Study on Sorptivity Test on Fly Ash Aggregate Concrete

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Abstract: Aggregate is most widely used in reinforced concrete construction. In this investigation, fly ash aggregates were used in concrete and its effect on durability of concrete was studied. The fly ash was collected from Mettur Thermal Power plant. Then the cement fly ash proportion of 10:90, 12.5:87.5, 15:85, 17.5:82.5, 20:80 and 22.5:77.5 were adopted to get fly ash aggregates. The Particle size distribution, Specific gravity and Water absorption tests on aggregates were conducted. M20 grade of concrete was considered. The fresh concrete tests like Slump test and Compacting factor test were conducted. For the plain concrete and fly ash aggregate concrete the cubes were cast. All the specimens were cured in a curing tank. The plain and fly ash aggregate concrete cube specimens were cast and tested at the age of 28days and 56days. Sorptivity and saturated water absorption tests were conducted on these plain and fly ash aggregate concrete specimens. The results were tabulated and compared by drawing graphs. Based on the results obtained, conclusions and suggestions were made.

Keywords: FA - Fly ash; FAFA - Fly ash fine aggregate ; FACA - Fly ash coarse aggregate; FAA - Fly ash aggregates; FAAC - Fly ash aggregate concrete; CC - Conventional concrete

FLY ASH

Definition

Fly ash is defined in Cement and Concrete Terminology (ACI Committee 116) as "the finely divided material resulting from the combustion of ground or powdered coal, which is transported from the firebox through the boiler by flue gases." Fly ash is a by-product of coal – fired electric generating plants. Two types classification of fly ash are produced, according to the type of coal used. Anthracite and bituminous coal produces fly ash classified as Class F. Class C fly ash is produced by burning lignite or sub-bituminous coal. Class C fly ash is preferable for the applications presented in the Green Building Guide and is the main type offered for residential applications from ready-mix suppliers.

MATERIALS USED

Cement

43 grade ordinary Portland cement (OPC) is used for the study programme and the properties were studied.

Fly Ash

Fly ash was collected from Mettur thermal power plant at Mettur near Salem. Fly ash has been collected using electrostatic precipitator in the plant was taken directly from hopper in dry state. It has been categorized as class F-fly ash. It is usually produced by burning anthracite or bituminous coal. In the sum of the percentage of the three principle constitutes i.e. Sio2, Al2o3, & Fe2o3 is equal to greater than 70%, so the fly ash is termed as class F. Cement and fly ash were mixed in concrete mixer in six proportions 10:90, 12.5:87.5, 15:85, 17.5:82.5, 20:80 and 22.5:77.5 with w/c of 0.3 and is mixed until the pellets are formed.

FORMATION OF FLY ASH AGGREGATES

Constituents for Fly Ash Aggregates

Cement and fly ash are constituents for preparation of the aggregates; also water is the binder where it is added to increase the workability. Six different proportions are taken and subjected to pelletisation process.

Proportions of Cement and Fly Ash

Cement and fly ash are mixed in six different proportions as shown in the figure below for the formation of fly ash aggregates

Pelletisation

It is a process of agglomeration of moisturized fines in a rotating drum or disc, to produce 'fresh pellet' having enough for further handling. Formation of pellets is based on the mechanisms involved in balling phenomenon of powdery materials. When a fine-grained material is moisturized, a thin liquid film develops on the surface of each grain and bridges are formed at points where the moisturized particles contact each other. The particles rotated into balls bonding forces develop gradually. The initial bonding between particles is due to a water bridge or meniscus. When more liquid is added, the liquid film on the particle surface began to coalesce, but closed and air-filled cavities remain between the grains.

The ball grows as more moisturized particles are coated onto the nucleus. Mechanical forces, produced by the balls bumping against each other and against the walls of the rotating device, expel the air enveloped in the balls. At this capillary stage, the liquid fills the free space between the particles. The filled capillary forces affect the particle coherence throughout the whole ball. The concave membrane on the surface of the liquid seals surface pores. Under uneven or excessive moisturizing, particle clusters are enveloped in the droplets that tend to produce large, irregular entities. Grain size distribution and surface texture of material influence the efficiency of pelletisation process. In the present study green pellets were produced from a mixture of fly ash, ordinary Portland cement and water as binder in the concrete mixer, which performed as a pelletiser.

Figure Preparation of pellets

Processing and Curing of Fly Ash Aggregates

The prepared green pellets are allowed to dry for a day. Fly ash aggregates are then placed under water for 7 days for curing.

Segregation of Fly Ash Aggregates

The cured aggregates are allowed to dry completely for 24 hours and segregated as fine and coarse aggregates based on particle size. Sieving is adopted for the separation of aggregates. The sieved aggregates having size 4.75mm are taken as flyash fine aggregates and the aggregates having size above 4.75mm to 20mm are taken as flyash coarse aggregates from them 20mm size were separately sieved and used in the mix .water Borewell water of MPNMJ Engineering College was used in the preparation of concrete.

PREPARATION OF SPECIMENS

Mixing

OPC 43Grade, Fly ash fine aggregate, Fly ash Coarse aggregate and water cement ratio are taken as per mix design and thoroughly mixed.

Casting

The concrete cubes of 150mm size were cast in moulds in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. The concrete is filled into the mould in three layers approximately 5cm deep. Each layer was well compacted. After the compaction, the top surface is finished level with the top of the mould using a trowel. The standard tamping rod was used and the strokes of the rod were distributed in a uniform manner over entire mould. The number of stokers per layer required to produce the specified conditions, vary according to the type of concrete. Similarly the control concrete cubes were also cast.

Curing

The specimens were demoulded after 24 hours. Necessary identification marks were made in the specimens and kept under water in a curing tank. The specimens were kept under water for 28 days and 56 days. After curing, they were taken out from the curing tank and air dried before testing.

TEST PROCEDURE AND RESULTS

SORPTIVITY TEST

Procedure

Concrete cubes of 150 x 150 x 150 mm were cast and tested at the age of 28 days and 56 days for Sorptivity evaluation. 3 numbers of control concrete specimens and 3 numbers each with aggregates made from all six cement fly ash proportions were cast both at 28 days and 56 days. The cubes were stored in an oven at 1050C for 72 hours and then the samples were cooled at room temperature for 24h. Protective coating of epoxy resin was applied to the five faces of the cube to prevent water from penetrating through the sides. One face of the specimen was placed in contact with water. The schematic arrangement of the sorptivity test is shown in Figure. The specimens were immersed in tray containing water on 10mm diameter steel rods to allow free access of water to the inflow. The water level was maintained at 5mm above the base of the cube. Immediately after the immersion of the cube surface into water, the start time of the test was recorded, the water absorption was measured at suitable intervals up to 72 hours. The sorptivity was calculated from the volume of water absorbed per unit cross- section, A, and the square root of time, t. Values of sorptivity were given in mm per min1/2. The slope of the line was considered as the parameter describing the sorptivity.

Figure Showing Schematic Arrangement for Sorptivity Test

Comparison of sorptivity of control concrete and fly ash aggregate Concrete after 28 days of curing

Time, t (Minutes)	√t	Cumulative water absorption						
		control concrete	FAAC 10:90	FAAC 12.5:87.5	FAAC 15:85	FAAC 17.5:82.5	FAAC 20:80	FAAC 22.5:77.5
15	3.87	20	40	40	30	30	20	10
30	5.48	40	130	80	60	50	40	20
60	7.75	50	150	100	70	60	50	30
120	10.95	70	180	130	90	80	70	40
240	15.49	220	410	280	220	190	160	120
480	21.91	370	530	360	300	260	220	170
960	30.98	520	690	490	420	380	330	270
1440	37.95	620	820	590	520	470	420	350
2880	53.67	960	1190	950	860	800	720	610
4320	65.73	1250	1500	1250	1140	1060	940	800

Comparison of sorptivity of control concrete and fly ash aggregate Concrete after 56 days of curing

Time, t (Minutes)	√t	Cumulative water absorption						
		control concrete	FAAC 10:90	FAAC 12.5:87.5	FAAC 15:85	FAAC 17.5:82.5	FAAC 20:80	FAAC 22.5:77.5
15	3.87	10	30	30	10	10	10	0
30	5.48	20	100	60	20	20	10	0
60	7.75	20	110	70	20	20	10	10
120	10.95	30	130	90	30	30	10	20
240	15.49	90	310	200	110	100	70	60
480	21.91	170	400	260	170	150	110	90
960	30.98	280	520	370	260	230	180	150
1440	37.95	350	620	440	320	290	230	180
2880	53.67	550	900	720	520	480	400	320
4320	65.73	710	1140	940	690	570	510	410

Results and Discussion

Based on the above study, the following results are obtained,

- At the infiltration zone, the cumulative water absorption and square root of time shown a linear relationship.
- The slope of the line shown in the graph defines the sorptivity of the concrete determined by linear regression.
- Fly ash aggregate concrete made with flyash aggregates obtained from cement flyash proportions 12.5:87.5, 15:85, 17.5:82.5, 20:80 and 22.5:77.5 have less Cumulative water absorption than control concrete at age of 28 days.
- Fly ash aggregate concrete made with flyash aggregates obtained from cement flyash proportions 15:85, 17.5:82.5, 20:80 and 22.5:77.5 have less Cumulative water absorption than control concrete at age of 56 days.
- The cumulative water absorption after 56 days of curing reduced to a greater extent when compared to that of 28 days of curing for flyash aggregate concrete.

SATURATED WATER ABSORPTION TEST

Procedure

The concrete cubes of 150x150x150 mm were cast and tested at age of used after 28days and 56days for saturated water absorption test. Three numbers control concrete specimens and three numbers each with aggregates made from all six cement fly ash proportions were cast both at 28 days and 56 days. After the specified periods of curing, the specimens were kept under the room temperature for 24 hours and then placed inside the oven at 1050C for 72 hours and then again cooled at room temperature for 24 hours and then the experiments were conducted. The initial weight of the specimens was taken and is recorded as W1. The weight of the specimens were taken after every one hour and recorded. The process is continued till ten consecutive weights of the specimen give the same value. The final weight of the specimen is recorded as W2. The saturated water absorption of the specimens is calculated by the following relation

Saturated water absorption, S = [(W2- W1)/W1] x100

Where, W1 - initial weight of the Specimen
W2 - final weight of the specimen

Comparison of water absorption of control concrete and fly ash aggregate concrete after 28days of curing

Time, T(hours)	Weight of the specimen in kgs						
	control concrete	FAA C 10: 90	FAAC 12.5 :87.5	FAA C 15: 85	FAAC 17.5 :82. 5	FAA C 20: 80	FAAC 22.5 :77.5
Initial	8.19	5.15	5.17	5.13	5.29	5.67	5.83
1	8.23	5.43	5.49	5.46	5.58	5.83	6.00
2	8.24	5.47	5.52	5.49	5.58	5.84	6.02
3	8.26	5.48	5.53	5.50	5.60	5.86	6.02
4	8.26	5.48	5.54	5.50	5.61	5.86	6.04
5	8.26	5.4	5.54	5.5	5.61	5.8	6.04
6	8.26	5.4 9	5.55	5.52	5.61	5.87	6.04
7	8.26	5.49	5.55	5.52	5.61	5.87	6.05
8	8.26	5.49	5.55	5.52	5.61	5.87	6.05
9	8.26	5.50	5.55	5.52	5.61	5.88	6.05
10	8.26	5.50	5.55	5.53	5.62	5.88	6.05
11	8.26	5.50	5.55	5.53	5.62	5.88	6.06
12	8.26	5.51	5.56	5.53	5.62	5.88	6.06
13	8.26	5.51	5.56	5.53	5.62	5.88	6.06
14	8.26	5.51	5.56	5.53	5.63	5.88	6.06
15	8.26	5.51	5.56	5.54	5.63	5.88	6.06
16	8.26	5.51	5.56	5.54	5.63	5.88	6.06
17	8.26	5.51	5.56	5.54	5.63	5.89	6.06
18	8.26	5.51	5.57	5.54	5.63	5.89	6.06
19	8.26	5.52	5.57	5.54	5.63	5.89	6.06
20	8.26	5.52	5.57	5.54	5.63	5.89	6.06
21	8.26	5.52	5.57	5.54	5.63	5.89	6.06
22	8.26	5.52	5.57	5.54	5.63	5.89	6.06
23	8.26	5.52	5.57	5.54	5.63	5.89	6.06

24	8.26	5.52	5.57	5.54	5.64	5.89	6.06
25	8.26	5.52	5.57	5.54	5.64	5.89	6.06
26	8.26	5.52	5.57	5.55	5.64	5.89	6.06
27	8.26	5.52	5.58	5.55	5.64	5.89	6.06
28	8.26	5.52	5.58	5.55	5.64	5.89	6.06
29	8.26	5.52	5.58	5.55	5.64	5.89	6.06
30	8.26	5.52	5.58	5.55	5.64	5.89	6.06
31	8.26	5.52	5.58	5.55	5.64	5.89	6.06
32	8.26	5.52	5.58	5.55	5.64	5.89	6.06
33	8.26	5.52	5.58	5.55	5.64	5.89	6.06
34	8.26	5.52	5.58	5.55	5.64	5.89	6.06
35	8.26	5.52	5.58	5.55	5.64	5.89	6.06
36	8.26	5.52	5.58	5.55	5.64	5.89	6.06
37	8.26	5.52	5.58	5.55	5.64	5.89	6.06
38	8.26	5.52	5.58	5.55	5.64	5.89	6.06
39	8.26	5.52	5.58	5.55	5.64	5.89	6.06

Results of saturated water absorption after 28 days of curing

Specimen	Initial weight , W1 in kg	Final weight, W 2 in kg	Saturated water absorption, %
Control	8.19	8.26	0.85
FAAC 10:90	5.15	5.52	7.18
FAAC 12.5:87.5	5.17	5.58	7.93
FAAC 15:85	5.13	5.56	7.99
FAAC 17.5:82.5	5.29	5.64	6.62
FAAC 20:80	5.67	5.89	3.88
FAAC 22.5:77.5	5.83	6.06	3.77

Comparison of water absorption of control concrete and fly ash aggregate concrete after 56days of curing water absorption indicating lower porosity.

Time ,T (hours)	Weight of the specimen in kgs						
	Control Concrete	FAAC 10:90	FAAC 12.5:87.5	FAAC 15:85	FAAC 17.5:82.5	FAAC 20:80	FAAC 22.5:77.5
Initial	8.19	5.42	5.44	5.39	5.50	5.82	5.72
1	8.22	5.46	5.52	5.49	5.60	5.86	5.75
2	8.23	5.49	5.55	5.52	5.62	5.87	5.76
3	8.24	5.50	5.55	5.52	5.63	5.87	5.76
4	8.24	5.50	5.56	5.53	5.63	5.87	5.76
5	8.24	5.51	5.57	5.53	5.63	5.87	5.76
6	8.24	5.51	5.57	5.53	5.64	5.87	5.77
7	8.24	5.52	5.58	5.54	5.64	5.87	5.77
8	8.24	5.52	5.58	5.54	5.64	5.88	5.77
9	8.24	5.52	5.58	5.54	5.64	5.88	5.77
10	8.24	5.52	5.58	5.54	5.64	5.88	5.77
11	8.24	5.52	5.58	5.54	5.64	5.88	5.77
12	8.24	5.52	5.58	5.55	5.65	5.88	5.78
13	8.25	5.53	5.59	5.55	5.65	5.88	5.78
14	8.25	5.53	5.59	5.55	5.65	5.88	5.78
15	8.25	5.53	5.59	5.55	5.65	5.88	5.78
16	8.25	5.53	5.59	5.55	5.65	5.88	5.78
17	8.25	5.53	5.59	5.55	5.65	5.89	5.78
18	8.25	5.53	5.59	5.55	5.65	5.89	5.78
19	8.25	5.53	5.59	5.56	5.65	5.89	5.79
20	8.25	5.53	5.60	5.56	5.65	5.89	5.79
21	8.26	5.53	5.60	5.56	5.66	5.89	5.79
22	8.26	5.54	5.60	5.56	5.66	5.89	5.79

23	8.26	5.54	5.60	5.56	5.66	5.89	5.79
24	8.26	5.54	5.60	5.56	5.66	5.89	5.79
25	8.26	5.54	5.60	5.56	5.66	5.89	5.79
26	8.26	5.54	5.60	5.56	5.66	5.89	5.79
27	8.26	5.54	5.60	5.56	5.66	5.89	5.79
28	8.26	5.54	5.60	5.56	5.66	5.89	5.79
29	8.26	5.54	5.60	5.56	5.66	5.89	5.79
30	8.26	5.54	5.60	5.56	5.66	5.89	5.79

The saturated water absorption at the age of 56 days is very much less when compared to that of 28 days for the fly ash aggregate concrete specimens, but for the conventional concrete specimen, it is the same at both the ages of curing.

SUGGESTIONS

Results of saturated water absorption after 56 days of curing

RESULTS AND DISCUSSION

Based on the above study, the following observations are made, Concretes having higher volume of cement replacement by fly ash showed lower values of saturated. The source of availability of ordinary Granite aggregate [HBG metal] and river sand are slowly reduced and limited. The granite aggregate also requires blasting which causes vibration and pollution to the environment. So fly ash aggregates may be thought and used as alternate aggregates in concrete. The above durability test show better result for flyash aggregate concrete. The environmental pollution and problems in disposal of fly ash can also be minimized when fly ash aggregates are used in concrete by replacing for conventional fine aggregate and granite stone aggregate.

CONCLUSIONS

- Control concrete has similar saturated water absorption for both the age of 28 days and 56 days.
- Fly ash aggregate concrete with fly ash aggregates made from cement fly ash proportions 10:90 as 69 % lesser saturated water absorption than at 56 days compare to 28days curing.
- The saturated water absorption of fly ash aggregate concrete with fly ash aggregates made from cement fly ash proportions 20:80 and 22.5:77.5 is 29% higher saturated water absorption than at 56 days compared to 28days curing.
- The saturated water absorption of fly ash aggregate concrete for all cement fly ash proportions is reduced considerably at age of 56days compared to 28days.
- If the curing after 56 days is done the saturated water absorption may still reduce and reach nil for the saturated water absorption stage.

Specimenn	Initialweight, W1 in kg	Final weight,W^2 in kg	Saturated water absorption, %
control	8.19	8.26	0.85
FAAC10:90	5.42	5.54	2.21
FAAC 12.5:87.5	5.44	5.60	2.94
FAAC15:85	5.39	5.56	3.15
FAAC 17.5:82.5	5.50	5.66	2.91
FAAC20:80	5.82	5.89	1.20

REFERENCES

[1]. Shetty, M.S. "Concrete Technology Theory and Practical", Reprint, 2005Publishers S. Chand and Company Ltd., New Delhi pp. 124 – 296.
[2]. IS 10262-1982 recommended guidelines for concrete "Mix Design", BIS Ne,Delhi.
[3]. Behra, J.P. and BD Nayak "Investigation on the development of blended cementusing Activated Fly ash", Indian concrete Journal, Vol 74, No 5, May 2000, pp260- 263.
[4]. Santha Kumar A.R. **"**Concrete Technology**"**, Oxford University Press, New Delhi,pp.75 – 169.
[5]. Indian Standard: Plain and reinforced concrete – Code of practice IS 456:2000 4th revision, Bureau of Indian Standards, New Delhi, India.
[6]. Anurag Misra,Rohit Ramtake and Madan Lal Bairva "Study on strength andsorptivity characteristics of fly ash concrete", APRN journal of engineering and applied sciences vol 2 no.5 October 2007 pp 54-59