Study of Fly Ash Cement Concrete Pavement

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Abstract

This experiment study is aimed to investigate the physical, chemical and mechanical properties of fly ash cement concrete for road construction. From research, it has been observed that the use of 30% of fly ash and 70% of cement possess a superior performance. Moreover, in construction, the use of fly ash would result in the reduction of the cost of materials and the reduction of greenhouse gas emission. High strength of concrete can be prepared and the incorporation of admixture or substitute to improve the properties of concrete. Test result of specimens indicates the bonding strength of properties, workability, and different reaction when the water ratio a change its content. Slump test having an appropriate workable mixing the slump of a concrete, gave sufficient compressive strength. Now a day's concrete pavements are achieving popularity for its own good paving properties, as such consumption of cement is increased to a great. As cement demand increases, production also increases. Every ton of production of cement releases approximately 7% carbon dioxide to environment. In many industries, including power plants, coal is used as fuel. This generates tones of coal ash, which is very difficult to dispose off, which in turn causes pollution. Thus the production of cement and electricity contributes huge amount of carbon dioxide emissions and coal ash causing environmental pollution. Fly ash contains reactive constituents and unreactive crystalline matter. Reactive constituents reacts with lime and offers hydrated minerals to impart strength and un reactive matter gives packing effect to the concrete, filling up of pores and thus increases the strength. Here an attempt is being made to consume this pollution causing material to a utility by using it in concrete.

Keywords- *Concrete, Fly ash, Greenhouse gas, crystalline matter and Slump test.*

I. INTRODUCTION

Electricity is important for development of any country. Coal is a major source of fuel for production of electricity in many countries in of the world. In the electricity generation process, a large quantity of fly ash gets produced and becomes available as a byproduct of coal-based power stations. Fly ash is a fine powder resulting from the combustion of powdered coal which is transported by the flue gases of the boiler and collected in the Electrostatic Precipitators (ESP). Conversion of waste into a resource material is an old practice of human society. In the year 1930, in USA, the fly ash became available in coal based thermal power station.

For its profitable utilization, scientist started research activities and R.E. Davis, in the year 1937, and his associates at university of California published research details on use of fly ash in cement concrete. This research had laid foundation for its specification, testing & usages.

Availability of power is one of the major factors responsible for economic and industrial growth of the country. In India also, coal is a major source of fuel for power generation. About 60% of power is produced using coal as fuel. Indian coal is having low calorific value (3000-3500 Kcal.) & very high ash content (30-45%) which results in the generation of huge quantity of ash in the coal based thermal power stations. During 2005-06 about 112 million tonne of ash has been generated in 125 such power stations.

II. SOURCES AND OCCURRENCE OF FLY ASH

The pulverized coal which is used by Coal-fired power plants is typically ground to fineness with 75 percent or more passing the 200 No. Sieve. Depending on the source and grade of coal, it consists of 10 to 40 percent non-combustible impurities in the form of clay, shale, quartz, feldspar, dolomite, and limestone. In the high-temperature zone of a furnace, the volatile matter and carbon are burnt, leaving the non-combustible impurities to be carried by the flue gases in the form of ash. This travels through the combustion zone where the particles become fused. As the molten ash leaves the combustion zone, it is cooled rapidly (from about 1500 °C to 200 °C), making it solidify into spherical glassy particles. While a fraction of the fused matter agglomerates and settles to form the bottom ash, a majority of it "flies" out with the flue gas

stream to be collected later as fly ash. Fly ash undergoes a sequence of processes to be separated from the flue gas. It passes through a series of mechanical separators followed by electrostatic precipitators. Fly ashes from modern thermal power plants do not require any further processing for use as a supplementary cementitious material.

III. FLY ASH FOR SUISTAINABLE DEVELOPMENT OF CONCRETE INDUSTRY

Carbon dioxide (CO2) emissions are at the highest levels in recorded history. CO2 concentrations are estimated to have increased from 315 ppm (mg/L) in 1950 to the current levels of about 390 ppm according to the National Oceanographic and Atmospheric Administration, with annual global output of over 29,000 million tons. Current rates of increase in CO2 levels are at an alarming level, and there is widespread recognition of the need for immediate actions to control irreversible and large-scale damage to humanity and the planet.

Portland cement is the most common building material worldwide. Currently, production is about 2.5 billion tons/yr. In the cement clinker manufacturing process, direct release of CO2 occurs from two sources. The first is from the decomposition of the principal raw material, calcium carbonate, amounting to about 0.53 ton of CO2/ton of clinker. The second source is from the combustion of fossil fuels amounting to about 0.37 ton of CO2/ton of clinker.

Therefore, nearly a ton of CO2 is produced for each ton of cement. Over 7 percent of the total human-produced CO2 is from the production of cement, and the potential for cement replacement with fly ash is a big step in the direction of reducing greenhouse gas emissions.

The use of fly ash reduces environmental impacts in two ways:

- It diverts coal power generation residue from landfills to beneficial use.
- It reduces the use of cement and hence cement production's impact on CO2 emissions.

Additionally, because fly ash is simply a byproduct of coal burned for electricity generation, no process energy is attributed to fly ash. According to the annual survey results published by the American Coal Ash Association (ACAA, 2009), for the year 2009 the following statistics are offered:

• 63 million tons of fly ash were produced.
• 25 million tons were used in various applications.
• 10 million tons were used in concrete and concrete products, and about 2.5 million tons were used in blended cements and raw feed for clinker.

A. Experimental Study: Working Procedure

In this experimental study works are done as following in step:-

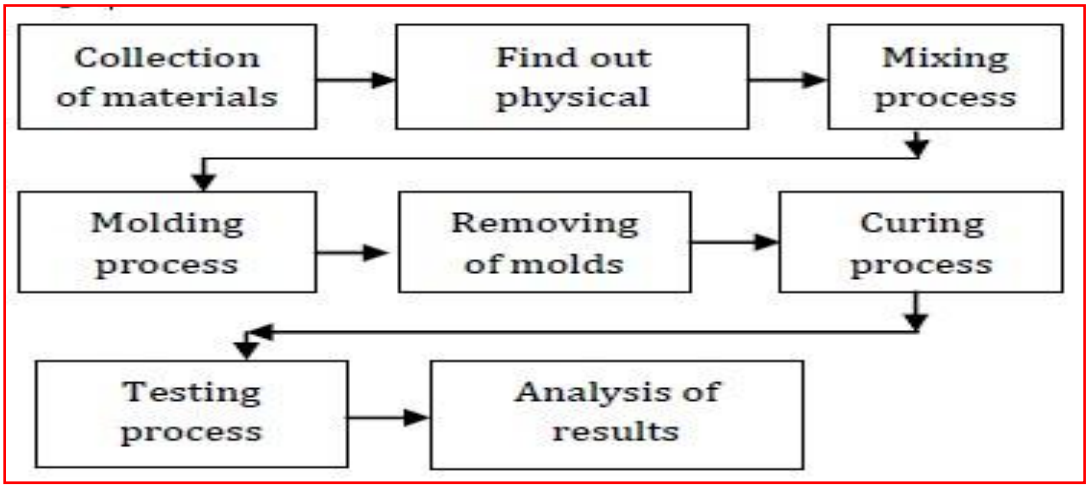

Fig 1: Block Diagram of Working Procedure

1) Collection of Materials:

For fly ash concrete, materials are collected and their physical properties also to defined by conducting experiments. Materials should be qualitive and obtained from proper place. Following materials are used for preparing of fly ash cement concrete –

- **Cement**- Ordinary Portland cement of 43 grades conforming to Indian standard IS 12269(1987) was used for the present experiments.

- **Fly Ash**-Fly Ash is obtained from thermal power plant.
- **Aggregates**- 20 mm to 4.75 mm aggregates taken as coarse aggregates and below 4.75 mm aggregates taken as fine aggregates.

2) ***Physical Property of Material:***

Physical property as color, specific gravity, initial setting time, moisture content etc., is determined by experiments.

3) ***Mixing Process:***

Materials are weighed in proper way and as required for mixing. After then, it mixed in proper way nominal mix method. For this experimental study M-20 grade of concrete was prepared, by nominal mix method. For present study concrete was mixed in 1:1.5:3 proportions and w/c ratio was kept 0.55. Cement was replaced with fly ash, fly ash added as 10 to 50% of cement weight which was used in mixing concrete. Materials are mixed as mentioned in table 1, as following:-

Table-1 Materials Mixing Proportions

Fly Ash Content (%)	Fly Ash (Kg)	Cement (Kg)	Sand (Kg)	Aggregates (Kg)
0%	0.000	7.500	11.250	22.500
10%	0.750	6.750	11.250	22.500
20%	1.500	6.000	11.250	22.500
30%	2.250	5.250	11.250	22.500
40%	3.000	4.500	11.250	22.500
50%	3.750	3.750	11.250	22.500

4) ***Molding Process:***

Concrete mixer molded in cube sized 150*150*150 mm3. Totally, 6 cubes were molded, in which 3 cubes tested after 7 days and rest 3 cubes tested after 28 days. Concrete is mixed by hand and thoroughly mixed and the concrete placed in cubes with the minimum delay. It was well compacted by rodding, temping and vibrating to remove all air voids after placing.

5) ***Removing Of Mold:***

After 24 hours molds were removed. After demolding, each cube was marked with a legible identification on the top or bottom using a waterproof marker.

6) ***Curing Process:***

Concrete cubes were cured normally in fresh water for 7 to 28 days at room temperature. Curing plays an important role in gaining of strength of concrete. If concrete cube not properly cured then it will not gain enough strength and on other hand if concrete cubes cured for more time then also its strength decrease. Curing process in concrete increases strength and decrease permeability.

7) ***Testing Process:***

After removing of mould, concrete cubes are tested in laboratory. Various tastes were done. For find physical property of material, specific gravity of cement, initial setting time, moisture content and standard consistency was determined, to check workability of concrete slump test was conducted, and for strength of concrete compressive strength was conducted by compressive strength testing machine.

8) ***Analysis and Test Results :***

Table-2:- Following Tests are Conducted on Materials and Concrete:

1.	Physical Property Of Cement 1. Specific Gravity 2. Moisture Content 3. Initial Setting Time 4. Fineness Modulus	 3.15 33 P 40-45 Minutes 8%
2.	Properties Of Fly Ash 1. Specific Gravity 2. Moisture Content	2.27 19.48%
3.	Properties Of Fine – aggregates 1. Standard Consistency 2. Moisture Content	 2.70 8.86%

Table -3: Standard Consistency of Fly Ash and Cement Mix

Content	Weight Of Cement (grams)	Weight Of Fly Ash (grams)	Consistency (%) P
0%	400	0	33.0
10%	360	40	32.0
20%	320	80	32.0
30%	280	120	31.0
40%	240	160	30.0
50%	200	200	30.0

Table -4: Initial Setting Time of Fly Ash and Cement Mix

Content	Weight Of Cement (grams)	Weight Of Fly Ash (grams)	Initial Setting Time (minutes)
0%	400	0	45
10%	360	40	50
20%	320	80	56
30%	280	120	65
40%	240	160	75
50%	200	200	90

Table -6: Compressive Strength of Concrete

Concrete grade	Sample Content	Compressive Strength (7 days N/mm^2)	Compressive Strength (28days N/mm^2)
M 20	0% (only concrete)	27.00	35.92
	10% Fly Ash	22.77	35.68
	20% Fly Ash	19.23	31.17
	30% Fly Ash	18.10	26.03
	40% Fly Ash	16.96	25.82
	50% Fly Ash	8.726	18.24

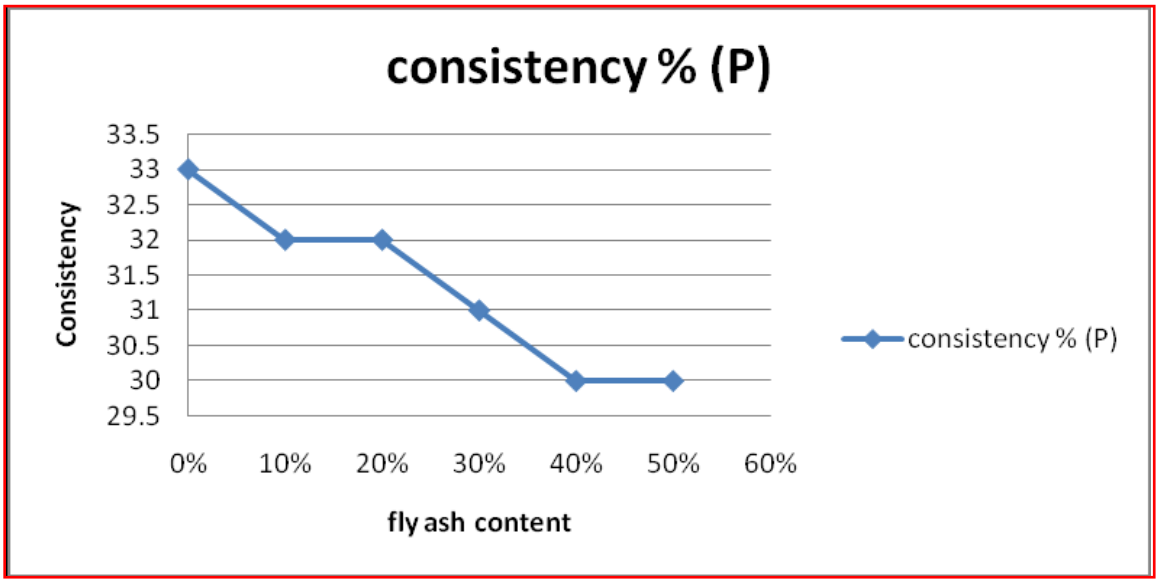

Fig. 2: Standard Consistency Of Cement And Fly Ash Mix

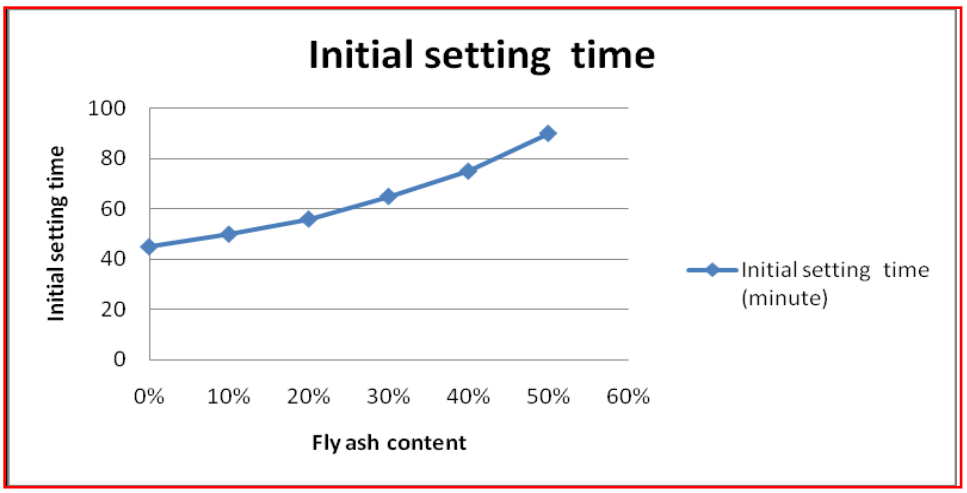

Fig. 3: Standard Consistency of Cement and Fly Ash Mix

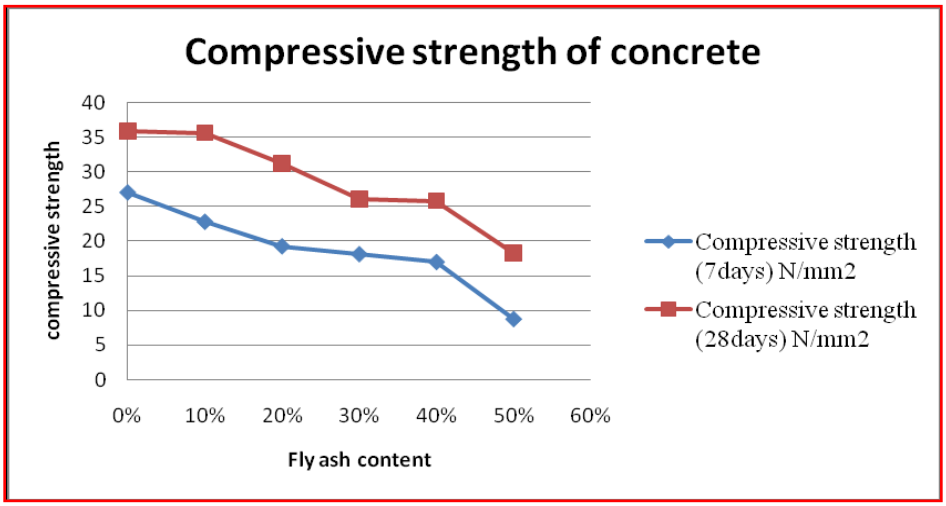

Fig.4: Compressive Strength of Concrete

TEST RESULTS:

- Thus, by results we can see as amount of fly ash is increased, consistency decreased. And as amount of fly ash is increased in mix, it requires less water as compare to cement.
- Thus by result it can also be seen that as amount of fly ash increased in cement, initial setting time also increased and it take more time to settle.
- It can also be seen that as amount of fly ash increased compressive strength decreased, up to 30-40% is safe to use in concrete mix and 50% fly ash cement concrete has not enough compressive strength to use for construction.

IV. OBJECTIVES AND SCOPE OF STUDY

The most important benefit is reduced permeability to water and aggressive chemicals. Properly cured concrete made with fly ash creates a denser product because the size of the pores is reduced. This increases strength and reduces permeability

A. Objective of This Study-

To tests and analysis on fly ash concrete prepared by fly ash optimum replacement with cement. 28 days compressive strength of fly ash concrete is to be checked.

B. Scope of work-

Following procedure to be done for this work-

- Experimental study is to be conducted on material to find out physical properties.
- Materials are to be mixed in proper proportion and molded in a cube,
- In this study, normal grade of cement have to be taken, and prepare fly ash concrete by mixing fly ash with maximum replacement of cement. Various specimen mixing proportion of cement and fly ash

prepared, replacement of cement by weight 0%, 10%, 20%, 30%, 40% and 50% by fly ash.

- These various specimens of fly ash cement concrete are to be tested and normal 28 days compressive strength is to be checked.
- Analyzing tests result.

V. ADVANTAGES OF FLY ASH IN CONCRETE

The advantages of using fly ash in concrete include the following

- Fly ash in the concrete mix efficiently replaces Portland cement that in turn can aid in making big savings in concrete material prices.
- It is also an environmentally-friendly solution, which meets the performance specifications. It can also contribute to LEED points.
- It improves the strength over time and thus, it offers greater strength to the building.
- Increased density and also the long-term strengthening action of flash that ties up with free lime and thus, results in lower bleed channels and also decreases the permeability.
- The reduced permeability of concrete by using fly ash, also aids to keep aggressive composites on the surface where the damaging action is reduced. It is also highly resistant to attack by mild acid, water and sulfate.
- It effectively combines with alkalis from cement, which thereby prevents the destructive expansion.
- It is also helpful in reducing the heat of hydration. The pozzolanic reaction in between lime and fly ash will significantly generate less heat and thus, prevents thermal cracking.
- It chemically and effectively binds salts and free lime, which can create efflorescence. The lower permeability of fly ash concrete can efficiently reduce the effects of efflorescence.

VI. SUMMARY

Fly ash is the finely divided spherical residue resulting from the combustion of ground or pulverized coal. Fly ashes are generally heterogeneous and consist of a mixture of glassy particles with various crystalline phases such as quartz, mullite, and oxides of iron. The chemical composition of fly ash chiefly includes CaO, SiO2, Al2O3, and Fe2O3. There are traces of several other chemicals. The chemical properties depend mostly on the source of the coal burnt to form the fly ash. ASTM C 618 uses two main classes to define fly ashes, Class C and Class F, based on the total amount of SiO2, Al2O3, and Fe2O3. There is also a requirement on the amount of unburnt carbon. An additional class of fly ash, defined by ASTM C 618 as Class N, represents raw or calcined natural pozzolans.

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