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# Partial Replacement of Cement by Fly Ash and Titanium Dioxide ($TiO_2$) in Concrete

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**Abstract -** *This study is mainly aimed to increase the compressive strength of concrete by partially replacing cement with fly ash and titanium dioxide. Cementitious concrete has great practical difficulties in achieving high compressive strength and durability of high performance structures. But it becomes a challenge to increase the compressive strength and durability of particular cementitious composite and also maintaining basic desirable properties of concrete. This project addresses these problems by the addition of fly ash and titanium dioxide. The use of fly ash as concrete admixtures not only extends technical advantages to the properties of concrete but also contributes to the environmental pollution control. Extensive research has been done all over the world on the benefits that could be accued in the utilization of fly ash as a supplementary cementitious material. High volume fly ash concrete is a subject of current interest all over the world. The main aim of this study is to analyse the compressive strength of concrete by partially replacing cement by fly ash and titanium dioxide ($TiO_2$) in concrete. In this study, we use $TiO_2$ of size 15 nanometer. An experimental study has been carried out by replacing cement with Nano titanium dioxide and fly ash in the proportions of 3% ,5% and 7% (by weight of cement).The mix design used in this study was M25 and the mix proportion of M25 concrete was arrived by using IS 10262:2009 and IS 456:2000.The cube specimens were casted, cured and tested after 7 days and 28 days to find out the compressive strength of cube specimens.*

***Key Words***: *Cementitious concrete, Fly Ash, Titanium Dioxide, Admixtures, High volume Fly Ash.*

## 1. INTRODUCTION

Concrete is a mixture of cement, fine aggregate, coarse aggregate, water and admixture. Admixture is basically added to improve the workability of concrete. Cement acts as a binding material in concrete. A cement is a substance that sets, hardens and adheres to other materials .Cement is used with sand to produce mortar for masonry. Cement used in construction is usually inorganic.

### 1.1 Concrete

Concrete is a composite material that is composed of fine and coarse aggregate bonded together with cement paste that hardens over time. Most concretes used are lime-based concretes or concretes made with other hydraulic cements. Asphalt concrete is the concrete which is frequently used for road surfaces. In asphalt concrete the cement material is bitumen and sometimes polymer concretes are used where the polymer is a cementing material.

### 1.2 Fly Ash

Fly Ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gas and collected by electrostatic precipitator. In U.K. it is referred as pulverized fuel ash. Fly ash is the most widely used pozzolanic material all over the world. Fly ash was first used in large scale in the construction of Hungry Horse dam in America in the approximate amount of 30 per cent by weight of cement. Later on it was used in Canyon and Ferry dams etc. In India, Fly ash was used in Rihand dam construction replacing cement up to 15 per cent.

In the recent time, the importance and use of fly ash in concrete has grown so much that it has almost become a common ingredient in concrete, particularly for making high strength and high performance concrete. There are two ways that the fly ash can be used: one way is to integrand certain percentage of fly ash with cement clinker at the factory to produce Portland pozzolana cement and the second way is to use the fly ash as an admixture at the time of making concrete at the site of work. The latter method gives freedom and flexibility to the user regarding the percentage addition of fly ash.

### 1.3 Titanium Dioxide

Titanium dioxide is the naturally occurring oxide of titanium. Its chemical formula is $TiO_2$. Titanium dioxide occurs in nature as the well known minerals rutile, anatase and brookite. Titanium dioxide is mainly sourced from ilmenite ore. It is the most widespread form of titanium dioxide-bearing ore all around the world. Titanium dioxide basically improves the strength and permeability of concrete by filling up the minute voids and pores in the microstructure.

### 1.4 Aim of present study

The main aim of this research work is to basically increase the compressive strength of concrete cubes by partially replacing cement by titanium dioxide and fly ash. Infrastructure required today are progressively increasing day by day, for which we require alternate material availability. Our research is basically aimed to enhance the quality of concrete.

## 2. Experimental Program

### 2.1 General

In the present study an experimental program was carried out to test various cube specimens of cement concrete to determine various properties coarse aggregate, fine aggregate, cement, fly ash and titanium dioxide. The simple step by step procedure of our project is as follows:

1) Firstly the mix design of the selected grade M25 of concrete was done using the Indian Standards.

2) Then according to the design batching of the materials was done.

3) The materials were weighed on the weighing machine.

4) One by one they were added in the machine mixer and were mixed properly.

5) After mixing, the concrete is then collected and is poured in slump cone apparatus for testing the slump value.

6) The concrete cube was then poured into cube of 15cm*15cm*15cm dimension.

7) The cube moulds were placed on the vibrator machine which helps in filling the air gaps. Then the concrete is allowed to set for few days.

8) The moulds are then removed and the blocks were placed in the water tank for curing.

9) Finally the compressive strength of the blocks were checked using compression testing machine i.e. at 7 days & 28 days respectively.

### 2.2 Materials

#### 2.2.1 Ordinary Portland Cement

Ordinary Portland Cement (OPC) of 43 grade conforming to IS 8112:1989 is used throughout this investigation. This cement is by far the most important type of cement. The OPC is classified into 3 grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of cement at 28 days when tested as per IS 4031-1988.

**Table 1- Properties of cement**

| Description | Numerical Values |
|---|---|
| Grade | 43 |
| Fineness(retained on 90 micron sieve) in % | 1.17 |
| Initial Setting Time (minutes) | 90 |
| Final Setting Time (minutes) | 540 |
| Specific Gravity | 3.15 |

#### 2.2.2 Fly Ash

Fly ash is generally taken from the chimneys of coal fired power plants. Ash is produced when pulverized coal at a fraction of about 70% with a grain size of greater than 75 micron is injected into the furnace with preheated air and rapid combustion occurs. In the present experimental work, low calcium class F dry fly ash obtained from Nagada Power Plant, Madhya Pradesh was used. The specific gravity and fineness modulus are 2.82 & 1.38 respectively.

#### 2.2.3 Aggregates

Aggregates can be classified on the basis of the size of the size of the aggregates as coarse aggregate and fine aggregate. The aggregates that pass through 4.75mm sieve are known as fine aggregates and the aggregates that are retained on 4.75mm sieve are known as coarse aggregates.

### 2.3 Mix Design of M25 Grade Concrete

We did mix design of M25 grade concrete and got the following result:

Obtained ratio = 1:1.20:2.17

We casted 6 cubes of normal proportions with no partial replacement of cement, 6 cubes with 3% partial replacement of cement, 6 cubes with 5% partial replacement of cement & 6 cubes with 7% partial replacement of cement. We tested 3 sets of each varieties of cubes in 7 days and remaining 3 sets of cubes in 28 days. We named normally casted cubes as K series cubes, cubes with 3% partial replacement of cement as A series cubes, cubes with 5% partial replacement of cement as D series cubes & cubes with 7% partial replacement of cement as R series cubes.

## 3. Results

The following results were obtained after the completion our research work:

1) The 7 day average compressive strength of K series cubes was found out to be 18.21 N/mm$^2$.

2) The 7 day average compressive strength of A series cubes was found out to be 19.40 N/mm$^2$.

3) The 7 day average compressive strength of D series cubes was found out to be 20.30 N/mm$^2$.

4) The 7 day average compressive strength of R series cubes was found out to be 21.60 N/mm$^2$.

5) The 28 days average compressive strength of K series cubes was found out to be 26.72 N/mm$^2$.

6) The 28 days average compressive strength of A series cubes was found out to be 27.24 N/mm$^2$.

7) The 28 days average compressive strength of K series cubes was found out to be 28.18 N/mm$^2$.

8) The 28 days average compressive strength of K series cubes was found out to be 30.04 N/mm$^2$.

9) The 7 day compressive strength of A series ( 3% fly ash and titanium dioxide) cubes was found out to increase by 6.53% as compared to that of K series cubes ( no replacement of cement).

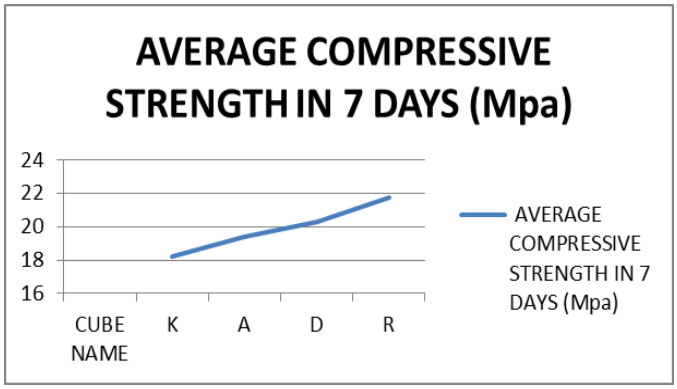
10) The 7 day compressive strength of D series ( 5% fly ash and titanium dioxide) cubes was found out to increase by 11.47% as compared to that of K series cubes ( no replacement of cement).

11) The 7 day compressive strength of R series ( 7% fly ash and titanium dioxide) cubes was found out to increase by 18.62% as compared to that of K series cubes ( no replacement of cement).

12) The 28 days compressive strength of A series ( 3% fly ash and titanium dioxide) cubes was found out to increase by 1.95% as compared to that of K series cubes ( no replacement of cement).

13) The 28 days compressive strength of D series ( 5% fly ash and titanium dioxide) cubes was found out to increase by 5.46% as compared to that of K series cubes ( no replacement of cement).

14) The 28 days compressive strength of R series ( 7% fly ash and titanium dioxide) cubes was found out to increase by 12.42% as compared to that of K series cubes ( no replacement of cement).




**Graph 1- Graphical comparison in 7 days**

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