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ANALYSIS OF FIBER AND FLY ASH CONCRETE IN RIGID PAVEMET

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Abstract : Fly ash is one of the by-products produced from the process of coal burning. Electricity generation using coal as the energy source is the main industry, which produces fly ash as its major solid waste. There are still other types of solid wastes produced from the coal generating plants like bottom ash and gypsum but their volumes are generally far less than that of the fly ash. There are difficulties around the world to achieve effective utilization of fly ash or even to get rid of it. This works particularly existing of analysis of fibre and fly ash concrete in rigit payment. Experimental work was done with 50% replacement of cement by fly ash and fibre use in different percentage 0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6 and 1.8 and check the strength properties of fiber reinforced high volume fly ash concrete such as compressive strength, tensile strength, flexural strength and impact strength required for rigid pavements and analysis the resistance of fiber reinforced high volume fly ash concrete and to study the behaviour of fiber reinforced high volume fly ash concrete under central loading, edge loading and comer loading condition. To determine the above properties Concrete cubes of size 150mm x 150mm x 150mm are used to prepare the specimens for determination of compressive strength of FRHV. Compressive strength of FRHVFAC shows an increasing trend up to 1.4% addition of steel fibers. Thereafter compressive strength shows a decreasing trend. The percentage increase of 7 days, 28 days and 90 days compressive strength for 1.4% addition of steel fibers are found to be 17%, 18% and 17% respectively. Tensile strength of FRHVFAC shows an increasing trend up to 1.4% addition of steel fibers. Thereafter tensile strength shows a decreasing trend. The percentage increase of 7 days, 28 days and 90 days tensile strength for 1.4% addition of steel fibers are found to be 38%, 41% and 19% respectively. Flexural strength of FRHVFAC shows an increasing trend up to 1.4% addition of steel fibers. Thereafter flexural strength shows a decreasing trend.

Key words:- Fly ash, fiber reinforced high volume fly ash concrete, flexural strength, compressive strength,

I. INTRODUCTION

Fly ash is one of the by-products produced from the process of coal burning. Electricity generation using coal as the energy source is the main industry, which produces fly ash as its major solid waste. There are still other types of solid wastes produced from the coal generating plants like bottom ash and gypsum but their volumes are generally far less than that of the fly ash. There are difficulties around the world to achieve effective utilization of fly ash or even to get rid of it. Majority of the fly ash is dumped or used in low-valued methods such as using as a land-fill material, soil improvement, road base, land reclamation, raw material for producing cement etc.

Types of Pavements

Based on mode of supporting and distributing wheel loads, pavements are generally classified under the following categories. 1. flexible pavements 2. rigid pavements

Flexible pavements The flexible pavements consist of a relatively thin wearing surface course built over a base course and sub-base course and the rest on compacted sub-grade. The design of the flexible pavement is based on the principle that the surface load is transferred through successive layers of granular material over sub-grade. The component layers of the flexible pavement.

Rigid pavements

Rigid pavements are made up of Portland cement concrete (PCC) as surface course and may or may not have the base/sub-base course between the surface course and sub-grade. The components of the rigid pavement. The main function of rigid pavement in the surface course is to take appreciable tensile stresses and to reduce impact (over stresses) on sub-grade layer. These are used for heavier loads and for relatively poor sub-grades such as black-cotton soils, peaty-organic, compressible soils.

OBJECTIVES

The main objective of this proposed research work is to develop the fiber reinforced high volume fly ash concrete (FRHVFAC) as a material for construction of rigid pavements.

- To achieve the above objective the following experimental works are planned.
- To find out the strength properties of fiber reinforced high volume fly ash concrete such as compressive strength, tensile strength, flexural strength and impact strength required for rigid pavements.
- To find out the resistance of fiber reinforced high volume fly ash concrete

- To study the behaviour of fiber reinforced high volume fly ash concrete under central loading, edge loading and comer loading condition.
- 50% replacement of cement by fly ash and fibre use in different percentage 0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6 and 1.8 % by volume fraction.

2 MATERIAL AND TESTS.

Cement: Ordinary Portland cement of 43 grade confirming to IS 8112 - 1989 with specific gravity of 3.15 is used.

• Fly ash: In the present investigation class F fly ash from RTPS, Raichur is used. Its specific gravity is 2.5 and fineness is 469 kg/m^2.

• Fine aggregate: The river sand, which is available in Tungabhadra River bank, near Harihar, is used as fine aggregate. It is confirmed to zone II of IS 383 - 1970 with specific gravity of 2.66 and finess modulus of 2.65.

• Coarse aggregate: Locally available granite aggregates of 20 mm and 12 mm down are blended as per the requirement and used. The specific gravity is 2.72, the combined finesse modulus is found to be 6.53 and water absorption is 0.94%.

• Superplasticizer: CONPLAST SP430, marketed by Mis Fosroc Chemicals, Bangaluru, is used in the present investigation as superplasticizer with a dosage of 1.1% by weight of binder content (cement + fly ash).

• Fiber: Crimped steel fiber of 38 mm length and average equivalent diameter of 0.75 mm thickness with aspect ratio of 50 is used.

Tests:-

Test for compressive strength (IS:516 - 1959) Concrete cubes of size 150mm x 150mm x 150mm are used to prepare the specimens for determination of compressive strength of FRHVFAC. All specimens are prepared in accordance with Indian Standard Specifications IS: 516 -1959.

Test for split tensile strength (IS:5816 - 1999) Concrete cylindrical specimen of diameter 150mm and height 300mm are cast for split tensile strength of FRHVFAC. All specimens are prepared in accordance with Indian Standard Specifications IS: 5816-1999.

Test for flexural strength (IS:516 - 1959) Concrete beam specimen of dimension 100mm x 100 mm x 500 mm are cast for flexural strength of FRHVFAC. All specimens are prepared in accordance with Indian standard specifications, IS: 516 -1959.

Experimental results.

Compressive strength test results Following tables give the compressive strength test results of FRHVFAC for different percentages of fibers and for different days of curing.

Table:-1 Compressive strength test results for 7 days curing

Percentage of fiber	Specimen identification	Failure load (kN)	7 days compressive strength (MPa)	Average compressive strength (MPa)
0.00	A	437.50	19.44	19.56
	A	440.00	19.56	
	A	442.50	19.67	
0.20	B	452.50	20.11	20.00
	B	450.00	20.00	
	B	447.50	19.89	
0.40	C	465.00	20.67	20.78
	C	467.50	20.78	
	C	470.00	20.89	
0.60	D	477.50	21.22	21.33
	D	480.00	21.33	
	D	482.50	21.44	
0.80	E	505.00	22.44	22.26
	E	497.50	22.11	
	E	500.00	22.22	
1.00	F	515.00	22.89	22.74
	F	510.00	22.67	
	F	510.00	22.67	
1.20	G	515.00	22.89	22.89
	G	515.00	22.89	
	G	515.00	22.89	

1.40	H	515.00	22.89	22.96
	H	520.00	23.11	
	H	515.00	22.89	
1.60	J	505.00	22.44	22.67
	J	510.00	22.67	
	J	515.00	22.89	
1.80	**K**	510.00	22.67	22.59
	K	505.00	22.44	
	K	510.00	22.67	

Table-2 Compressive strength test results for 28 days curing

Percentage of fiber	**Specimen identification**	**Failure load (kN)**	**28 days compressive strength(MPa)**	**Average compressive strength (MPa)**
0.00	A	970.00	43.11	43.33
	A	975.00	43.33	
	A	980 .00	43.56	
0.20	B	1010.00	44.89	44.74
	B	1000.00	44.44	
	B	1010.00	44.89	
0.40	C	1030.00	45.78	46.07
	C	1040.00	46.22	
	C	1040.00	46.22	
0.60	**D**	1060.00	47.11	47.41
	D	1070.00	47.56	
	D	1070.00	47.56	
0.80	E	1110.00	49.33	49.19
	E	1100.00	48.89	
	E	1110.00	49.33	
1.00	F	1140.00	50.67	50.37
	F	1130.00	50.22	
	F	1 130 .00	50.22	
1.20	G	1130.00	50.22	50.37
	G	1130.00	50.22	
	G	11 40.00	50.67	
1.40	**H**	1140.00	50.67	50.96
	H	1150.00	51.11	
	H	1150.00	51.11	
1.60	J	1130.00	50.22	50.37
	J	1130.00	50.22	
	J	11 40.00	50.67	
1.80	**K**	1130 .00	50.22	50.22
	K	11 20.00	49.78	
	K	11 40.00	50.67	

Table3 Compressive strength test results for 90 days curing

Percentage of fiber	Specimen identification	Failure load **(kN)**	90 days compressive strength **(MPa)**	Average compressive strength (MPa)
0.00	A	1150.00	51.11	51.11
	A	1140.00	50.67	
	A	1160.00	51.56	
0.20	B	1190.00	52.89	52.74
	B	1180.00	52.44	
	B	1190 .00	52.89	
0.40	C	1220.00	54.22	54.37
	C	1220.00	54.22	
	C	1230.00	54.67	
0.60	D	1250.00	55.56	56.00
	D	1260.00	56.00	
	D	1270.00	56.44	
0.80	E	1320.00	58.67	58.22
	E	1310.00	58.22	
	E	1300.00	57.78	
1.00	F	1340.00	59.56	59.41
	F	1340.00	59.56	

	F	1330.00	59.11	
1.20	G	1340 .00	59.56	59.70
	G	1340.00	59.56	
	G	1350.00	60.00	
1.40	**H**	1350 .00	60.00	60.00
	H	1350.00	60.00	
	H	1350.00	60.00	
1.60	J	1340.00	59.56	59.41
	J	1330.00	59.11	
	J	1340.00	59.56	
1.80	**K**	1330.00	59.11	59.26
	K	1330.00	59.11	
	K	1340.00	59.56	

Overall results of compressive strength

Following table 4 gives the overall results of compressive strength of FRHVFAC. Also,it gives the percentage increase or decrease of compressive strength with respect to reference mix. Variation in the compressive strength can be depicted in the form of graph as shown in Table. 5.4.

Table 4 Variation in the compressive strength

Percentage of fiber	**7 days compressi ve strength (MPa)**	**Percentage increase or decrease of 7 days compressive strength with respect to referenc e mix.**	**28 days compressive strength (MPa)**	**Percentage increase or decrease of 28da ys compressive strength with respect to reference mix.**	**90 days compressive strength (MPa)**	**Percentage increase or decrease of 90 days compressive strength with respect to reference mix.**
0.00 (Reference mix)	19.56	-	43.33	-	51.11	-
0.20	20.00	2	44.74	3	52.74	3
0.40	20.78	6	46.07	6	54.37	6
0.60	21.33	9	47.41	9	56.00	10
0.80	22.26	14	49.19	14	58.22	14
1.00	22.74	16	50.37	16	59.41	16
1.20	22.89	17	50.37	16	59.70	17
1.40	22.96	17	50.96	18	60.00	17
1.60	22.67	16	50.37	16	59.41	16
1.80	22.59	16	50.22	16	59.26	16

Tensile strength test results

Following tables give the split tensile strength test results of FRHVFAC for differentpercentages of fibers and for different days of curing.

Table 5 Tensile strength test results for 7 days curing

Percentage offiber	Specimen identification	Failure load(kN)	7 days tensile strength (MPa)	Average tensile strength (MPa)
0.00	**A**	127.50	1.80	1.74
	A	120.00	1.70	
	A	122.50	1.73	
0.20	B	137.50	1.95	1.86
	B	122.50	1.73	
	B	135.00	1.91	
0.40	C	137.50	1.95	1.91
	C	130.00	1.84	
	C	137.50	1.95	
0.60	D	145.00	2.05	2.02
	D	140.00	1.98	
	D	142.50	2.02	
0.80	E	147.50	2.09	2.09
	E	150.00	2.12	
	E	145.00	2.05	
1.00	F	152.50	2.16	2.22
	F	157.50	2.23	
	F	160.00	2.26	
1.20	G	167.50	2.37	2.32
	G	160.00	2.26	
	G	165.00	2.33	
1.40	H	172.50	2.44	2.41
	H	170.00	2.41	
	H	167.50	2.37	
1.60	J	167.50	2.37	2.38
	J	167.50	2.37	
	J	170.00	2.41	
1.80	**K**	165.00	2.33	2.31
	K	162.50	2.30	
	K	162.50	2.30	

Table 6 Tensile strength test results for 28 days curing

Percentage of fiber	Specimen identification	Failure load **(kN)**	28 days tensile **strength** (MPa)	Average tensile **strength(MPa)**
0.00	**A**	160.00	2.26	2.35
	A	180.00	2.55	
	A	157 .50	2.23	
0.20	**B**	192.50	2.72	2.65
	B	190.00	2.69	
	B	180.00	2.55	
0.40	C	195.00	2.76	2.74
	C	192.50	2.72	
	C	192.50	2.72	
0.60	**D**	200.00	2.83	2.83
	D	202.50	2.86	
	D	197.50	2.79	
0.80	E	215.00	3.04	3.02
	E	217.50	3.08	
	E	207.50	2.94	
1.00	F	220.00	3.11	3.17
	F	225.00	3.18	
	F	227.50	3.22	
1.20	G	227.50	3.22	3.27
	G	230.00	3.25	
	G	235.00	3.32	
1.40	**H**	235.00	3.32	3.30
	H	230.00	3.25	
	H	235.00	3.32	
1.60	J	227.50	3.22	3.28
	J	230.00	3.25	
	J	237.50	3.36	
1.80	**K**	227.50	3.22	3.21
	K	225.00	3.18	

	K	227.50	3.22	

Table 7 Tensile strength test results for 90 days curing

Percentage of fiber	**Specimen identification**	**Failure load(kN)**	**90 days tensilestrength (MPa)**	**Averagetensile strength(MPa)**
0.00	**A**	270.00	3.82	3.30
	A	210.00	2.97	
	A	220.00	3.11	
0.20	B	230.00	3.25	3.30
	B	240.00	3.40	
	B	230.00	3.25	
0.40	C	240.00	3.40	3.37
	C	235.00	3.32	
	C	240.00	3.40	
0.60	D	240.00	3.40	3.54
	D	250.00	3.54	
	D	260.00	3.68	
0.80	E	255.00	3.61	3.57
	E	247.50	3.50	
	E	255.00	3.61	
1.00	F	252.50	3.57	3.62
	F	250.00	3.54	
	F	265.00	3.75	
1.20	G	272.50	3.86	3.86
	G	270.00	3.82	
	G	275.00	3.89	
1.40	H	280.00	3.96	3.94
	H	275.00	3.89	
	H	280.00	3.96	
1.60	J	275.00	3.89	3.87
	J	270.00	3.82	
	J	275.00	3.89	
1.80	**K**	267.50	3.78	3.82
	K	270.00	3.82	
	K	272.50	3.86	

Overall results of tensile strength

Following table .8 gives the overall results of tensile strength of FRHVFAC.

Table 8 Overall results of tensile strength for FRHVFAC

Percentage of fiber	7 days tensile strength **(MPa)**	Percentage increase or decrease of 7days tensile strength with respect to reference mix.	**28** days tensile strength **(MPa)**	Percentage increase or decrease of 28 days tensile strength with respect to reference mi x.	90 daystensile strength**(MPa)**	Percentage increase or decrease of 90 days tensile strength with respect to reference mix.
0.00 (Reference *mi x)*	1.74	-	2.35	-	3.30	-
0.20	1.86	7	2.65	13	3.30	0
0.40	1.91	9	2.74	17	3.37	2
0.60	2.02	16	2.83	21	3.54	7
0.80	2.09	20	3.02	29	3.57	8
1.00	2.22	27	3.17	35	3.62	10
1.20	2.32	33	3.27	39	3.86	17
1.40	2.41	38	3.30	41	3.94	19
1.60	2.38	36	3.28	40	3.87	17
1.80	2.31	32	3.21	37	3.82	16

Flexural strength test results

Following tables gives the flexural strength test results of FRHVFAC for different percentages of fibers and for different days of curing.

Table 5.9 Flexural strength test results for 7 days curing

Percentage of fiber	**Specimen identification**	**Failure load(kN)**	**7 days flexural strength (MPa)**	**Averageflexural strength(MPa)**
0.00	**A**	4.90	1.96	2.21
	A	5.80	2.32	
	A	5.90	2.36	
0.20	B	6.90	2.76	2.77
	B	6.80	2.72	
	B	7.10	2.84	
	C	7.90	3.16	
0.40	C	7.60	3.04	3.07
	C	7.50	3.00	
0.60	D	8.30	3.32	3.15
	D	7.40	2.96	
	D	7.90	3.16	
0.80	E	8.40	3.36	3.43
	E	8.50	3.40	
	E	8.80	3.52	
1.00	F	9.50	3.80	3.81
	F	9.60	3.84	
	F	9.50	3.80	
1.20	G	9.40	3.76	3.84
	G	9.60	3.84	

	G	9.80	3.92	
1.40	**H**	10.10	4.04	3.97
	H	9.80	3.92	
	H	9.90	3.96	
1.60	J	9.70	3.88	3.93
	J	9.90	3.96	
	J	9.90	3.96	
1.80	**K**	9.70	3.88	3.87
	K	9.50	3.80	
	K	9.80	3.92	

Table 10 Flexural strength test results for 28 days curing

Percentage of fiber	**Specimen identification**	**Failure load(kN)**	**28 days flexuralstrength (MPa)**	**Average flexural strength(MPa)**
0.00	**A**	7.50	3.00	3.37
	A	8.90	3.49	
	A	9.20	3.61	
0.20	B	10.70	4.20	4.20
	B	10.50	4.12	
	B	10.90	4.28	
0.40	C	12.20	4.79	4.63
	C	11.70	4.59	
	C	11 .50	4.51	
0.60	D	12.80	5.02	4.96
	D	13.00	5.10	
	D	12.10	4.75	
0.80	E	12.90	5.06	5.18
	E	13.20	5.18	
	E	13.50	5.30	
1.00	F	14.60	5.73	5.77
	F	14.80	5.81	
	F	14.70	5.77	
1.20	G	14.50	5.69	5.87
	G	14.80	5.81	
	G	15.60	6.12	
1.40	**H**	15.50	6.08	5.99
	H	15.00	5.89	
	H	15.30	6.00	
1.60	J	15.00	5.89	5.94
	J	15.20	5.96	

	J	15.20	5.96	
1.80	K	15.00	5.89	5.91
	K	15.20	5.96	
	K	15.00	5.89	

Table 11 Flexural strength test results for 90 days curing

Percentage of fiber	Specimen identification	Failure load(kN)	90 days flexural strength (MPa)	Averageflexural strength(MPa)
0.00	A	14.20	5.68	5.77
	A	14.50	5.80	
	A	14.60	5.84	
0.20	B	15.30	6.12	6.29
	B	16.10	6.44	
	B	15.80	6.32	
0.40	C	16.40	6.56	6.64
	C	16.60	6.64	
	C	16.80	6.72	
0.60	D	17.50	7.00	7.05
	D	17.60	7.04	
	D	17.80	7.12	
0.80	E	17.80	7.12	7.11
	E	17.60	7.04	
	E	17.90	7.16	
1.00	F	18.00	7.20	7.13
	F	17.70	7.08	
	F	17.80	7.12	
1.20	G	18.40	7.36	7.32
	G	18.30	7.32	
	G	18.20	7.28	
1.40	H	18.30	7.32	7.44
	H	18.90	7.56	
	H	18.60	7.44	
1.60	J	18.50	7.40	7.40
	J	18.60	7.44	
	J	18.40	7.36	
1.80	K	18.40	7.36	7.37
	K	18.60	7.44	
	K	18.30	7.32	

Overall results of flexural strength

Following table 12 gives the overall results of flexural strength of FRHVFAC.

Table 12 Overall results of flexural strength for FRHVFAC

Percentage of fiber	7 days flexural strength (MPa)	Percentage increase or decrease of 7 days flexural strength with respect to reference mix.	28 days flexural strength(MPa)	Percentage increase or decrease of 28 days flexural strength with respect to reference mix.	90 days flexural strength (MPa)	Percentage increase or decrease of 90 days flexural strength with respect to reference mix.
0.00 (Reference mix)	2.21	-	3.37	-	5.77	-
0.20	2.77	25	4.20	25	6.29	9
0.40	3.07	39	4.63	38	6.64	15
0.60	3.15	42	4.96	47	7.05	22
0.80	3.43	55	5.18	54	7.11	23
1.00	3.81	72	5.77	71	7.13	24
1.20	3.84	73	5.87	74	7.32	27
1.40	3.97	80	5.99	78	7.44	29
1.60	3.93	78	5.94	76	7.40	28
1.80	3.87	75	5.91	76	7.37	28

OBSERVATIONS AND DISCUSSIONS

Following observations were made based on the studies conducted on FRHVFAC.

It is observed that the compressive strength of FRHVFAC increases as the percentage of steel fibers in it increases up to 1.4%. Thereafter the compressive strength shows a decreasing trend. Thus, the higher ':'value of compressive strength may be obtained by using 1.4% steel fibers. This is true for 7 days, 28 days and 90 days compressive strength.

At 1.4% addition of steel fibers the percentage increase of 7 days, 28 days and 90 days compressive strength are found to be 17%, 18% and 17% respectively. It is also observedthat a small percentage addition of fibers has improved the compressive strength of high- volume fly ash concrete.

It is observed that the tensile strength of FRHVFAC increases as the percentage of steel fibers in it increases up to 1.4%. Thereafter the tensile strength shows a decreasing trend. Thus, the higher value of tensile strength may be obtained by using 1.4% steel fibers. This is true for 7 days, 28 days and 90 days tensile strength. At 1.4% addition of steel fibers the percentage increase of 7 days, 28 days and 90 days tensile strength are found to be 38%, 41% and 19% respectively. Also, it is observed that a small percentage addition of fibers has improved the tensile strength of high-volume fly ash concrete.

It is observed that the flexural strength of FRHVFAC increases as the percentage of steel fibers in it increases up to 1.4%. Thereafter the flexural strength shows a decreasing trend. Thus, the higher value of flexural strength may be obtained by using 1.4% steel fibers. This is true for 7 days, 28 days and 90 days flexural strength. At 1.4% addition ofsteel fibers the percentage increase of 7 days, 28 days and 90 days flexural strength are found to be 80%, 78% and 29% respectively. Also, it is observed that a small percentage addition of fibers has improved the flexural strength of high-volume fly ash concrete.

CONCLUSIONS

Following conclusions can be drawn based on the study conducted Compressive strength of FRHVFAC shows an increasing trend up to 1.4% addition of steel fibers. Thereafter compressive strength shows a decreasing trend. The percentage increase of 7 days, 28 days and 90 days compressive strength for 1.4% addition of steel fibers are found to be 17%, 18% and 17% respectively. Tensile strength of FRHVFAC shows an increasing trend up to 1.4% addition of steel fibers. Thereafter tensile strength shows a decreasing trend. The percentage increase of 7 days, 28 days and 90 days tensile strength for 1.4% addition of steel fibers are found to be 38%, 41% and 19% respectively. Flexural strength of FRHVFAC shows an increasing trend up to 1.4% addition of steel fibers. Thereafter flexural strength shows a decreasing trend. The percentage increase of 7 days, 28 days and 90 days flexural strength for 1.4% addition of steel fibers are found to be 80%, 78% and 29% respectively.

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