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# Experimental Study On Pollution Control Concrete

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**Abstract:** ***Our study involves experimental investigation of concrete by replacement of cement with $TIO_2$ and charcoal powder. Now-a-days $CO_2$ emission is greater in the atmosphere, it creates harmful effects. The manufacturing of cement process emits large amount of $CO_2$. Due to this reason we decided to reduce cement content up to 35% by adding the mineral admixtures like $TIO_2$ and Charcoal powder. We use $M_{30}$ grade of concrete. It is the result of cutting, drilling wood. It is composed of fine particles of wood, certain animals, birds and insects which live in wood such as carpenter are also responsible for producing the wooden dust. In this paper main objective is to study the partial replacement of the charcoal powder and titanium dioxide with the varying proportion in the concrete and to check the different properties of the concrete by comparing with the normal concrete. The replacement of cement with certain charcoal powder and $Tio_2$in concrete that makes the structure more light in weight. The workability, strength and test are studied in this paper. The most important properties of concrete is the compressive strength. Also, increasing the charcoal powder in corporation caused decreases in unit weights and compressive strength values of mortars with a parallel increase in water absorption values at all ages. The replacement of cement with charcoal powder and $Tio_2$gives the properties and all the benefits in the actual production of concrete.***

## 1. INTRODUCTION

In many countries sources of natural sand for use as an aggregate in construction are becoming scarce as sand pits are exhausted and environmental legislation prevents dredging. This is driving the need to source alternative aggregates, such as those from construction and demolition waste. One possible source of construction aggregate is sand that has been manufactured from the surplus material (crusher dust) that results when coarse aggregate is produced in hard rock quarries. Coarse aggregate production typically yields 25% to 45% crusher dust depending on the parent rock, crushing equipment and crushing conditions. Concrete batching plants must be located in an area where they will not pose a hazard to the environment or the amenity of the local community. Highly alkaline wastewater, dust emissions and noise are the key potential impacts associated with concrete batching plants. These problems need to be considered when planning new operations and major upgrades of existing sites. Plants should be located so that contaminated storm water and process wastewater can be retained on-site.

Potential pollutants in batching plant wastewater include cement, sand, aggregate sand petroleum products. These substances can adversely affect the environment by:

- Increasing soil and water pH
- Increasing the turbidity of waterways (turbidity is a measure of the cloudiness of a suspension).
- Increased turbidity results in less light entering an aquatic environment. This in turn affects the rate of photosynthesis by plants, and reduces the visibility of aquatic organisms. Turbidity can also clog fish gills, smother bottom feeding flora and fauna and generally decrease the amenity of an area.

## 2. METHODOLOGY

Figure 1. Shows the methodology adopted in this study

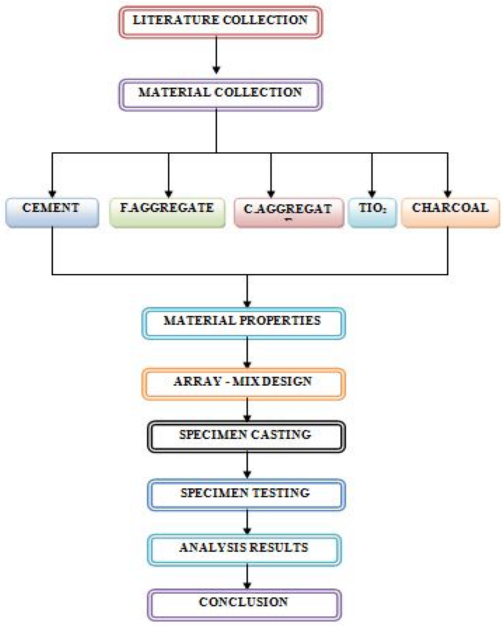


**Figure 1** Methodology

## 3. MATERIAL COLLECTION

### 3.1 Cement

Ordinary Portland cement was chosen so that the influence of Tuticorin thermal power plant fly ash could be studied without any other intervention. The 53 grade ordinary portland cement was chosen because of its greater fineness which would have effective hydration and also secondary hydration. The properties of cement during hydration vary according to:

- Chemical composition
- Degree of fineness

It is possible to manufacture different types of cement by changing the percentages of their raw materials. The raw materials used in the manufacture of Portland cement consist mainly of lime, silica, alumina and iron oxide. The oxides account for over 90% of the cement. The oxide composition of (ordinary) Portland cement.

### 3.2 Use of Aggregate

- Reduce the cost of the concrete – 1/4 - 1/8 of the cement price.
- Reduce thermal cracking – 100 kg of OPC produces about 12$^{o}$C temperature rise.
- Reduces shrinkage – 10% reduction in aggregate volume can double shrinkage.
- High aggregate : cement ratio (A/C) desirable
- A/C mainly influenced by cement content
- Imparts unit weight to concrete

### 3.3 Fine Aggregate

Aggregates generally occupy 65- 80% of a concrete's volume. Aggregates are inert fillers floating in the cement paste matrix for concretes of low strength. The strength of aggregates do not contribute to the strength of concrete for low strength concrete. The characteristics of aggregates impact performance of fresh and hardened concrete.

#### 3.3.1 Absorption, Porosity, and Permeability

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption relates to the particle's ability to take in a liquid.

Porosity is a ratio of the volume of the pores to the total volume of the particle. Permeability refers to the particle's ability to allow liquids to pass through. If the rock pores are not connected, a rock may have high porosity and low permeability.

### 3.4 Coarse Aggregate

#### 3.4.1 Aggregate Classification

- Size :- Coarse Aggregates & Fine Aggregates.
- Specific Gravity:- Light Weight, Normal Weight And Heavy Weight Aggregates.
- Availability :-Natural Gravel and Crushed Aggregates.
- Shape :- Round, Cubical, Angular, Elongated and Flaky Aggregates.
- Texture :- Smooth, Granular, Crystalline, Honey combed and Porous.

Conventional Coarse Aggregate from an established quarry was used. The coarse aggregates used were of size 20 mm and 10 mm. Demolished concrete from an old building at Diamond Park, Visakhapatnam was the source for recycled coarse aggregate. The grade of source concrete was M15 and was with coarse aggregate of basalt origin with 20mm down size. Demolished concrete was transported to Strength of Materials lab of Civil Engineering Department where it was broken manually. Broken aggregates were sieved through standard sieves to obtain the aggregates of 20 mm and 10 mm size. Utmost care has been taken to minimize the adhered mortar to the aggregates. No specimens from testing laboratory of S.M lab were used as concrete made with aggregates obtained from such specimens yield aggregates with high content of adhered mortar. The percentage usage of coarse aggregates in the production of concrete was 60%, 40% for 20 mm and 10 mm respectively.

### 3.5 Water

The water used for experiments was potable water. Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. It should be free from organic matter and the pH value should be between 6 to 7.

### 3.6 Titanium Dioxide

Titanium dioxide (TiO2) is a white solid inorganic substance that is thermally stable, non-flammable, poorly soluble.TiO2, the oxide of the metal titanium, occurs naturally in several kinds of rock and mineral sands. Titanium is the ninth most common element in the earth's crust. TiO2 is typically thought of as being chemically inert. The light passes through the crystal slowly and its path is substantially altered compared to air. If you have many small particles orientated in different directions, a high refractive index will lead to the scattering of light as not much light passes through. In lenses, high refractive index means high clarity and high polarising power. Titanium dioxide has a higher refractive index than diamond and there are only a few other substances that have a higher refractive index. Cinnabar (mercury sulphide) is an example. Historically, cinnabar was used as a red pigment. Figure 2 shows the titanium dioxide of the study.

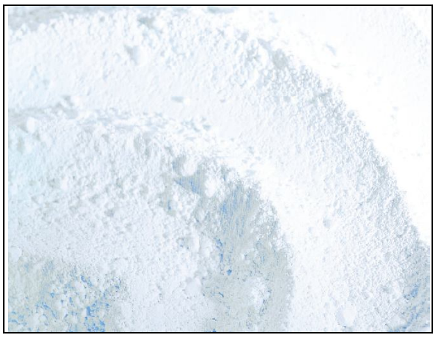

**Figure 2** Titanium dioxide

**3.7 Charcoal**

Charcoal is a highly porous and brittle material which properties are determined by the condition of the carbonization process and used raw materials. Nowadays it plays an important role in people' lives, but nobody has fully understood the mechanism by which charcoal works, from either a physical or chemical standpoint. Depending on the way of preparation charcoal is found in either lump, briquette, or extruded forms. It should be added that it is a common misconception to think that some kind of charcoal burns hotter or longer. Figure 3 shows the charcoal of the study.

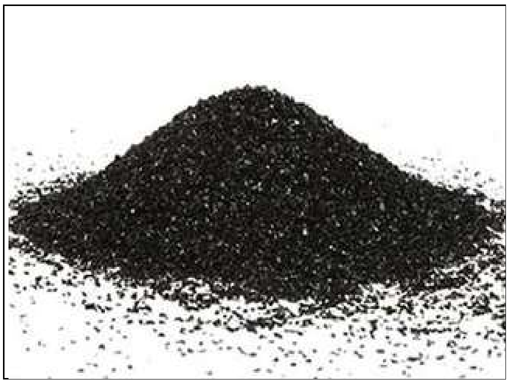

**Figure 3** Charcoal

## 4. MATERIAL PROPERTIES

**4.1 Cement**

The ordinary portland cement which conforms to IS 12269 –1987was used for making concrete.

**4.1.1 Hydration of Cement**

The raw material used in the manufacture of Portland cement consists of lime, silica, alumina and iron oxide. These compounds interact with one another in the kiln to form a series of more complex products. The relative proportions of these compounds are responsible for influencing the various properties of cement.

Four compounds are usually regarded as the major constituents of cement. They are tricalcium silicate, dicalcium silicate tricalcium aluminate and tetra calcium alumino ferrite. Anhydrous cement does not bind the fine and coarse aggregate. It acquires cohesive and adhesive property only when water is mixed with it. The chemical reaction that takes place between cement and water is referred as hydration of cement. When Portland cement is mixed with water, its constituent compounds undergo a series of chemical reactions that are responsible for the eventual hardening of concrete. Reactions with water are designated as hydration, and the new solids formed on hydration are collectively referred to as hydration products. This involves the replacement of water that separates individual cement grains in the fluid paste with solid hydration products that form a continuous matrix and bind. The calcium silicates provide most of the strength developed by Portland cement. C3S provides most of the early strength (in the first three to four weeks) and both C3S and C2S contribute equally to ultimate strength.

**4.2 Fine Aggregate**

The material which passes through 4.75 mm sieve is termed as fine aggregates Gate. The sand used for the experimental works is locally procured from Patiala and conformed to grading zone II. The sieve analysis and physical properties of fine aggregates are listed.

**4.2.1 Absorption, Porosity, and Permeability**

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption relates to the particle's ability to take in a liquid.

Porosity is a ratio of the volume of the pores to the total volume of the particle. Permeability refers to the particle's ability to allow liquids to pass through. If the rock pores are not connected, a rock may have high porosity and low permeability.

**4.2.2 Surface Texture**

Surface texture is the pattern and the relative roughness or smoothness of the aggregate particle. Surface texture plays a big role in developing the bond between an aggregate particle and a cementing material. A rough surface texture gives the cementing material something to grip, producing a stronger bond, and thus creating a stronger hot mix asphalt or Portland cement concrete. Surface texture also affects the workability of hot mix asphalt, the asphalt requirements of hot mix asphalt, and the water requirements of Portland cement concrete. Some aggregates may initially have good surface texture, but may polish smooth later under traffic. These aggregates are unacceptable for final wearing surfaces. Limestone usually falls into this category.

**4.2.3 Hardness**

The hardness of the minerals that make up the aggregate particles and the firmness with which the individual grains are cemented or interlocked control the resistance of the aggregate to abrasion and degradation. Soft aggregate particles are composed of minerals with a low degree of hardness.

### 4.3 Coarse Aggregates

Aggregates were first considered to simply be filler for concrete to reduce the amount of cement required. However, it is now known that the type of Aggregate used for concrete can have considerable effects on the plastic and hardened state properties of concrete. Aggregates can form up to 80% of the concrete mix so their properties are crucial to the properties of the concrete. Aggregates can be broadly classified into four different categories, they are heavy weight, normal weight, light weight and ultra-light weight aggregates. However, in most concrete practices only normal weight and light weight aggregates are used. The other types of aggregates are for specialist uses, such as nuclear radiation shielding for heavy weight concrete and thermal insulation for light weight concrete.

To ensure a consistent quality and grading so that alterations were not required for the mix, enough manufactured sand to complete all of the mixes was sourced at the beginning of the testing phase. The manufactured sand used came from Wagner'sMalloo quarry, where the manufactured sand is produced from the by-product of blue metal crushing operations. Due to the increased surface area of the fines, increased amounts of water and cement will be required to achieve target workability's and strengths. The irregular particle shape also has a negative impact on the workability of the concrete due to the increased number of voids created in the concrete. Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

#### 4.3.1 Water Absorption

100g of nominal coarse aggregate was taken and their weight was determined, say W1. The sample was then immersed in water for 24 hours. It was then taken out, drained and its weight was determined, says W2. The difference between W1 and W2 gives the water absorption of the sample.

#### 4.3.2 Fineness Modulus

The sample was brought to an air-dry condition by drying at room temperature. The required quantity of the sample was taken (3Kg). Sieving was done for 10 minutes.

#### 4.3.3 Aggregate Crushing Value

This test helps to determine the aggregate crushing value of coarse aggregates as per IS: 2386 (Part IV) – 1963. The apparatus used is cylindrical measure and plunger, Compression testing machine, IS Sieves of sizes – 12.5mm, 10mm and 2.36mm.

#### 4.3.4 Procedure to Determine Aggregate Crushing Value

- The aggregates passing through 12.5mm and retained on 10mm IS Sieve are oven-dried at a temperature of 100 to 110oC for 3 to 4hrs.
- The cylinder of the apparatus is filled in 3 layers, each layer tamped with 25 strokes of a tamping rod.
- The weight of aggregates is measured (Weight 'A').
- The surface of the aggregates is then levelled, and the plunger inserted. The apparatus is then placed in the compression testing machine and loaded at a uniform rate to achieve 40t load in 10 minutes. After this, the load is released.
- The sample is then sieved through a 2.36mm IS Sieve and the fraction passing through the sieve is weighed (Weight 'B').
- Two tests should be conducted.

**Aggregate crushing value = (B/A) x 100%.**

### 4.4 Charcoal

#### 4.4.1 Charcoal's Physical Characteristics

Charcoal is a highly porous and brittle material which properties are determined by the condition of the carbonization process and used raw materials. Nowadays it plays an important role in people' lives, but nobody has fully understood the mechanism by which charcoal works, from either a physical or chemical standpoint. Depending on the way of preparation charcoal is found in either lump, briquette, or extruded forms. It should be added that it is a common misconception to think that some kind of charcoal burns hotter or longer.

The most basic physical characteristic of charcoal, its particle size, has a great influence on its adsorption properties. Thus, the ability of charcoal to retain soil water is widely attributed to its porosity. This expanded surface is due to the fact that charcoal particles have thousands of crevices, pits, grooves, and holes which, when opened out, make quite a large surface area. In fact, the surface area per gram of material can range from 500 to 1400 square meters, and values as high as 2500 m2/g have been reported. The complex internal surface area is usually divided into three components. Channels and pores with diameters less than 2 nm (micropores) generally contain the largest portion of the carbon's surface area; pores with diameters between 2 and 50 nm are known as mesopores, and pores with diameters greater than 50 nm are defined as macropores. Charcoal porosity varies primarily as a function of feedstock and secondarily as a function of pyrolysis conditions.

#### 4.4.2 Charcoal's Chemical Characteristics

Charcoal is mostly pure carbon, made by cooking wood with low oxygen. The process can take days and burns off volatile compounds such as water, methane, hydrogen, and tar, and leaves about 25% of black lumps and powder of the original weight. The quality of charcoal is defined by various chemical characteristics, although properties are interrelated, but they are measured and appraised separately. Most of the specifications that control charcoal quality have originated in the steel or chemical industry. Regarding quality of charcoal, better chemical properties of charcoal are reached with higher levels of fixed carbon and lower levels of ash and volatiles. It is associated with high levels of lignin and low levels of holo celluloses and extractives in wood.

*4.4.3 Adsorption Capacity*

Wood charcoal is an important raw material for activated charcoal. This product is beyond the scope of this manual but some data could be useful where charcoal producers are selling charcoal to be turned into activated charcoal by specialist factories.As produced, normal wood charcoal is not a very active adsorption material for either liquids or vapours because its fine structure is blocked by tarry residues. To convert the charcoal to "activated" this structure must be opened up by removing the tarry residues. The most widely used method today consists in heating the pulverised raw charcoal in a furnace to low red heat in an atmosphere of superheated steam. The steam prevents the charcoal from burning away by excluding oxygen.

### 4.5 Titanium Dioxide

#### 4.5.1 Uses for White Pigment

Four million tons of pigmentary TiO2 are consumed annually. Apart from producing a white colour in liquids, paste or as coating on solids, TiO2 is also an effective opacifier, making substances more opaque. Here are some examples of the extensive range of applications:

- Paints
- Plastics
- Papers
- Inks
- Medicines
- Most toothpastes
- Skimmed milk

Adding TiO2 to skimmed milk makes it appear brighter, more opaque and more palatable. Titanium dioxide can be added to the surface of cements, tiles and paints to give the material sterilising, deodorising and anti-fouling properties. This is because the photo catalytic properties of$TiO_2$ mean that, in the presence of water, hydroxyl free radicals are formed which can convert organic molecules to CO2 and water and destroy microorganisms.

Pigment grade TiO2 is manufactured in order to maximise the number of primary particles in this size range (approx. 200 – 350 nm). However as in all production processes of particulate materials, there will be a distribution of primary particle sizes around the average value and it is likely that a small fraction of the primary particles are < 100 nm, and therefore covered by the nanoparticle ISO definition (ISO/TC 229 Nomenclature system for nanoparticles). In practice, all these particles tend to agglomerate into the micron (μm) size range.TiO2 as a nanomaterial is engineered to have primary particles less than 100 nm in order to optimize such properties.

## 5. MIX DESIGN

**Design Stipulations**

- Grade Designation - M-30
- Type of cement - O.P.C-53grade
- Fine Aggregate - Zone-I
- Sp. Gravity Cement - 3.14
- Sp. Gravity Fine Aggregate - 2.6
- Sp. Gravity Coarse Aggregate - 2.68

**Mix Proportion**

Table 1 shows mix proportion of the study

**Table 1:** Mix proportion

| Cement (kg)/m³ | FA (kg)/m³ | CA (kg)/m³ | Water (liter) /m³ |
|---|---|---|---|
| 531.43 | 582.779 | 1045.07 | 186 |

## 6. TEST PROCEDURE

The study was conducted to find out the influence of charcoal on strength properties of plain concrete. The effects of following parameters were studied. Compressive strength, Split tensile strength and flexural strength at various percentage replacement of fine aggregate with charcoal on some of plain concrete.

### 6.1 Workability

The dosage of super plasticizer was kept constant throughout the experimental program at 0.5% of the weight of the binder.

### 6.2 Segregation and Bleeding

Furnace slag reduces bleeding significantly because the free water is consumed in wetting of the large surface area of the furnace slag and hence the free water left in the mix for bleeding also decreases. Furnace slag also blocks the pores in the fresh concrete so water within the concrete is not allowed to come to the surface.

### 6.3 Compressive Strength Test Setup

By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a 37 compressive test. The apparatus used for this experiment is the same as that used in a tensile test. However, rather than applying a uniaxial tensile load, a uniaxial compressive load is applied. As can be imagined, the specimen (usually cylindrical) is shortened as well as spread laterally.

In the study of strength of materials, the compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures .At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block will be noted. From the noted values, the compressive strength may $calculated by using below formula.

**Compressive Strength = Load / Area**

**Size of the test specimen=150mm x 150mm x 150mm**

Figure 4 shows the compressive strength test setup of the study

**Figure 4** Compressive strength test setup

### 6.4 Water Absorption Test

One of the most important properties of a good quality concrete is low permeability, especially one resistant to freezing and thawing. A concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing. Water enters pores in the cement paste and even in the aggregate. The permeability of concrete is a measure of the rate at which a liquid pass through it. The permeability of concrete depends upon its pore network, which arises from the excess water used during mixing and during initial hardening process. The overall porosity includes closed or logged pores in addition to a network of inter connected pores. Pore size ranges from a few angstroms to about 100 $A^0$ for the so called ‘gel pores’, from 100 to 100000 $A^0$ in ‘capillary pores’ and a few millimeter in ‘air or large pores’. Inter connected pores endow the concrete permeability.

All the hydrated cement products are subjected to attack by sulphates, chlorides, and acids and less by water. This is because of low equilibrium solubility of the hydrated components and low mass transfer of well cured concrete. It is a usual practice to assess the water permeability characteristics when assessing the durability characteristics. Permeability can be measured by conducting standard test methods.

### 6.5 Split Tensile Test

The size of cylinders 300 mm length and 150 mm diameter are placed in the machine such that load is applied on the opposite side of the cubes are casted. Align carefully and load is applied, till the specimen breaks. The formula used for calculation.

**Split tensile strength = 2P/ µdl**

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature.

Figure 5. Shows the split tensile test setup of the study

**Figure 5** Split tensile test setup

However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. Apart from the flexure test the other methods to determine the tensile strength of concrete can be broadly classified as (a) direct methods, and (b) indirect methods. The direct method suffers from a number of difficulties related to holding the specimen properly in the testing machine without introducing stress concentration, and to the application of uniaxial tensile load which is free from eccentricity to the specimen. As the concrete is weak in tension even a small eccentricity of load will induce combined bending and axial force condition and the concrete fails at the apparent tensile stress other than the tensile strength.

As there are many difficulties associated with the direct tension test, a number of indirect methods have been developed to determine the tensile strength. In these tests in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses developed in the specimen. The tensile stress at which the failure occurs is termed the tensile strength of concrete.

## 7. TESTING RESULT

### 7.1 Ratios for Special Concrete (Extra Ingredients)

**RATIO –I**

Sand Replacing 5 % of Charcoal
Sand Replacing 25 % of Charcoal
$Tio_2$ Adding 10 % of Water

### 7.2 Compressive Strength of Cube

Table 2 shows the value of compressive strength of cube

**Table 2:** Compressive Strength Test Result

| MIX DESIGN | % OF REPLACE MENT | COMPRESSIVE STRENGTH(N/mm²) | | |
|---|---|---|---|---|
| | | 7DAYS | 14 DAYS | 28DAYS |
| $M_{30}$ | 0 | 27.33 | 34.44 | 37.06 |
| | 5 | 28.33 | 36.44 | 39.08 |
| | 25 | 32.7 | 42.87 | 47.87 |

Figure 6. shows the compression test graph result of the study

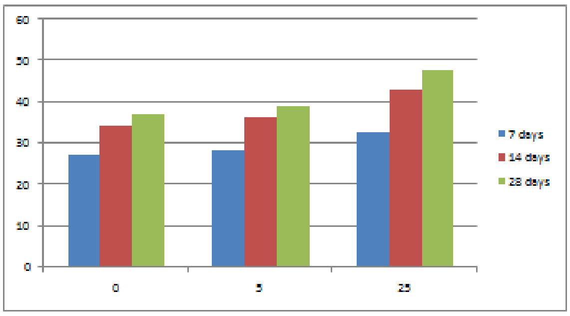


**Figure 6** Compression Test Graph Result

### 7.3 Unit Weight

Table 3 shows the unit weight results of the study

**Table 3:** Unit weight results

| S.NO | TYPE | WEIGHT IN KG | UNIT WT KG / M³ |
|---|---|---|---|
| 1 | 0 % cc | 8.1 | 2385 |
| 2 | 5 % | 7.93 | 2380 |
| 3 | 25% | 7.6 | 2375 |

Figure 7. Shows the graph of unit weight results

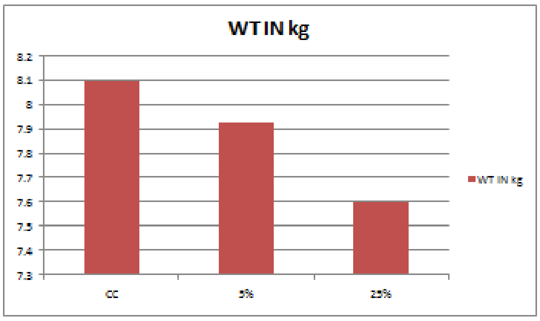


**Figure 7** Graph shows unit weight results

### 7.4 Water Absorption

Table 4 shows the Pollution Control Test Result

**Table 4:** Pollution Control Test Result

| Grade Of Concrete | Samples | Dry Wt In Grams (W1) | Wet Wt In Grams (W2) | % Of Water Absorption |
|---|---|---|---|---|
| M30 | M0% | 1068 | 1074 | 0.56 |
| | M25% | 1022 | 1027 | 0.48 |
| | M50% | 1060 | 1072 | 1.13 |

Figure 8 shows the Pollution Control Test Graph Result

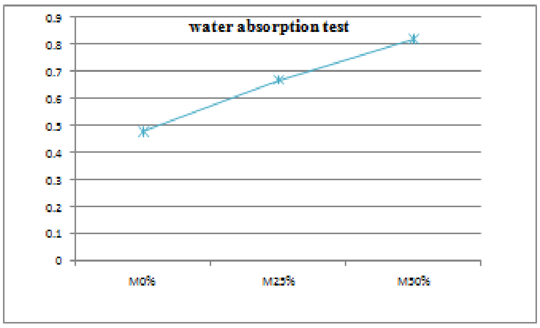


**Figure 8** Pollution Control Test Graph Result

## 8. CONCLUSION

The world has become increasingly aware of the need to preserve and conserve resources. Control of pollution is not only a legislative requirement, but has also become a tool for competitiveness.

- Optimum percentage range of replacement of $Tio_2$ & Charcoal lies between 5% to 25%, which provided higher strength as that of the conventional concrete.
- Through our results increase the percentage of charcoal will similarly increases the compressive strength of concrete as 47.87 $N/mm^2$ at 28 days.
- Cost of charcoal is found to be 46% lesser than the cost of fine aggregate. So it is economical by reducing the construction cost and also preserve the environment.

- Water absorption will be decreases at 25% replacement compared to conventional concrete.

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