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An Experimental Study on Properties of Fly ash Aggregate Comparing with Natural Aggregate

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Abstract : *In this paper details of experimental studies carried out on fly ash aggregates as a replacement to stone aggregates has been presented, these aggregates are economical and environmental friendly. The artificial fly ash aggregates are manufactured by using ordinary mixer, in three different proportions of cement and fly ash, they are 12.5:87.5, 15:85, and 17.5:82.5 in the form of pellets. the experiments conducted are Grain size distribution, Specific gravity, absorption, impact value, crushing value, fineness modulus of three different proportions of fly ash aggregate as per the Indian standards and the results are comparing with natural aggregates. The 17.5:82.5 proportions aggregates give good strength properties, fly ash aggregates is a good alternative for civil engineering works.*

Keywords: *Industrial fly ash, Manufacturing technique, Aggregate properties.*

1. INTRODUCTION

The environmental impacts of crushed stone aggregate, extraction are a source of increasing in many parts of the country. The impacts include loss of forests, noise, dust, blasting, vibrations and pollution hazards. Unplanned exploitation of rocks may lead to landslides of weak and steep hill slopes. In growing need for electricity in India, 70% of power is generated through thermal power plants. The environmental dreads from these plants include air pollution due to particulate emission, water pollution and shortage of land for dumping the fly ash. Further, the poor quality of Indian coal has high ash content, which worsens the disposal problem. The amount of ash contained in coal or lignite burned in power plant can vary greatly depending on the source of coal. The fine particles of fly ash by virtue of their lightness become air borne and create health problems to all livings. Concern about the depletion of natural sources and the effect on environment has particularly focused attention on possibility of use synthetically produced (from waste materials) aggregates as an alternative to naturally occurring materials. In order to achieve alternative as over a natural, the waste products has to be used effectively.

The usage of fly ash in a construction industry is a challenging job and will make tremendous change all over world. There are different ways of using fly ash in industry like it can be used as partial replacement of cement. But major challenge will be complete use fly ash as aggregate in a construction industry. So, fly ash can be used in making artificial light weight coarse aggregates. The aggregates so prepared are known as Fly ash aggregates, the method of formation is known as pelletisation.

These aggregates can be manufactured in different proportion of fly ash, cement, the aggregate which is manufactured is light weight aggregate. When this aggregate used in concrete i.e., indirectly in construction industry having so much application. Due to use of this type of aggregate in concrete production of light weight concrete can be done. Design and construction by this type of concrete is economical, because due to nature of light weight reduces the self weight. It leads to decrease in self weight of structure, so that there is no need of any other additional structures.

In conventional concrete, weight of concrete is one of the parameters to compare with weight of fly ash aggregate concrete. Normally density of concrete is in the order of 2200 to 2600 kg/m^3. This heavy self weight makes an uneconomical structural material compared to low self weight of fly ash aggregate concrete. In order to produce concrete of desired density to suit the required application, the self weight of structural and nonstructural members are to be reduced. Hence economy is achieved in the design of supporting structural elements which lead to the development of light weight concrete. Lightweight concrete is defined as a concrete that has been made lighter than the conventional concrete by changing material composition or production method. Lightweight aggregate concrete is made by replacing the usual material aggregate by lightweight aggregates. Though lightweight concrete can't always substitute normal concrete for its strength potential, it has its own advantages like reduced dead load, and thus economic structures and enhanced

seismic resistance, high sound absorption and good fire resistance.

2. MATERIALS

2.1. Cement

Ordinary Portland 53 grade cement with specific gravity 3.15 was used as the binder. The initial and final setting was 110 minutes and 260 minutes respectively.

2.2. Fly ash

The chemical composition of fly ash is given in the Table1. Class F Fly ash was procured from Raichur Thermal power plant (RTPS). RTPS is a coal-fired electric power station located at 16°21′18″N77°20′31″E / 16.355°N77.34194°ECoordinates:16°21′18″N77°20′31″E / 16.355°N 77.34194°E in the Raichur district of the state of Karnataka, India. It is operated by the sample was homogenized and air-dried at 50º C to constant mass prior to further investigations. The air-dried mass was pulverized to pass through 1.18 mm Indian Standard (IS) sieve and stored in air-tight polythene bags prior to use in various tests.

Table1-Chemical Composition of Class-F Fly ash

constituents		percentage
Silica	SiO2	50-60
Alumina	Al2O3	20-30
Calcium Oxide	CaO	5-20
Ferric Oxide	Fe2O3	4-10
Loss on Ignition	LIO	1-5

Table 2 Physico-chemical properties of fly ash

Physical properties	
Specific gravity	2
Particle size distribution Sand fraction (4.75mm to.075mm) Silt fraction (.075mm to .002mm) Clay fraction(<0.002mm)	 26% 72% 2%
Chemical properties	
pH	8.4
EC(µS/cm)	225
TDS(mg/l)	144

2.3. Water

Portable drinking water having pH value of 7 and conforming to IS 456-2000 was used for making of fly ash aggregates.

3. METHODOLOGY

Fly ash and Ordinary Portland cement were selected in different proportions like [cement: fly ash] 12.5:87.5, 85:15, 17.5:82.5.These proportions are thoroughly dry mixed in Concrete Mixer. After dry mix in a mixer start sprinkling the water until formation of fly ash aggregates.

The contents were thoroughly mixed in concrete mixer until the formation of fly ash aggregate. The method of formation is called pelletisation. Once the aggregate formed from the mixer allowed to dry for a day dried aggregate carried for 7, 28days for water curing and two days of steam curing at 80 degrees C is carried.

Figure 3. Collection of fly ash aggregates from mixer

3.1 Curing of aggregates

Curing may be done either by steam curing or water curing, in this present study curing of aggregates can be done by 28days water curing.

Figure 3.1 Steam curing unit

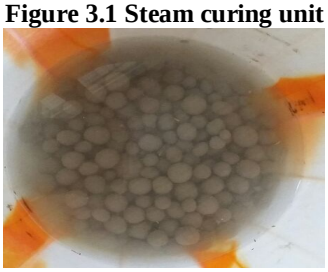

Figure 3.1.2 Water curing

4. SEGREGATION OF FLY ASH AGGREGATES

After curing, fly ash aggregates were segregated into fine and coarse aggregates based on the size of the pellets shown in the figure. The aggregates having size less than 4.75mm were sieved as fine aggregates and size more than 4.75 mm were sieved as coarse aggregates. The aggregate below 20 mm size sieve used in the concrete specimen as a filler material

Figure 4. Segregation of fly ash aggregates.

5. SIEVE ANALYSIS

5.1. Sieve Analysis of Fly ash Aggregates

Total weight of Fly ash Aggregates =5kg

Table 3- Sieve Analysis of Fly ash Aggregates

Sl no	IS Sieve mm	Wt retained in kg	Correct mass in kg	% retained	% pass	Cum % retained
1	20	0.170	0.213	4.26	95.74	4.260
2	16	0.650	0.693	13.86	86.14	18.120
3	12.5	0.635	0.678	13.56	86.44	31.680
4	10	2.815	2.858	57.16	42.84	88.840
5	4.75	0.515	0.558	11.16	88.84	100

Ec= 242.9

Fineness modulus of coarse aggregates=(Ec+500)/100
=7.429

5.2. Sieve Analysis of Conventional Aggregates

Total weight of Conventional Aggregates =5kg

Table 4- Sieve Analysis of Conventional Aggregates

Sl no	IS Sieve mm	Wt retained in kg	Correct mass in kg	% retain	% pass	Cum % retained
1	20	0.200	0.260	5.200	94.80	5.200
2	16	0.812	0.872	17.440	82.56	22.640
3	12.5	1.450	1.510	30.200	69.80	52.840
4	10	1.650	1.710	34.200	65.80	87.040
5	4.75	0.588	0.648	12.960	87.04	100

Ec=267.72

Fineness modulus of coarse aggregates = (Ec+500)/100
= (267+500)/100
=7.67

The fineness modulus of fly ash aggregate is within the range, as comparing with natural aggregates.

6. WATER ABSORPTION OF AGGREGATES

Table 5- Water Absorption of Aggregates

Time (min)	12.5:87.5 Aggregates	15:85 Aggregates	17.5:82.5 Aggregates
	Absorption in (%)		
0	12	11.5	11.5
10	11.4	10.6	10.3
15	10.6	9.6	9.2
20	10.1	8.9	9.1
25	9.5	8.9	8.5
30	9.5	8.7	8.5

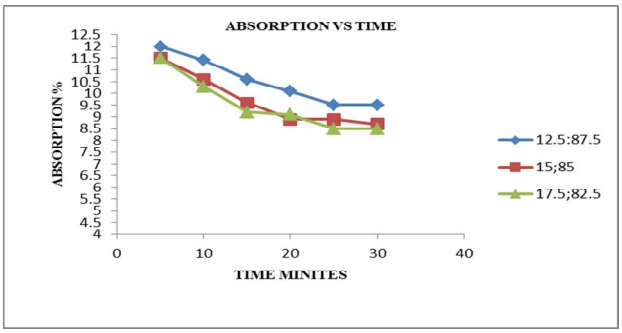

Figure 6. Water Absorption of Aggregates

Water absorption gives an idea of strength of aggregates. Aggregates having more water absorption are more porous. The water absorption of aggregates is a one of the important factor for aggregates while considering designing mix, the absorption of aggregates is more the amount of water added in concrete is also more. The Aggregates of proportion 17.5:82.5 the water absorption is less when compare to other proportions.

7. TEST RESULTS AND DISCUSSION

7.1 7 Days Water Cured Aggregates

Table 6-Fly ash Aggregates Properties for 7 days

Tests	Ratios of fly ash and cement			Conventional aggregate
	12.5:87.5	15:85	17.5:82.5	
Specific gravity	1.49	1.52	1.62	2.73
Bulk density (kg/m3)	910	940	964	1600
Angularity	12.1	11.5	12.2	9
Fineness modulus	7.43	7.82	7.95	7

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Aggregates having low specific gravity are generally weaker than those with higher specific gravity values. The specific gravity helps in identification of aggregates. In the present study 7days cured aggregates 17.5:82.5 aggregates as more specific gravity compare to the other two different proportions.

7.2. 28 Days Water Cured Aggregates

Table 7-Fly ash Aggregates Properties for 28 days

Tests	Ratios of fly ash and cement			Conventional aggregate
	12.5:87.5	15:85	17.5:82.5	
Specific gravity	1.604	1.63	1.8	2.73
Bulk density (kg/m3)	1000	1050	1100	1600
Angularity	12.1	11.5	12.2	9
Fineness modulus	7.4	7.6	7.75	7

In the present study 28 days cured aggregates specific gravity and bulk density is improved compared to 7 days cure aggregates. In these aggregates 17.5:82.5 aggregates as specific gravity and bulk density is more compare to other proportion aggregates.

7.3 Crushing and Impact values

7.3.1. 7 Days Water Cured Aggregates

Table 8-Impact and Crushing Value for 7Days

Ratios of fly ash and cement	Impact value (%)	Crushing value (%)
12.5:87.5	46	42
15:85	40	38
17.5:82.5	38	36
Conventional aggregates	27	25

7.3.2. 28 Days Water Cured Aggregates

Table 8-Impact and Crushing Value for 28Days

Ratios of fly ash and cement	Impact value (%)	Crushing value (%)
12.5:87.5	41	37
15:85	36	32
17.5:82.5	29	28.8
Conventional aggregates	27	25

Indian road congress and ISI have specified that the aggregate crushing value of the coarse aggregate used for the cement concrete pavement at surface should not exceed 30%. For aggregates used for concrete other than wearing surfaces the aggregate crushing value should not exceed 45%.The 17.5:82.5 proportion aggregates have good compressive and impact value compare to other proportion aggregates.

8. CONCLUSION

The following conclusions are made from the above study, which is applicable to the materials used and range of parameters studied.

1. In this study will provide an increase to utilization of wastes. Recycle and reuse of industrial wastes help a decrease in the demand for natural mineral resources.
2. The characterization studies on fly ash aggregates show that the properties of aggregates depend on the type of binder and its dosage.
3. Moisture content is the major factor whereas angle is the second parameter that influences size growth of pellets. Interaction effect between angle and moisture content also influences size growth of pellets.
4. Fineness modulus of fly ash aggregates are good, so the artificial aggregates can be used all civil engineering works.
5. Specific gravity of artificial aggregates are small below the natural aggregates.
6. Density of artificial fly ash aggregates is low, compare to conventional aggregates, these aggregates can be easily handle.
7. Crushing and impact value of 17.5:87.5 aggregates is good compare to conventional aggregates.

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