3.20	0.41	0.146	14.6
M6	2.77	3.23	0.46	0.166	16.6
M7	2.53	2.89	0.36	0.142	14.2
M8	2.88	3.20	0.32	0.111	11.1
M9	2.86	3.14	0.28	0.097	9.7
M10	3.45	3.80	0.35	0.101	10.1

C. EFFLORESCENCE

For this test, brick was placed vertically in water and immersed for 24 hrs. They were then removed and examined for white spots on the surface area of the brick. In our study, efflorescence was found to be nil.

IV. CONCLUSION

Brick specimens of size 230mm x 110mm x 90mm were casted for different mix proportions of flyash , cement, ecosand and other admixtures. The mechanical properties such as compressive strength were studied for different mix proportions, at different stages of curing. From the results, the following conclusion can be drawn:

1. It is observed that the mix proportion 5 and 9 provided the maximum compressive strength of 7.62 N/mm^2 and 7.76N/mm^2. Mix proportion 5 consists of fly ash, ecosand, cement and karur plastic waste (10kg) and mix proportion 9 consists of fly ash, ecosand, cement and silica fume (10kg).
2. Water absorption of the bricks manufactured in our study was within the standard water absorption limit of 15%.
3. Efflorescence was found to be nil in the present study.

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