

Experimental Study on Artificial Fly Ash Aggregate Concrete

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ABSTRACT: Aggregate is most widely used in reinforced concrete construction. In this project, artificial fly ash aggregates were used in concrete and its effect on strength of concrete was studied. The fly ash was collected from the thermal plant. Then the cement fly ash proportions of 25:75, 27.5:72.5, 30:70, 32.5:67.5, 35:65, 37.5:62.5 were adopted to artificial fly ash aggregates. The particle size distribution, specific gravity, bulk density and impact test on aggregate were conducted. M20 grade of concrete was considered. The conventional and artificial fly ash aggregates concrete cubes and beam specimens were cast. All the specimens were cured in curing tank. The normal and fly ash aggregate concrete cube specimens were tested for 1,3,7,14,28 days. The beam specimens were tested for 7 and 28 days. Compressive and flexural strength tests were conducted on these normal and artificial fly ash aggregates concrete specimens. The results were tabulated. Based on the results obtained, conclusions and suggestions were made.

KEYWORDS: Artificial fly ash aggregates, Compressive strength and flexural strength.

I. INTRODUCTION

Fly ash is not a polluting industrial waste, but a resource material useful for various construction applications, in cement and concrete. The utilization of fly ash in India has increased substantially in recent years. Both coarse and fine aggregates for making concrete are become scarce and many cities and towns worldwide including India, do not allow the quarrying of sand or stone. This problem will become very acute in the future. These aggregates, in addition to being lightweight, are not subjected to alkali-aggregate reaction. India produces about 100 million tonnes of fly ash annually at present. The projections based on energy needs of India show that this amount will increase to about 200 million tones by year 2015, as coal will remain to be the major source of energy in India and elsewhere in the world. In the construction industry, fly ash is used in the roof insulation, Trench reinstatement, Road formation, Bridge abutment, Land reclamation, void filling, Light weight pre cast blocks, Fire resistance, Insulation screed and soil stabilization.

The Alternative materials:

- Fly ash coarse aggregate
- Construction demolition waste
- Broken glasses
- Rubber wastes
- Silica sand
- Granite stones

Recycled concrete aggregates (RCA) is obtained mainly by crushing and processing concrete elements that have been previously used in construction, where the masonry content material, including approximately a 30-35 percent of material less than 4mm, is fed to a plant in which the fines are separated. The process has produced satisfactory aggregates and the research has proved that there is no decrease in the properties of medium grade concrete, with the use of 20 percent recycled aggregate and 80 percent natural stone and aggregates are widely used in concrete.

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II. MATERIALS USED

Cement

43 grade ordinary Portland cement (OPC) is used for the study programme and the specific gravity of cement was found to be 3.15. The physical, chemical and strength properties of 43 grade cement are given in the Table 1.

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 C-fly ash. It is usually produced by burning lignite or sub-bituminous coal. Cement and fly ash were mixed in concrete mixer with 25:75, 27.5:72.5, 30:70, 32.5:67.5, 35:65 and 37.5:62.5 ratios with w/c of 0.3 and is mixed until the pellets are formed.

Fine Aggregate

For ordinary Concrete River sand was used in preparing the concrete as it is locally available in sand quarry. The specific gravity was found to be 2.60. The natural fine aggregate was compared with fly ash aggregates prepared from various cement fly ash proportion.

Coarse Aggregate

For ordinary concrete 20mm normal size grades aggregate was used. The specific gravity was found to be 2.85. The natural coarse aggregate was compared with fly ash aggregates prepared from various cement fly ash proportion.

Table 1
Physical, Chemical & Strength Properties of 43 Grade Cement

S. No.	Characteristics	Value
1	Standard consistency	31%
2	Fineness by Sieving through IS 90 Micro Sieve	2%
3	Setting Time	
	Initial Setting Time	30 min
	Final Setting Time	8 hours
4	Compressive Strength	
	3 Days	28.00 Mpa
	7 Days	34.66 Mpa
	28 Days	48.00 Mpa
5	Soundness (using Le-Chatelier apparatus)	6 mm
6	Specific Gravity	3.15
7	Ratio of Percentage of alumina to that of iron oxide	0.7
8	Insoluble Residue (%)	1.3%
9	Magnesia (%)	5.5%

III. CONSTITUENTS OF FLY ASH AGGREGATES

Cement and fly ash are constituents for prepare aggregates and water is the binder to increase the workability. Six different proportions are taken and subjected to pelletisation process.

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Table 2
Proportions of Cement and Fly Ash

Trial	Cement (%)	Fly ash (%)
1	25	75
2	27.5	72.5
3	30	70
4	32.5	67.5
5	35	65
6	37.5	62.5

Pelletisation:

It is a process of agglomeration of moisturized fines in rotating drum or disc, to produce 'fresh pellet'. 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 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 material influence the efficiency 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.

Processing and Curing of Fly Ash Aggregates:

The prepared green pellets are allowed to dry for three days. Fly ash aggregates are then put for 7 days curing.



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IV. TESTS ON FINE AGGREGATES

Determination of particle size distribution

Weight of sample taken = 500gm

Table 3

Particle Size Distribution of Conventional Fine Aggregate and Fly Ash Fine Aggregates

Sieve size	Cumulative percentage of aggregates retained						
	Conventional	25:75	27.5:72.5	30:70	32.5:67.5	35:65	37.5:62.5
4.75mm	1.2	3	2	4	3	1.5	6
2.36mm	3.4	7.2	3.6	8.2	3.7	23.6	9.2
1.18mm	9.4	11.2	33.7	15.2	29.9	43.6	18.2
600µm	25.2	30.4	47.7	27	43.2	46	32.4
300µm	72.6	62.0	62.8	61	58.3	52.6	59.8
150µm	96.2	86.0	86.1	85.2	82.5	75.8	82.6
Retaining	100	100	100	100	100	100	100

Determination of Specific Gravity:

Table 4

Specific Gravities of Conventional Fine Aggregates and Fly Ash Fine Aggregates

Material	Specific gravity
Conventional fine aggregate	2.60
25:75	1.77
27.5:72.5	2.11
30:70	1.56
32.5:67.5	1.62
35:65	1.56
37.5:62.5	1.68

V. TESTS ON COARSE AGGREGATES

Determination of particle size distribution

Weight of sample taken = 5000gm

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Table 5

Particle Size Distribution of Conventional Coarse Aggregate and Fly Ash Coarse Aggregates

Sieve size	Cumulative percentage of aggregates retained						
	Conventional	25:75	27.5:72.5	30:70	32.5:67.5	35:65	37.5:62.5
80mm	-	-	-	-	-	-	-
40mm	-	-	-	-	-	-	-
37.5mm	-	-	-	-	-	-	-
20mm	29.8	72.6	58.4	52.6	44.8	42.6	38.4
12.5mm	97.4	88.8	88.6	90.4	92.6	93.8	94.8
10mm	98.8	98.8	96.8	96.8	97.2	97.6	98.2
Retaining	100	100	100	100	100	100	100

Determination of Specific Gravity:

Table 6

Specific Gravities of Conventional Coarse Aggregates and Fly Ash Coarse Aggregates

Material	Specific gravity
Conventional coarse aggregate	2.85
25:75	1.30
27.5:72.5	1.90
30:70	1.12
32.5:67.5	1.18
35:65	1.24
37.5:62.5	1.28

VI. CONCRETE MIX DESIGN

Concrete is made with the design mix ratio of 1: 1.34: 3.12 with the water cement ratio of 0.45.

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VII. WORKABILITY TESTS ON FRESH CONCRETE

Table 7
Slump Test

Material	Slump Value(cm)
Conventional Concrete	7
25:75	8
27.5:72.5	7
30:70	8
32.5:67.5	8
35:65	9
37.5:62.5	9

Table 8
Compaction Factor Test

Material	Compaction Factor
Conventional concrete	0.80
25:75	0.93
27.5:72.5	0.91
30:70	0.92
32.5:67.5	0.93
35:65	0.93
37.5:62.5	0.94

VIII. PREPARATION OF SPECIMENS

Ordinary OPC 43Grade, Fly ash fine aggregate, Fly ash Coarse aggregate and water were taken as per mix design and thoroughly mixed and casted in 15x15x15cm cubes & 50x10x10cm prism. The cube and beam specimens were demoulded after 24 hours. Necessary identification marks were made in the specimens and kept under water in a curing tank. The cube specimens were kept under water for 1 day, 3 days, 7 days, 14 days, and 28 days and the beam specimens for 7 days and 28 days. After curing, they were taken out from the curing tank and air dried before testing.



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IX. COMPRESSIVE STRENGTH TEST

By definition, the compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test on 15cm concrete cubes. The test was conducted in 120T compressive testing machine. The load was applied at the rate approximately 140 kg/cm²/min until the failure of the specimen. The maximum load applied to the specimen until failure

Table 9
Compressive Strength of Concrete

Age of Concrete (days)	Cement : Fly Ash proportion	Compressive Strength (MPa)
1	25:75	2.12
	27.5:72.5	2.35
	30:70	2.96
	32.5:67.5	2.21
	35:65	2.57
	37.5:62.5	2.10
	Control concrete	2.92
3	25:75	6.15
	27.5:72.5	6.45
	30:70	8.54
	32.5:67.5	6.88
	35:65	6.22
	37.5:62.5	6.35
	Control concrete	8.39
7	25:75	10.25
	27.5:72.5	11.58
	30:70	15.93
	32.5:67.5	12.88
	35:65	13.90
	37.5:62.5	10.24
	Control concrete	14.62
14	25:75	14.50
	27.5:72.5	15.55
	30:70	20.24
	32.5:67.5	16.22
	35:65	15.80
	37.5:62.5	12.55
	Control concrete	18.54
28	25:75	16.80
	27.5:72.5	17.23
	30:70	23.80
	32.5:67.5	17.90
	35:65	17.89
	37.5:62.5	15.08
	Control concrete	20.56

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X. FLEXURAL STRENGTH TEST

The concrete beams of size 10cmx 10cmx 50cm were tested as per IS 516-1959. The load was applied through two similar rollers mounted at one third points of the supporting span. The load was applied without shock until the failure. The maximum load at failure was noted.

Table 10
Flexural Strength of Concrete

Age of Concrete (days)	Cement:Fly Ash Proportion	Flexural Strength (MPa)
7	25:75	4.50
	27.5:72.5	4.85
	30:70	5.50
	32.5:67.5	4.48
	35:65	4.20
	37.5:62.5	3.89
	Control concrete	5.25
28	25:75	4.40
	27.5:72.5	4.88
	30:70	6.23
	32.5:67.5	4.50
	35:65	4.42
	37.5:62.5	4.22
	Control concrete	6.10

XI. CONCLUSION

- ✓ While comparing the compression strength, the fly ash aggregate concrete with aggregate made from cement fly ash proportion 30:70 showed high compressive strength than control concrete at all ages of concrete.
- ✓ The increase in compressive strength of fly ash aggregate concrete with cement fly ash proportion 30:70 at one day increased by 1.36% over control concrete.
- ✓ The increase in compressive strength of fly ash aggregate concrete with cement fly ash proportion 30:70 at 3 days increased by 1.78% over control.
- ✓ The increase in compressive strength of fly ash aggregate concrete with cement fly ash proportion 30:70 at 7 days increased by 8.96% over control concrete.
- ✓ The increase in compressive strength of fly ash aggregate concrete with cement fly ash proportion 30:70 at 14 days increased by 9.16% over control concrete.
- ✓ The increase in compressive strength of fly ash aggregate concrete with cement fly ash proportion 30:70 at 28 days increased by 15.75% over control concrete.
- ✓ High flexural strength was observed for fly ash aggregate concrete with cement fly ash proportion 30:70.
- ✓ At 7 days increase in flexural strength of 4.76% over control concrete.
- ✓ At 28 days increase in flexural strength of 2.13% over control concrete.

XII. SUGGESTIONS

The source of availability of ordinary Granite aggregate is slowly reduced and limited. So fly ash aggregate may be thought and used as alternate aggregates in concrete. The environmental pollution and problems in disposal of fly ash can also be minimized when fly ash aggregate are used in concrete for conventional granite stone aggregate.

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