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# AN EXPERIMENTAL INVESTIGATION ON PHYSICAL PROPERTIES OF ARTIFICIAL AGGREGATE

**[1]Atul S. Kurzekar, [2]Dr. K. Ravi, [3]Akul Sawarkar, [4]Yash Matey, [5]Gaurav Barade, [6]Rupali Bhanarkar**

[1]*Asst. Professor, Civil Department, YCCE, Nagpur*
[2]*Professor, Civil Department, BNCOE, Pusad*
[3456]*Student, Civil Department, YCCE, Nagpur*

**Abstract**

In many countries, the use of waste materials in the construction sector is a viable option due to rising raw material costs and the continuous depletion of natural resources. Waste materials have shown to be valuable as construction materials when properly processed, and they readily fulfil design criteria. Natural aggregate extraction is still prevalent, but it's wreaking havoc on the environment. Aggregate extraction alters the landscape and may cause other issues, such as weathering, which frequently results in lasting harm to rural areas. Fly ash aggregates, which are created from industrial waste, not only supply additional aggregate sources but also aid in pollution reduction.

Fly-ash is a finely dispersed waste produced by the combustion of powdered coal that is carried by flue gases and collected using an electrostatic precipitator. Fly ash is an environmentally toxic waste product that is difficult to decompose. Fly ash from power stations is utilized in a variety of civil engineering applications, including blended cement, lightweight aggregates, fly ash bricks and blocks, and lightweight concrete. India's energy industry is currently reliant on coal-fired thermal power plants, which generate a considerable quantity of fly ash (about 200 million tons per year). Fly ash has mostly been used in concrete as a cement replacement element or as aggregate fillers. Fly ash is utilized to substitute cement in around 30% of concrete applications. This degree of replacement must be increased. Future additions of high-volume fly ash are projected.

Fly ash aggregates are a novel breakthrough in the construction industry, directly replacing coarse aggregates which are typically a major constituent of buildings. The strength characteristics of fly ash aggregate concrete were investigated in this experimental investigation by manufacturing aggregates with cement and fly ash in the ratios of 10:90, 15:85, and 20:80. The tests were performed on concrete to look at qualities like compressive and split tensile strength.

**Keywords**: Aggregate, Waste materials, Fly-ash.

## 1. INTRODUCTION

M In many sections of the nation, the exploitation of crushed and fine stone aggregates has been a source of significant concern; forest loss, noise, dust, blasting tremors, and environmental dangers are just a few of its consequences. Unplanned rock extraction on fragile and steep hill slopes might result in landslides. India today suffers a scarcity of power as a result of industrialization. There are 85 thermal power stations in India that provide energy. Each thermal plant emits 85 million tons of carbon dioxide per year as a result of its energy output. In the building sector, using fly ash powder solely as an aggregate is a big difficulty. As a result, fly ash may be combined to make lightweight artificial coarse aggregates. This procedure is called palletization and the resultant aggregates are called fly ash aggregates. These aggregates may be made with various proportions of fly ash and cement, and the final product is lightweight.

The use of low-weight aggregates in the design and production of this type of concrete is cost-effective; the lightweight reduces the self-weight by nature. It starts with a dry mix of cement and fly ash, followed by a tiny proportion of water in a mixer to make aggregates. One of the parameters that can be compared to the weight of fly ash aggregate concrete is the weight of conventional concrete.

In most circumstances, concrete has a density of 2200 to 2600 kg/m3. When compared to fly ash aggregate concrete, which has a low self-weight, it is an uneconomical structural material due to its high self-weight. With a focus on to outstretch the appropriate density for the implementation, gravity of architectural as well as unstructured components ought to be lessened. As a result, cost savings in the design of supporting structural sections are realized, as well as the development of lightweight concrete. Lightweight concrete is concrete that has been made lighter than standard concrete by modifying the material composition or production technology. Lightweight aggregate concrete is formed by substituting light aggregate for the regular material aggregate. Though lightweight concrete cannot always replace traditional concrete in terms of strength, it does have its own set of benefits, such as reduced dead loads and therefore more cost-effective structures, greater earthquake protection, good sound absorption, and strong fire resistance.

Coal power plants produce a lot of waste fly ash, which is not only bad for the environment but also bad for your health [13, 14]. In 2016, China produced over 600 million tons of fly ash, making it the world's largest producer [15]. By the end of 2016, the waste fly ash had amassed to three billion tons. Fly ash must be kept in a concentrated or distributed manner around thermal power plants due to its poor comprehensive utilization rate, which not only takes up a lot of space but also pollutes the surrounding soil, water, and air. As a result, efficient techniques for improving onsite fly ash utilization in the construction industry must be devised. [16]. In the contemporary decennium, an enormous quantity of exploration has been executed on the utilization of adsorption in the cement concrete technology.

Fly ash is a by-product of industrial production that has aided in the resolution of several long-term building issues [17]. For example, between 2010 and 2012, its use in building applications expanded by around 55 %, and it is now regarded as a commercial commodity delivered in bulk. The positive role of fly ash as a cement substitute, on the other hand, is limited since its strength rises more slowly than cement [16]. As a result, AIJ [17] recommended that fly ash be used as a partial fine aggregate replacement. Some fly ash acts as a cementitious material and has a micro aggregate effect due to the presence of $SiO_2$, while the rest has a volcanic ash influence.

## 2. MATERIALS USED

### 2.1 FLY ASH:

Fly ash, also known as flue ash, is the most well-known and commonly utilized pozzolanic substance. It is a by-product of powdered coal-burning that's carried away by flue gases before being captured by the removal of suspended particles(such as dust and acid mists) from a gas by charging the particles and precipitating them by applying a strong electric field. [3]. Base embers is ash .which has proscription in ascending to the apex of the mass and composes at the base, When coal is burnt for heat, 80 % of the trash produced is fly ash, and 20 % is bottom ash. Fly ash has a wide variety of elements depending on the origin of the coal bed being burnt, but virtually all includes a small proportion of silicon dioxide [$SiO_2$] and calcium oxide [CaO],in addition to discover aggregate of selenium, boron, beryllium, arsenic, cadmium, chromium, cobalt, mercury, strontium, lead, thallium, manganese, molybdenum and brown lead.

There are two types of fly ash:

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

Burning rougher, older bituminous and anthracite coal produces the majority of class F fly ash. It is pozzolanic in nature, with less than 20% lime content [5]. To make cementitious compounds, fly ash cementing agents for instance quick lime, hydrated lime, or Portland cement is essential.

Burning lighter, fresher sub-bituminous coal produces the majority of Class C fly ash. Apart from its pozzolanic properties, the major feature of this fly ash is its ability to self-cement. It contains a lot of lime (more than 20 %). There is no need for an activator with this fly ash. It frequently contains a lot of calcium fly ash and has a carbon content of less than 2 %.

2.2 CEMENT:

Portland Pozzolana Cement [P.P.C.] is utilized in this project, according to IS 1489[PART1]:1991. [7].

2.3 WATER:

Portable water was used for making fly ash pellets.

## 3. TEST

3.1. SPECIFIC GRAVITY TEST:

| Weight of sample (g) | W1 (g) | W2 (g) | W3 (g) | W4 (g) | G | Average (G) |
|---|---|---|---|---|---|---|
| 100 | 648.0 | 748 | 1566.0 | 1523.0 | 1.75 | |
| 150 | 648.0 | 798 | 1588.0 | 1523.0 | 1.76 | 1.75 |
| 200 | 648.0 | 848 | 1610.0 | 1523.0 | 1.76 | |

Result: A particular aggregate sample's average specific gravity is found to be 1.75.

3.2. CRUSHING TEST:

Weight of empty mold (W1) = 14.650 kg

Weight of mold + aggregate (W2) = 17.220 kg

Weight of crushing aggregate passing through IS sieve (W3) = 1.170 kg

Crushing Value =W3/((W2-W1))X100 = 45.52%

Result: The given aggregate has a crushing value of 45.52 %.

3.3. IMPACT TEST:

Empty weight of mold (W1) = 1656.5 gm

Weight of mold + aggregate (W2) = 2056.5 gm

Weight of fines passing through 2.36 mm sieve (W3) = 131.0 gm

Impact value = W3/(W2-W1)x100 = 32.75%

Result: The impact value of a given sample of aggregate is found to be 32.75%

3.4. ABRASION TEST:

Weight of aggregate sample (W1) = 7 kg

Weight of ball = 5 kg

Number of balls = 12

Weight of aggregate that passes through 1.75 IS sieve (W2) = 46.15 gm

| SN | Sieve No (mm) | Weight retained | Ultimate weight | % Cumulative | % Fineness |
|---|---|---|---|---|---|
| 1 | 31.5 | 0.060 | 0.060 | 6 | 99.4 |
| 2 | 25 | 0.170 | 0.23 | 2.3 | 97.7 |
| 3 | 20 | 0.770 | 1 | 10 | 90 |
| 4 | 16 | 0.900 | 1.9 | 19 | 81 |
| 5 | 12.5 | 0.980 | 2.88 | 28.8 | 71.2 |
| 6 | 10 | 1.025 | 3.905 | 39.05 | 61 |
| 7 | 6.7 | 1.035 | 4.94 | 49.5 | 50.6 |
| 8 | Pan | 2.060 | 7 | 70 | 30 |

3.5. FLAKINESS TEST:

| Sr. No. | Passing through IS sieve (mm) | Retained On IS sieve (mm) | Weight retained in gm (W) | Slot size | Weight passing through specific slot in gm (W) |
|---|---|---|---|---|---|
| 1 | 40 | 25 | 0.020 | 40-25 | 4.980 |
| 2 | 25 | 20 | 0.060 | 25-20 | 4.920 |
| 3 | 20 | 16 | 0.572 | 20-16 | 4.348 |
| 4 | 16 | 12.5 | 1.828 | 16-12.5 | 2.520 |
| 5 | 12.5 | 10 | 2.512 | 12.5-10 | 0.008 |
| 6 | 10 | 6.3 | 0.008 | 10-6.3 | 0 |
| 7 | 6.3 | PAN | | | |

Result: The flakiness index of an aggregate sample was determined to be 29.80%.

## 4. PROCEDURE OF MAKING AGGREGATES

A. PREPARATION OF FLY ASH AGGREGATES:

- Fly ash and PCC grade 53 (PCC) were mixed in various quantities, including 80:20, 85:15, and 90:10.
- The fly ash and cement were dry mixed for 3 to 5 minutes in the concrete mix.
- Chemicals (Sodium Hydroxide and Sodium Silicate) were added to water in varying amounts depending on the sample.
- For example, 50 grams of each ingredient (Sodium Hydroxide and Sodium Silicate) were added to 2 liters of water to make 5 kilograms of the combination.
- A chemical solution was sprayed over the fly ash and cement mixture, then mixed into the concrete until aggregates formed.
- These aggregates were oven-dried for one day at temperatures ranging from 100 to 105 degrees Celsius.

● These aggregates were held for 7 days for curing and 1 day for sun drying after being dried in the oven.

B. SEPARATION OF FLY ASH AGGREGATE:

● Based on particle size, fly-ash aggregates were separated into fine and coarse aggregates after curing.

● Fine aggregates are those that pass through a sieve with a size of 4.75mm.

● The coarse particles that make it through the 4.75mm screen were retained.

## 5. CONCLUSION

I. The Impact value and crushing value of artificial aggregate which is obtained from test result is comparatively less than the acceptable limit.

II. Abrasion test result value is comparatively less than the acceptable limit but still it cannot be used as a highway material.

III. Artificial aggregate shows Low specific gravity than natural gravel and hence it can be used as a lightweight aggregate material also when we used artificial aggregate as a coarse aggregate in concrete it can consume large volume and therefore it can solve the problem of dumping as landfills to greater extent.

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