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Use of Fly Ash Aggregate as Partial Replacement of Natural Aggregate in Concrete

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Abstract :- In recent decades, we have noticed a gradual increase in disposal of different wastes in the environment, as well as problems arising from the shortage of natural raw materials in the civil construction business. These factors have encouraged the development of research in universities, academic centers, institutes and companies in search of specific alternatives to the use of industrial waste as new materials in an attempt to reduce their environmental impact.The research aimed at providing the use of some byproducts, such as ground blast furnace slag and silica fume in concrete, turned this waste into commercially valuable materials. Especially for the efficient use of these residues as well as their combinations, which produce concrete with improved characteristics.

key words - Aggregates propertirs, Manufacturing techniques, Industrial fly ash ,Fly ash aggregates.

I. INTRODUCTION

The concern about the depletion of natural sources and the effect on environment has particularly focused attention on the possibility of the use of synthetically produced (aggregates from waste materials) as an alternative to naturally occurring materials. In order to find alternatives over natural resources, the waste products have to be used effectively. Each industry or powerplants have their own waste products, as by-product of the main product. Nowadays due to industrialization there is a scarcity of electricity throughout India. India has 85 thermal power plants for generation of electricity and in thermal plant 85 million tones of fly ash is generated as residual waste per annum.Almost in all thermal power plants availability of fly ash is plenty, but only some amount of fly ash are using in cement industry for manufacturing cement (PPC) and the rest remains as waste. In order to overcome this disposal problem and to avoid an extraction and depletion of natural source, this residual fly ash can be effectively used in construction industry.The usage of fly ash in construction industry is a challenging job and will make tremendous change all over the world. There are different ways of using fly ash in industry, example, it can be used as partial replacement of cement. But the major challenge will be to completely use fly ash as an aggregate in 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. The palletisation technique is presented in figure.

II. PROPERTIES OF MATERIAL

- **Physical Properties of Cement are given in Table**

Sr. No	PROPERTY OF CEMENT	VALUE
1	Fines of cement	7.5%
2	Grade of cement	53 Grade(OPC)
3	Specific gravity of cement	3.15
4	Initial setting time	30min
5	Final setting time	600min
6	Normal consistency	35%

- **Property of Fine Aggregate**

Clean and dry river sand available locally will be used. Sand passing through IS 4.75 mm Sieve will be used for casting all the specimens.

Sr. No	PROPERTIES	VALUE
1	Specific Gravity	2.65
2	Fineness Modulus	2.25
3	Water absorption	1.5%

- **Property of Coarse Aggregate**

Crushed basalt aggregate with specific gravity of 2.78 to 2.83 for 10 – 20 mm will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

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Sr. No	PROPERTY	VALUE
1	Specific Gravity	2.78 - 2.83
2	Size of Aggregates	10 – 20 mm
3	Fineness Modulus	5.96
4	Water Absorption	1.5 %
5	Bulk Density	1687 – 1792.31
6	Fineness Modulus	6.26 – 6.734

- **Properties of Water**

Water used for mixing and curing shall be clean and free from injurious amounts of Oils, Acids, Alkalis, Salts, Sugar, Organic materials Potable water is generally considered satisfactory for mixing concrete Mixing and curing with sea water shall not be permitted. The pH value shall not be less than 6.

- **CONCRETE MIX DESIGN**

Step 1)Target strength for mix proportions

f'ck = fck + 1.65 x standard deviation

f'ck= 20 + 1.65 x 4

f'ck = 26.6 N/mm²

Step 2) Selection of w/c ratio

As per book M.S. Shetty and S. Chand page no. 523 fig. 11.9

	Cement	Fly ash
95:05	950 gm	50 gm
90:10	900 gm	100 gm
85:15	850 gm	150 gm
80:20	800 gm	200 gm

w/c ratio for M20 concrete = 0.54

Step 3)Selection of water content

As per IS 10262:2009

Water content = 186 litres

Step 4)Calculation of cement content

Cement content = $\frac{186}{0.54}$ = 344 kg/m³

344 > 250   Therefore it's ok.

Step 5)Proportion of volume of C.A. and F.A. content

From IS 10262:2009 Table no. 3, volume of coarse aggregate for 20mm and F.A. falling onzone – II.

W/C of 0.54 = 0.62

Volume of C.A. = 0.62 , Volume of F.A. = 1 – 0.62 = 0.38

Step 6) Mix Calculation

Volume of concrete = 1 m³

Volume of cement = $\frac{mass.cement}{mass\ density} = \frac{344}{3.15 \times 1000}$ = 0.109 m³

Volume of water = $\frac{186}{1 \times 1000}$ = 0.186 m³

Volume of all in aggregate = 1 – 0.109 – 0.186 = 0.705 m³

Mass of coarse aggregate = 1215.138 kg

Mass of F.A. = 723.33 kg

Step 7) Mix Proportions

Cement – 344 kg
Water–186 kg
F.A. – 723 kg
C.A.– 1215 kg
W/C ratio – 0.54
1 : 2.10 : 3.53 : 0.50
F.A. C.A. W/C

- **PREPERATION OF FLY ASH AGGREGATE**

Fly ash and Ordinary Portland cement were selected in different proprrtions like (fly ash :cemnt) 90:10, 87.5:12.5 , 85:15 ,82.5:17.5 .These proportions were thoroughly dry mixed in a concrete mixer.After dry mix in mixer, water was sprinkled until the 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 was formed from the mixer, they were collected in tray and allowed to dry for a day.Dried aggregates were cured for 7,28 days water curing and two days of steam curing at 80˚C.

- **PREPARATION OF CUBE SPECIMENS**
- **Mixing**

Mix the concrete either by hand or in a laboratory batch mixer.

- **Hand Mixing**

(i) Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color.

(ii) Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.

(iii) Add water and mix it until the concrete appears to be homogeneous and of the desired consistency.

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- **Sampling**

(i) Clean the mounds and apply oil.

(ii) Fill the concrete in the molds in layers approximately 5 cm thick.

(iii) Compact each layer with not less than 35 strokes per layer using a tamping rod (steel bar 16mm diameter and 60 cm long, bullet pointed at lower end) [IX].

(iv) Level the top surface and smoothen it with a trowel

- **Curing**

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the molds and kept submerged in clear fresh water until taken out prior to test.

- **Precautions**

The water for curing should be tested every 7 days and the temperature of water must be at 27 ± 2^0C. It is quite clear that due to Poisson's effect, cube or cylinder specimens undergo lateral expansion. The steel plates don't undergo lateral expansion to the same extent that of concrete. There exists a differential tendencies of lateral expansion between steel plates and concrete cube faces; as a result of which tangential forces are induced between the end surfaces of the concrete specimen and the adjacent steel plates of the testing machine. The degree of platen restraint on the concrete section depends on the friction developed at the concrete-platen interfaces, and on the distance from the end surfaces of the concrete. As a result, in addition to applied compressive stress, lateral shearing stresses are also effective in the concrete specimen. Effect of this shear decreases towards the center of cube; so that sides of cube have near vertical cracks at cube's center, or completely disintegrates so as to leave a relatively undamaged central core. As the degree of end restraint depends on the friction at the interfaces, this frictional value can be eliminated by applying grease, graphite or paraffin wax to the bearing surfaces of the specimen. It helps the specimen to undergo a larger and uniform lateral expansion and eventually splits along its full length.

III. TESTING PROCEDUR

- Compressive Strength Test

At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block will be noted. From the noted values, the compressive strength may calculated by using below formula.

Compressive Strength = Load / Area

Size of the test specimen=150mm x 150mm x 150mm

1.Representative samples of concrete shall be taken and used for casting cubes 15 cm x 15 cm x 15 cm or cylindrical specimens of 15 cm dia x 30 cm long.

2.The concrete shall be filled into the molds in layers approximately 5 cm deep. It would be distributed evenly and compacted either by vibration or by hand tamping. After the top layer has been compacted, the surface of concrete shall be finished level with the top of the mold using a trowel; and covered with a glass plate to prevent evaporation.

3.The specimen shall be stored at site for 24+ ½ h under damp matting or sack. After that, the samples shall be stored in clean water at 27 ± 2^0C; untilthe time of test. The ends of all cylindrical specimens that are not plane within 0.05 mm shall be capped.

4.Just prior to testing, the cylindrical specimen shall be capped with sulphur mixture comprising 3 parts sulphur to 1 part of inert filler such as fire clay.

5.Specimen shall be tested immediately on removal from water and while they are still in wet condition.

6.The bearing surface of the testing specimen shall be wiped clean and any loose material removed from the surface. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load cube as cast, that is, not to the top and bottom.

7.Align the axis of the specimen with the steel plates, do not use any packing.

8.The load shall be applied slowly without shock and increased continuously at a rate of approximately 140 kg/sq.cm/min until the resistance of the specimen to the increased load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and any unusual features noted at the time of failure brought out in the report

IV. OBSERVATION AND TEST RESULTS

Concrete block specification and observation table

1. Grade of concrete – M 20
2. Size – 150*150*150 mm
3. Cement –Ultratech, 53 Grade O.P.C.

1) Conventional Sample

Concrete block	Weight	Load	Compressive Strength	
(150*150*150) mm	(Kg)	(N)×10^3	(N/MM^2)	Average
Sample – 1	9.283	1000	44.44	
Sample - 2	9.207	960	42.66	43.85
Sample - 3	9.363	1000	44.44	

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2) 90:10 = 25% FAA

Concrete block (150*150*150) mm	Weight (Kg)	Load (N)×10^3	Compressive Strength (N/MM^2)	Average
Sample – 1	8.972	880	39.11	
Sample – 2	8.593	800	35.55	36.59
Sample - 3	8.681	790	35.11	

3) 90:10 = 50% FAA

Concrete block (150*150*150) mm	Weight (Kg)	Load (N)×10^3	Compressive Strength (N/MM^2)	Average
Sample – 1	8.626	820	36.54	
Sample - 2	8.522	830	36.88	37.48
Sample - 3	8.464	880	39.11	

4) 87.5:12.5 = 25% FAA

Concrete block (150*150*150) mm	Weight (Kg)	Load (N)×10^3	Compressive Strength (N/MM^2)	Average
Sample – 1	8.883	730	32.44	
Sample - 2	8.752	730	32.44	32.44
Sample - 3	8.886	730	32.44	

5) 87.5:12.5 = 50% FAA

Concrete block (150*150*150) mm	Weight (Kg)	Load (N)×10^3	Compressive Strength (N/MM^2)	Average
Sample – 1	8.464	620	27.55	
Sample - 2	8.649	720	32	30.36
Sample - 3	8.398	710	31.55	

6) 85:15 = 25% FAA

Concrete block (150*150*150) mm	Weight (Kg)	Load (N)×10^3	Compressive Strength (N/MM^2)	Average
Sample – 1	8.765	810	36	
Sample - 2	8.782	700	31.11	35.40
Sample - 3	8.795	880	39.11	

7) 85:15 = 50% FAA

Concrete block (150*150*150) mm	Weight (Kg)	Load (N)×10^3	Compressive Strength (N/MM^2)	Average
Sample – 1	8.512	900	40	
Sample - 2	8.269	800	36.55	39.25
Sample - 3	8.656	950	42.22	

8) 82.5:17.5 = 25% FAA

Concrete block (150*150*150) mm	Weight (Kg)	Load (N)×10^3	Compressive Strength (N/MM^2)	Average
Sample – 1	8.550	900	40	
Sample - 2	8.749	820	36.44	37.18
Sample - 3	8.610	790	35.11	

9) 82.5:17.5 = 50% FAA

Concrete block (150*150*150) mm	Weight (Kg)	Load (N)×10^3	Compressive Strength (N/MM^2)	Average
Sample – 1	8.560	810	36	
Sample - 2	8.540	880	39.11	39.26
Sample – 3	8.477	960	42.67	

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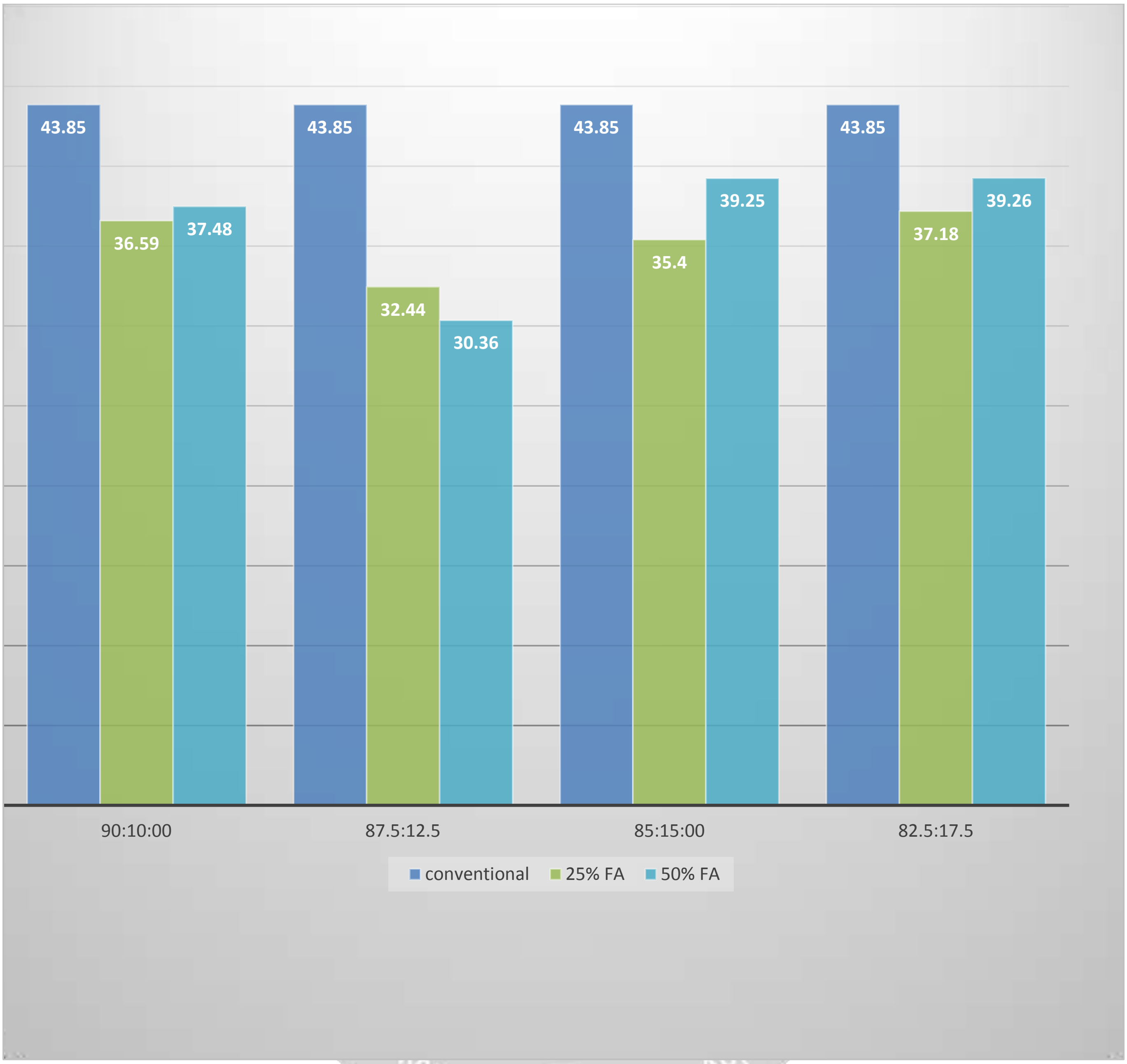

V. CONCLUSION

Based on relevant literature and extensive laboratory work and the obtained results following modest conclusion could be drawn.

1. Fly ash and cement in the range of 90:10, 87.5:12.5, 85:15 and 82.5:17.5 respectively where dry mixed and fed in concrete mixer with a known amount of water and required rotations were given until the formation of fly ash aggregates.
2. Formed FA aggregates after curing were graded.
3. The specific gravity of the manufactured FA aggregate is in the range of 1.51 to 1.75 as compared to conventional aggregate is 2.73.
4. It clearly indicate manufactured FA aggregate are light weight material.
5. From the four different proportion of fly ash aggregate conducted the one with 82.5:17.5 proportion is showing better result upto 50% replacement in natural aggregate as compared to others.
6. The compressive strength of the fly ash aggregate (artificial aggregate) result is some what similar to the results of conventional aggregate.
7. Due to poor bonding of fly ash aggregate and cement the proportion of 80:20 was not considered for further analysis.

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REFERENCES

[1] S.SHANMUGASUNDARAM, DR. S.JAYANTHI "Study on utilization of fly ash aggregate in concrete"

[2] PRIYADARSHINI.P, MOHAN GANESH.G "Production of artificial aggregate with fly ash in utilizing large volume of ash in concrete"

[3] NIYAZIUGURKOCKAL, TURANOZTURAN "Different light weight fly ash aggregate on the behaviour of concrete mixture"

[4] MEHMETGESOGLU, TURENOZTUMN AND GUNEYISI (2006)"Effect of cold bonded fly ash aggregate properties on the shrinkage cracking of light weight concrete (2006) PP592-605"

[5] RAJAMANI N.P AND AMBILY P.S. (2006"Selection of mortar for light weight aggregate concrete made with fly ash based aggregate", New building materials and construction world journal June (2006) PP : 80 to 88 August (2006)

 DOI : 10.35291/2454-9150.2020.0530