

# To study the effect of different binders on the properties of Fly-ash based aggregates

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## Abstract

Aggregates are a very vital and very integral part of the construction industry and are used in the construction of reinforced concrete structure. But, with excessive use of natural aggregate, they are becoming scarce day by day and there is a need to create artificial aggregates that could replace the naturally occurring coarse aggregate. The goal of this project is to create a method for creating fly-ash-based aggregate by mixing in specific binders and chemicals. This study tests the impact of various binders on aggregate made from fly-ash. Power plant fly ash is used to make blended cement, brick blocks, less weight concrete, and other products for civil engineering. Since coal will continue to be the main source of energy production in our nation in the future, there will be an abundance of fly-ash produced, making it the greatest option for creating artificial aggregates.

**Keywords:** Artificial Flyash Based Aggregate, Effect of Binders on fly ash-based aggregates..

## 1. INTRODUCTION

Natural resources are exploited to produce natural aggregate. Natural aggregate has been the only option for use in the making of concrete and hence it has been exploited to a large extent. The natural aggregate is becoming scarce with excessive use and hence there is a need to find alternates for natural aggregate. This study shows the result of application of different binders on the artificial aggregate. Production of fly ash-based aggregate involves mixing of cement, water, chemicals, and binders. Burning of coal produces fly ash; it is also a highly inventive substance with numerous applications in both construction and concrete. Since coal is India's main energy source, a very large amount of fly ash is released in India each year. India currently produces about 165 Mt of fly ash every year, and it is anticipated that this quantity would eventually reach up to 2000 Mt. Fly ash disposal is exceedingly expensive and a significant contributor to environmental damage. As a result, fly ash continues to be the best and most suitable material for making artificial aggregates.

## 2. VARIOUS RESOURCES WERE CONSULTED IN THIS INVESTIGATION, INCLUDING: -

### 2.1. CEMENT

This project employs P.P.C. in accordance with IS 1489[PART1]:1991.

	Calcium Oxide	Sulphur-dioxide	Aluminium - oxide	Ferrous-Oxide	Sodium oxide	Potassium oxide	Magnesium Oxide	Density [gm/cc]
PPC	62.6	21.5	2.36	1.83	0.57	0.38	1.24	2.84

### 2.2. Fly ash

The most popular and often utilised pozzolanic substance worldwide is fly ash. Flue ash is another name for it. It is the by-product of the burning of coal. Bottom ash is ash that sinks to the bottom and does not rise. Fly ash is separated into two groups:

- Class F fly ash and
- Class C fly ash.

Top classification is F. flies' ashes: Most of the fly ash produced now comes from burning bituminous and anthracite coal, which is harder, older coal.

In addition to its pozzolanic properties, Class C fly ash's main attribute is its ability to self-cement. Lime makes up more than 20% of the material. It typically consists of less than 2% carbon and is rich in calcium fly ash.

	Calcium Oxide	Sulphur dioxide	Aluminium - oxide	Ferrous Oxide	Sodium oxide	Potassium oxide	Magnesium Oxide	DENSITY [gm/cc]
FLY ASH	1.6	54.96	31.26	8.99	1.3	2.13	1.65	2.59

### 2.3. Sodium Hydroxide and Sodium Silicate

#### Sodium Silicate

Alkaline and neutral solutions do not affect the stability of sodium silicates. Silicic acids are created when silicate ions combine with hydrogen ions in acidic situations; these acids have a propensity to break down into hydrated silicon dioxide gel. The outcome of heating silica gel to drive off the water is a hard, transparent material known as desiccant that is utilized extensively. It is resistant to heat up to 1100 °C.

#### Sodium Hydroxide

Sodium hydroxide is an inorganic compound that has a strong alkaline inclination. Its chemical name is NaOH. Sodium cations and hydroxide anions make up this white, solid ionic combination. It is a synthetic product. It produces a significant quantity of heat that could be sufficient to ignite combustible objects when dissolved in water or neutralised with acid. It is a corrosive chemical. Drops of sodium hydroxide solution can rapidly amide hydrolyse, and ester hydrolyse proteins and lipids in living tissues, just like other corrosive acids and alkalis.

### 2.4. Bentonite

The main component of montmorillonite, a hydrous aluminium silicate with minute particle size and a member of the smectite group, is bentonite, an incredibly soft, flexible clay. Most bentonites are made from rocks and volcanic ash that have been significantly altered by water. Thixotropy, viscosity, swelling, and water absorption are some of its unique traits. Due to its appealing properties, which are in demand throughout the numerous industries covered by IMERY'S, this mineral is referred to as "the mineral with a thousand uses."

### 2.5. GBFS

GBFS is a granular, amorphous substance the size of sand. If it were a finely milled form, it would display hydraulic cementitious characteristics. Although it varies depending on its source and other reasons, the average GBFS granule size is roughly 1-1.5 mm. When finely powdered and mixed with Portland cement, GBFS demonstrates outstanding cementitious properties and has an off-white or near-white tint (PC). The GGBFS has a specific gravity of approximately 2.90. The fineness of GGBFS is a crucial factor that determines its reactivity and is measured by the specific surface area that governs it. In general, greater fineness leads to higher strength development, but fineness is constrained by factors including setting times, shrinkage, and economic and performance considerations.

### 2.6. Glass Powder

Concrete's compressive strength at various glass powder concentrations. Concrete's porosity would be reduced, and its strength could rise because of this operation.

### 2.7 Constituents Of Fly ash based Aggregates

Cement, fly ash, Water, Chemicals and Binders are the constituents of fly ash aggregate. Water is used for increasing the workability of the mixture. Three different binders were used to make three samples. Only different binders were used whereas the rest of the constituents were kept the same. Cement, fly-ash, chemicals, binders were used in the same proportion for all the different samples with different binders.

SR. No.	Fly-ash	Binders	Chemicals (NaOH, Na <sub>2</sub> SiO <sub>3</sub> )	Cement
Sample 1	80%	GBFS 10%	4% (2% Each)	6%

Sample 2	80%	BENTONITE 10%	4% (2% Each)	6%
Sample 3	80%	GLASS POWDER 10%	4% (2% Each)	6%

### 3. MANUFACTURING OF FLY ASH AGGREGATES

The process for making fly ash aggregate:

- The following ingredients were used in the ratio 80:6:10:4: Type F fly ash, PCC grade 53 (PCC), specific Binders, and some chemicals (sodium hydroxide and sodium silicate).
- The fly ash and cement were dry mixed in the concrete mix for 3 to 5 minutes.
- Chemicals were induced to water in different quantities according to the sample.
- For instance, 50gm of each chemical were induced in 2 litres of water to make 5 kilogrammes of the artificial aggregates.
- The fly ash and cement mixture were sprayed with water containing a chemical solution, and the aggregates were then manually formed. Because we had to remove the concrete's blade and the mixer's required RPM was 60, which was not accessible, the aggregates were formed by hand.
- The size of aggregate passed through 20mm sieve and retained on 16.5mm sieve'
- These aggregates were put in the oven for drying at temperatures between 1000C to 1050C.
- A curing of 21 days was given to the artificial aggregates and were kept for drying in the sun for 1 day.

### 4. TESTING ON COARSE AGGREGATE

Different tests were conducted on the fly ash-based aggregates to test their strength, impact value, abrasion values, water absorption and specific gravity tests.

#### 4.1 Abrasion Test

$$\text{Abrasion Value} = \frac{w_2}{w_1} \times 100$$

#### FLY ASH AGGREGATES WITH GRANULATED BLAST FURNACE SLAG

Weight of aggregate sample (W1) = 3 kg

Weight of ball = 2.2 Kg

No. of balls = 5

Weight of aggregate that pass through 1.75 IS sieve (W2) = 2100gm

Abrasion Value = 70%

#### FLY ASH AGGREGATES WITH GLASS POWDER

Weight of aggregate sample (W1) = 3 kg

Weight of ball = 2.2 Kg

No. of balls = 5

Weight of aggregate that pass through 1.75 IS sieve (W2) = 1650gm

Abrasion Value = 55%

#### FLY ASH AGGREGATES WITH BENTONITE

Weight of aggregate sample (W1) = 3 kg

Weight of ball = 2.2 Kg

No. of balls = 5

Weight of aggregate that pass through 1.75 IS sieve (W2) = 2550gm

Abrasion Value = 85%

## CONVENTIONAL AGGREGATE

Sr. no.	Type Of Pavement	Max. Permissible Abrasion value (%)
1	Water Bound Macadam Sub base Course	60
2	WBM Base course with bituminous Surfacing	50
3	Bituminous bound Macadam	50
4	WBM Surfacing Course	40
5	Bituminous Penetration macadam	40
6	Bituminous Surface Dressing, CC surface Course	35
7	Bituminous Concrete Surface Course	30

### 4.2 Impact Test:-

$$\text{Value of impact} = \frac{w_3}{w_2 - w_1} \times 100$$

SAMPLE 1: -Fly ash aggregates with granulated blast furnace slag

Weight of mould when empty (W1) = 1660 gm

Aggregate plus mould weight (W2) = 1660+410=2170 gm

Fines passing through a 2.36-millimetresieve (W3) = 240.0 grammes.

Impact value = 58.54%

SAMPLE 2: -Fly ash aggregates with glass powder

Weight of mould when empty (W1) = 1660 gm

Aggregate plus mould weight (W2)= 1660+355= 2015 gm

Fines passing through a 2.36 mm filter (W3) weigh 185 grammes.

Impact value = 52.11%

SAMPLE 3: -Fly ash aggregates with bentonite

Weight of mould when empty (W1) = 1660 gm

Aggregate plus mould weight (W2)= 1660+370= 2030 gm

Fines passing through a 2.36 mm filter (W3) weigh 190 grammes

Impact value = 51.35%

### CONVENTIONAL AGGREGATES

Weight of mould when empty(W1) = 1.799 kg

Aggregate plus mould weight(W2)= 2.486 kg

Fines passing through a 2.36 mm filter weigh(W3) =190 grammes

Impact value = 7.279%

### 4.3 Water Absorption Test: -

Ww = wet weight of aggregate

Wd = Weight of oven dried sample

$$\text{Water absorption of aggregate} = \frac{w_w - w_d}{w_d} \times 100$$

SAMPLE 1: -Fly ash aggregates with granulated blast furnace slag

Ww = 245 gm

Wd = 225gm

% Water absorption of aggregate = 8.88%

SAMPLE 2:-Fly ash aggregates with glass powder

Ww = 227 gm

Wd = 215 gm

% Water absorption of aggregate = 5.58%

SAMPLE 3:-Fly ash aggregates with bentonite

Ww = 211.5 gm

Wd = 200 gm

% Water absorption of aggregates = 5.75 %

#### 4.4 SPECIFIC GRAVITY TEST:

W1= Weight of empty Pycnometer

W2= Weight of empty Pycnometer + Aggregates

W3= Weight of empty Pycnometer + Aggregates + Distilled Water

W4= Weight of empty Pycnometer + Distilled Water

$$G (\text{specific gravity}) = \frac{w_2 - w_1}{(w_2 - w_1) - (w_3 - w_4)}$$

#### FLY ASH AGGREGATES WITH GRANULATED BLAST FURNACE SLAG

Weight of sample (gm)	W1 (gm)	W2 (gm)	W3 (gm)	W4 (gm)	G	Average (G)
100	652.0	752	1582.0	1540.0	1.053	1.58
150	652.0	802	1605.0	1540.0	1.765	
200	652.0	852	1626.0	1540.0	1.754	
250	652.0	902	1648.0	1540.0	1.761	

Weight of sample (gm)	W1 (gm)	W2 (gm)	W3 (gm)	W4 (gm)	G	Average (G)
100	621.0	721	1545.0	1502.0	1.754	1.79
150	621.0	771	1569.0	1502.0	1.807	
200	621.0	821	1591.0	1502.0	1.802	
250	621.0	871	1613.0	1502.0	1.799	

#### FLYASH AGGREGATE WITH GLASS POWDER

#### FLYASH AGGREGATE WITH BENTONITE

Weight of sample (gm)	W1 (gm)	W2 (gm)	W3 (gm)	W4 (gm)	G	Average (G)
100	649.0	749.0	1562.0	1520.0	1.724	

150	649.0	799.0	1585.0	1520.0	1.765	1.73
200	649.0	849.0	1605.0	1520.0	1.739	
250	649.0	899.0	1623.0	1520.0	1.701	

#### CONVENTIONAL AGGREGATES

Weight of sample (gm)	W1 (gm)	W2 (gm)	W3 (gm)	W4 (gm)	g	Average (G)
150	622.0	772	1595	1504	2.54	2.85
200	622.0	822	1636	1504	2.94	
250	622.0	872	1673	1504	3.08	

## 5. CONCLUSIONS

### 1. Abrasion Test

- The Los Angeles abrasion value of good aggregate must be less than 30% to be accepted for use in cement concrete and other high-quality pavement materials, as stated in IS 2386 (Part 4) 1963 (D). The values 30% are allowed in concrete like water bond.
- The abrasion value for natural aggregates is discovered to be 8.35%, while the abrasion value for synthetic aggregates is discovered to be greater than 30%.
- The natural coarse aggregate is clearly better than the Fly ash Aggregate.
- This Result could be improved by making if they were made using proper machinery.

### 2. Impact Value

- According to IS 2386 (Part 4) 1963 (c) aggregates having an impact value less than 10% is considered strong.
- 20%-30% is satisfactory.
- An impact value should not exceed more than 30% for aggregates to be used in Wearing coat or base coat.
- For base coat this value should not exceed more than 45%.
- For Natural Aggregates the value of impact test is found as 7.279% and the impact value for the artificial aggregates is more than 45 % .
- Natural aggregates are clearly better when compared to fly ash based aggregates.
- This result could've been improved if Glass powder was added to every sample in significant quantities.

### 3. Water Absorption Test

- Water absorption should not be greater than 3% or 2%, per IS 6349.
- The IS - 812 (part 120) drying shrinkage test is only applicable to aggregates with water absorption below 3.5%.
- The water absorption value of natural aggregates is determined to be 1.86%, while the water absorption value of artificial aggregates is determined to be greater than 3%..
- Natural aggregate is better than Artificial fly ash-based aggregate

### 4. Sp. Gr. Test

- The range of Specific Gravity is 2.5 to 3.
- For Natural Aggregates the Sp. Gr. is Found out as 2.85 whereas the sp.Gr. of the artificial aggregates was found as less than 2.5 % .
- Conventional Aggregate is better than fly ash aggregate.

#### Suggestions

The results could have been improved if the mixing and manufacturing of aggregates would've been done in a concrete mixer whose blades were detachable and could rotate at more than 70rpm. Also, if the quantity of glass powder is increased in all the samples, significant improvement in the strength could be achieved. Achieving the angular shape of the aggregate is very important to achieve strength of the aggregates.

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