IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# STRENGTH CHARACTERISTICS OF CONCRETE USING MODIFIED AND ACTIVATED FLY ASH AS AN ECO FRIENDLY GREEN MATERIAL

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***Abstract***

Due to rapid modernization, the number of building is increasing day by day. One of the main components of building is concrete since a huge amount of concrete is used in the construction of the building, the concrete should be eco-friendly, durable and its strength should be high. Concrete is a composite mixture of cement, coarse aggregate, fine aggregate, and water. But cement has many adverse effects on environment as well as on health. During the manufacture of cement, for 1kg of cement, it emits 900gm of Carbon dioxide ($CO_2$). So, we found out many alternatives to cement, in that "Fly Ash" is an eco-friendly green material, which is produced by burning the coal in the electricity-producing Thermal Plant. Fly Ash in the concrete reduce the heat of hydration so the reduction of thermal crack is observed. The replacement of the cement by the Fly Ash improves the workability and pump ability of the concrete. The life of the concrete structure is estimated to be 40 years but in many research, it is found that if 35% of the cement are replaced by Fly Ash increases the life of cement structure by 120 years, but if the replacement is more in the concrete the compressive strength may decrease slightly. The cost of Fly Ash is more economical than cement. Direct disposal of Fly Ash causes environmental problem and health issues as it is a waste material. Hence considering all the research, the strength of the concrete increases using modified and activated Fly Ash in all research, the strength of the concrete increases using modified and activated Fly Ash in the correct amount.

**Keywords:** Eco-friendly, Durable, Modified, Activated, Workability.

## I. INTRODUCTION

Fly Ash is a fine solid particle of ashes, dust, and soot carried out from burning fuel (such as coal or oil) by the draft. Fly ash is a microscopically partitioned residue of thin coal combustion; it is carried by groove gases and collected by electrostatic precipitates, particularly used to make high-strength concrete and high-performance concrete. Fly ash increases strength, decreases permeability, reduces corrosion of strong steel, increases sulfate resistance, and reduces alkali-aggregate reaction.

**Fig.1: Fly Ash**

***Classes of Fly Ash:***

Two classes of Fly Ash are defined by the American Society for Testing and Materials (ASTM). Class F Fly Ash and Class C Fly Ash. The chief difference between these classes is the amount of calcium, Silica, alumina. And iron content in the ash.

- ***Class F Fly ash:***

Fly ash generally produced by burning anthracite or bituminous coal is classified as class 'F' fly ash. Commonly produced flash by burning anthracite or bituminous coal usually has less than 5% lime. This fly ash is pozzolanic and contains less than 20% lime (CaO).

- ***Class C Fly ash:***

Fly ash normally manufactured by burning lignite or sub-bituminous coal is classified as Class 'C' fly ash. It comes with pozzolanic and cementation properties. It is usually made by burning lignite or sub-bituminous coal usually contains more than 20% lime. The content of alkali and sulfate (SO4) is generally higher in Class C fly ash.

**Fly Ash Properties:**

1. Fineness
2. Specific Gravity
3. Size and shape
4. Color

**Fineness:**

According to ASTM, the beauty of fly ash is to be tested in both dry and wet seasons. The fly ash sample is sieved in a 45-µm strainer and the proportion of retaining on the 45-µm strainer is calculated. In addition, beauty is also measured by the Lechartlier method and the Blaine specification.

**Specific Gravity:**

The specific gravity of fly ash varies from a low value of 1.90 for sub- bituminous ash to a high value of 2.96 for iron-rich bituminous ash.

**Size and shape:**

Since flash is a really fine material, the particle dimension is between 10 and 100 µm. The flash is usually shaped like a circular glass.

**COLOR:**

The color of fly ash is determined by the chemical and mineral elements. The materials of lime in flash provide tan and light-weight color whereas brown color is applied by the presence of iron content material. A dark brown to black color is usuallyattributed to an enhanced un-burn material.

**Advantages of Fly Ash:**

1. The heat of hydration can be reduced by replacing cement with fly ash.
2. The amount of water is reduced for the given functionality or betterworkability at the same water content.
3. Bleeding rate decreases as work efficiency increases.
4. Superior long-time strength and durability performance.
5. Lower water content results in less shrinkage and perforation.
6. Low permeability and improved resistance to sulfate attack.

**Disadvantages of Fly Ash:**

1. It can prolong the time as concrete takes more time to set.
2. It reduces the amount of air ingress, and high concrete admixture oftenrequires more air-entraining penetration.
3. The color of concrete is more difficult to control with flyash than blendswith only Portland cement.

**Aim/scope of Project:**

1. To improve the Strength and durability of concrete.
2. To decrease environmental pollution.
3. To reduce thermal crack in the concrete.
4. To reduce the waste i.e. Fly Ash which is generated by the electricity-producing thermal plant.

## II. Materials and Methodology

Following materials were used in the experimental work:

Cement: Ordinary Portland cement (Ultra-Tech Cements of 53 grades) was used having specific gravity: 3.15, 32.5% Consistency and Compressive strength 54 MPa.

Fly ash: Fly ash is finely divided residue resulting from the combustion of pulverized coal and transported by the flue gases of boilers by pulverized coal. It was obtained from thermal power station, dried and used.

Fine Aggregate: Natural sand with maximum size of 4.75 mm was used (zone II) with specific gravity 2.6 and fineness modulus 2.63.

Coarse Aggregate: Natural aggregates with maximum size of 40 mm were used with specific gravity of 2.7 and fine modulus 7.51.

Water: Potable water of pH 6.5 is used

The concrete mix was designed for M30, M40 and M50 grade and the mix design was done as per IS 10262-1982 and IS 456-2000. Mix design for concrete was made considering the properties of constituents of concrete. Different concrete mixes with varying fly ash content percentage were produced, replacing 0% (reference concrete), 10%, 20%, 30%, 40%, 50% and 60% cement in terms of weight. Cubic specimens of 150 mm size were casted for compressive strength test. The cubes were casted in stainless steel moulds and wet cured at standard temperature until the time of test. The cubes were cured for a time period of 7, 14 and 28 days.

At first the materials which are required for the project were collected. Since Cement are replaced by the fly ash in our project, we had collected the fly ash from Mysore [Second Largest Thermal power plant of Karnataka]. We brought all most 200kg of Fly ash from the Power plant. After bringing the main ingredients i.e fly ash, we had done some basic experiment required for our project like: Specific gravity test of fly ash, fineness test of fly ash, the $P^h$ value test of water which we are using for our project, etc. Now the remaining things which we have to do are mix design, the XRD test, and SEM test. Since while replacing the cement with fly ash the concrete will lose its some main characteristics like its strength might be decrease so to balance its strength and other characteristics we have to use catalyst like [NaOH, $Ca(OH)_2$, $H_2SO_4$, $HNO_3$ etc] After adding the catalyst the cubes are cured and its XRD test are conducted , if the demand are not fulfilled then again the percentage of catalyst are increased and the procedure are

repeated again. After the XRD test the SEM test are carried out in which the sample provided are scanned with an electron beam to produce a magnified image for analysis. If all condition are fulfilled in the test then the final result are noted.

## FLOW CHART

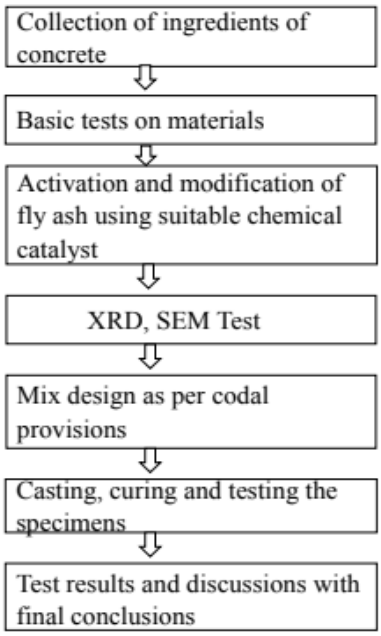


**Fig.2: Methodology**

## III. RESULTS OF TEST CONDUCTED

**PHYSICAL PROPERTIES OF FLY ASH**

| Sl. No. | Description | Test Result |
|---|---|---|
| 1 | Fineness of Fly Ash | 36.6% |
| 2 | Specific Gravity | 2.1 |

**PHYSICAL PROPERTIES OF CEMENT**

| SL. No. | Properties | Obtained values | Requirement as per IS : 8113-1989 |
|---|---|---|---|
| 1 | Fineness of Cement | 8% | <10% |
| 2 | Standard consistency | 29% | 28 to 32% |
| 3 | Specific Gravity | 3.12 | 3.1 to 3.15 |

**PHYSICAL PROPERTIES OF FINE AGGREGATE**

| Sl. NO. | Properties | Fine aggregate | Requirement as per IS: 383-1970 |
|---|---|---|---|
| 1 | Specific Gravity | 2.76 | 2.3 to 3.2 |
| 2 | Fineness Modulus | 2.8 | 2.2 to 3.2 |
| 3 | Bulking of Sand | 24% | 15 to 30% |

**PHYSICAL PROPERTIES OF LIME**

| Sl. No. | Description | Test Result |
|---|---|---|
| 1 | Bulk Density | 430 |
| 2 | Specific Gravity | 3.2 |

## IV. XRD AND SEM TEST

- X-ray diffraction analysis (XRD) is a technique used in materials science to determine the crystallographic structure of a material. XRD works by irradiating a material with incident X-rays and then measuring the intensities and scattering angles of the X-rays that leave the material.

Its application is:

a. XRD is a nondestructive technique.
b. To identify crystalline phases and orientation.
c. To determine structural properties: Lattice parameters (10-4Å), strain, grain size, expitaxy, phase composition, preferred orientation (Laue) order-disorder transformation, and thermal expansion.
d. To measure thickness of thin films and multi-layers.
e. To determine atomic arrangement.
f. Detection limits: ~3% in a two phase mixture; can be ~0.1% with synchrotron radiation.

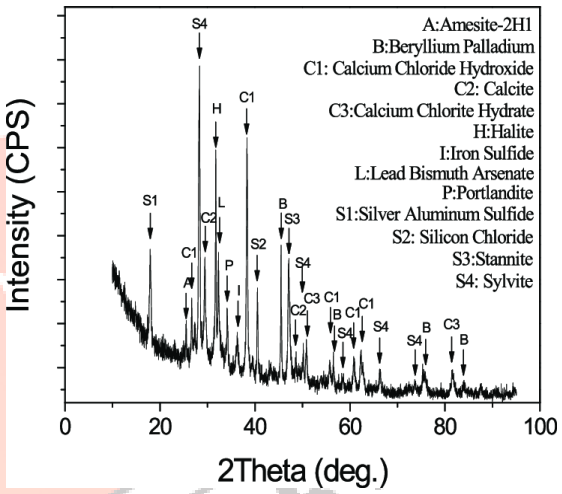


**Fig.3: XRD analysis of class Fly Ash**

- **SEM Analysis:**

A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample.

**Fig.4: SCANNING ELECTRON MICROSCOPE (SEM)**

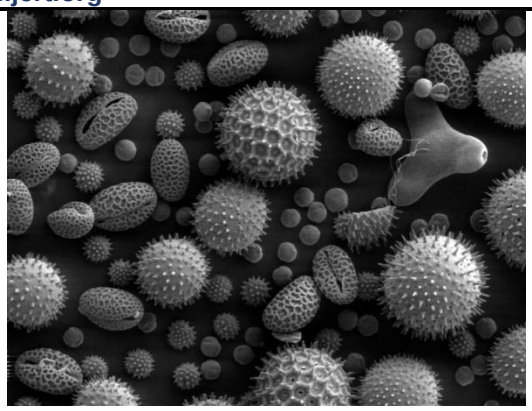

**Fig.5: SEM OUTPUT**

## V. EXPERIMENTAL ANALYSIS

**Compressive Strength test**

The cubes were casted and removed from mould cured specimen consist of activated and normal fly ash concrete. The volume of cube is 3375cm$^3$in accordance to IS Specification. The casted cubes were taken for curing and tested after 7days, and 28days and the capacity of concrete cube noted in KN i.e. Force (P) by placing on any one side of the cube. The cross sectional area (A) of cube is 225cm$^2$. The load at which the specimen fails to take the load to the cross sectional area which is subjected to the load gives the compressive strength of that particular cube. This test is carried out for M30 grade of concrete.

The formula for compressive strength can be given by,

$$F_c = (P/A)\ N/mm^2$$

| Curing Days | Compressive Strength (N/mm$^2$) |
|---|---|
| 7 days | 26.3 |
| 14 days | 36.6 |
| 28 days | 45.3 |

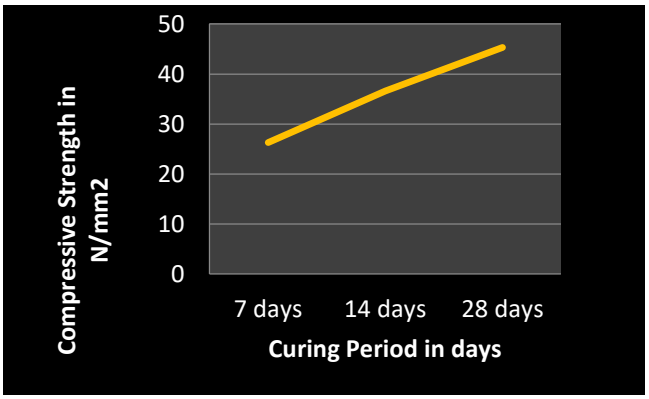


**Fig.6 Compressive strength in 7, 14 and 28 days**

## VI. CONCLUSION

1. The workability of concrete will get affected by increase in the fly ash content in concrete.
2. It is observed that the fly ash content in the concrete can be replace by a value of up to 30% and activated fly ash will give a good result up to a value of 40%.
3. There is the reduction in the strength of fly ash replaced concrete (30% fly ash) of 6.8% when compared to the normal conventional concrete.
4. But activated fly ash concrete proves to be more useful replacement when compared to conventional and fly ash replaced concrete there has been an increase of 6.16 and 12.5 % compressive strength w.r.t conventional and fly ash based counter parts.
5. 40% replacement of activated fly ash process to be optimum replacement there is a increase in strength of 7.8%.

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