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# EFFECT OF SIEVED COAL BOTTOM ASH AS A PARTIALLY REPLACEMENT IN PROPERTIES OF CONCRETE.

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## ABSTRACT

*This paper presents the results on an experimental investigation of the effects of sieved coal bottom ash as a replacement for natural sand on the properties of concrete. The test results of compressive strength, split tensile strength, flexural strength, and water permeability are studied. The natural sand was replaced with sieved coal bottom ash by 0%, 20%, 30%, 35%, 40%, 60%, 80%, 100% by weight, at fixed water- cement ratio. The results indicate that there is a decrease in the density of sieved coal bottom ash concrete with the decrease of workability with increase in sieved coal bottom ash percentage. The results shows that the compressive strength, split tensile strength and flexural strength decreased as the percentage of replacement of sieved coal bottom ash increased as compared to controlled concrete. In this work w/c ratio and slump was kept constant as 0.43 and 100 ± 10 mm respectively. It was observed that up to 35 % replacement the results of compressive, flexural, split tensile strength and water permeability are greater than controlled concrete*.

**Keyword -** *Optimum Content Coal Bottom ash1 M40 Concrete2, Mechanical Properties3, and Environmental Assessment4 etc*

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### 1.1 Introduction of study

World at present produces around approximately 1528 Million Tons of coal bottom ash when India at present produces around 120 Million Tons of Ash per annum. Out of this bottom ash 30 percent bottom ash were used as Portland cement replacement in concrete and other application were as low-value road base material and fills. The remainder had to be disposed of as solid waste in landfills. Disposal of bottom ash in this manner is not only wasteful it is costly because of the lack of landfill space and stringent environmental policy. The beneficial use of bottom ash in concrete is the preferable option for safe and economical utilization of millions tons of bottom ash. There is a critical need to find new methods for using bottom ash for its highest and best use. Even though the beneficial use of bottom ash in concrete has been known for many decades, it is still not yet fully utilized. The major obstacles to further use of bottom ash are the large variation in physical and chemical properties, the high amount of carbon and sulfur the delayed setting and low early strength of bottom ash concrete. According to, bottom ash, which varies considerably in its properties, can be divided into two categories (a) bottom ash meeting the physical and chemical standards as a pozzolna, and (b) those not meeting that standard. Malohtra (1996) reported that at least

60% of total bottom ash is generally suitable for use as a cement replacement in concrete but still only small amounts have been used. Moreover, its use as cement replacement is restricted to 20% of the cementitious mass. Because bottom ash improves concrete workability, lower the heat of hydration, increases the ultimate strength and improves the durability of concrete, many researchers are studying the method to increase utilization of bottom ash as cementitious material. For example by Malhotra (1995) have shown that concrete with up to 60 % cement replacement passed producing high strength and more durable concrete.

Energy is the main backbone of modern civilization of the world over, and the electric power from thermal power stations is a major source of energy, in the form of electricity. In India, over 70% of electricity generated in India, is by combustion of fossil fuels, out which nearly 61% is produced by coal-fired plants. This results in the production of roughly 100 ton of ash. Most of the ash has to be disposed off either dry, or wet to an open area available near the plant or by grounding both the fly ash and bottom ash and mixing it with water and pumping into artificial lagoon or dumping yards. This causes the pollution in water bodies and loss of productive land.

### 1.2. Problem Statement

The growing demand for electricity resulted in the construction of many coal fired power plants. As the consumption of coal by power plants increases, so does the production of coal by product such as bottom ash and coal bottom ash. While the use of coal increases, waste issues associated with coal production are tempted more and more thoughtfulness.

Disposal of unused coal ash is costly and places a considerable burden on the power industry, and finally transferred to the electricity consumer. In addition, the disposing of ash in landfills contributes to the ongoing problem of diminishing landfill space in the Malaysia. And at the same time, ash disposal may pose an environmental hazard.

Changeability of bottom ash is a latency problem because of the variability in type and origin of coal burned, boiler types, degree of coal pulverization, firing conditions in the furnace and ash handling practice (Huang, 1990). There is a requirement for a systematic manner to estimate locally available bottom ashes for potential construction utilization because even bottom ash produced from unitary source can be entirely difference depending on the Operating conditions and procedures.The using of bottom ash as alternative measures to replace the natural sand in concrete production. Therefore, a great potential to turn its abundant supply of electrical by coal industry by products into value added products especially in construction material. The conventional method of burning these residues often creates environmental problems, which generates air pollution and it is prohibited by the Environment Protection Act. In abiding by the regulations, these residues are becoming expensive to dispose. Nevertheless, looking on the brighter side of things, extensive research has provided an alternative way of optimizing the usage of coal residues based into value added product in construction industry.

1.2.1 Dumped pound coal bottom ash at Eklahare thermal power plan

**1.3. Objectives Of Study**

The main objectives for this research are:

i. To determine the optimum content of bottom ash as a substitute for fine aggregate (sand) in concrete.

ii. To evaluate the mechanical properties (compressive strength) of concrete containing bottom ash from power plant as sand replacement in concrete.

## 2. METHODOLOGY-2

## 2.1 Flow chart of work

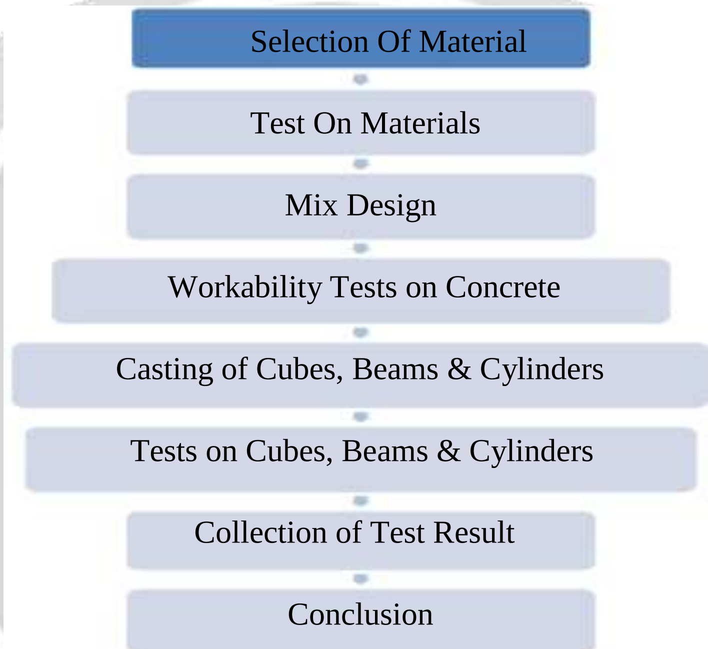


Fig. no 3.1.1 Flow chart of work

**2.2 Properties and Test of Ingredients**

**2.2.1 Properties of Cement**

Among The Chemical Constituents of Cement, the Most Important Ones Are $C_3A$ (Tricalcium Aluminate), $C_3S$ (Tricalcium Silicate) and $C_2S$ (Declaim Silicate). The $C_3A$ Portion Of Cement Hydrates More Rapidly, Thereby Reducing The Workability Of Fresh Concrete. It also absorb the chemical admixtures quickly which leads to reduction in availability of those admixtures for comparatively slower setting components of cements viz., $C_2S$ and $C_3S$. This Further Affect the Workability of Fresh Concrete and Also It's Rate of Retention of Workability.

Regarding Particle Size Distribution It May Be Noted That Final Particle Hydrate Faster than Coarser Particle and Hence Contribute More to Early age strength concrete. However at the same time the faster the rate of hydration may lead to quicker loss of workability due to rapid and large release of heat of hydration. However with reference to standard FAC test methods for properties of cement such as standard consistency, setting time, heat of hydration etc. After reviewing all requirements 53 grade Ultra tech ordinary Portland cement is used throughout experiment.

For cement we are conducting test like sieve analysis, soundness test and initial final setting time as per IS 12269 - (1987).

We obtained following results:

Table 3.2.1.1 Properties of Cement

| Sr. No. | Test | Reading |
|---|---|---|
| 1. | Fineness Test | 8.16 |
| 2. | Initial and Final setting time | 35min & 293 min |
| 3. | Soundness | 1.7 mm |
| 4. | Specific Gravity | 3.15 |

3.2.1.1 Cement bags (Ultratech 53 grade)

### 2.2 Properties of Fine aggregate

River sand is used as a fine aggregate. Among various characteristics, the most important one for fine aggregate is its grading. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in fine aggregate as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, silica fume etc. Also the water demand because of addition of fibres. The sand particles should also pack to give minimum void ratio, as the test result show that higher void content leads to requirement of more mixing water.

Properties such as void ratio, gradation, specific gravity and bulk density have to be assessed to design a dense fine aggregate mix with optimum cement content and reduced mixing water.

The sand should be tested properly as it is the ingredient of the concrete that is to be partially replaced in this project.

For Fine aggregate we are conducting test like Fineness Modulus, Specific Gravity test and Water Absorption as per IS 383 – (1970)

We obtained following results:

Table 3.2.2.1 Properties of Fine aggregate

| Sr. No. | Test | Reading |
|---|---|---|
| 1. | Fineness Modulus | 3.14 |
| 2. | Specific Gravity | 2.62 |
| 3. | Water Absorption | 1.00% |

### 2.3 Properties of Coarse aggregate

The properties such as moisture content, water absorption, etc., would help in adjusting the quality of mixing water for the concrete mix. The strength properties of coarse aggregate such as aggregate crushing abrasion value, aggregate impact value, compressive strength, aggregate crushing value( 10% fine value) etc. would determine the limits of strength of coarse aggregate which can be achieved with a given aggregate and these limits need to be investigated for creating database for rational design of. Locally available crushed stone aggregates with size 5mm to 12.5 mm and of maximum size 20 mm are used.

For Coarse aggregate we are conducting test like Fineness Modulus, Specific Gravity test and Water Absorption as per IS 383 – (1970).

We obtained following results:

Table 3.2.3.1 Properties of Coarse aggregate

| Sr. No. | Test | Reading |
|---|---|---|
| 1. | Fineness Modulus | |
| 2. | Specific Gravity | 2.67 |
| 3. | Water Absorption | 0.50% |

## 2.4 Properties of Coal Bottom Ash

Bottom ash is part of the non-combustible residue of combustion in a furnace or incinerator. In an industrial context, it usually refers to coal combustion and comprises traces of combustibles embedded in forming clinkers and sticking to hot side walls of a coal-burning furnace during its operation. The portion of the ash that escapes up the chimney or stack is, however, referred to as fly ash. The clinkers fall by themselves into the bottom hopper of a coal-burning furnace and are cooled. The above portion of the ash is referred to as bottom ash too

For Coal bottom ash we are conducting test like Fineness Modulus, Specific Gravity test and as per IS 5816 – (1959).

We obtained following results:

Table 3.2.4.1 Properties of Coal Bottom Ash

| Sr. No. | Test | Reading |
|---|---|---|
| 1. | Fineness Modulus | 3.51 |
| 2. | Specific Gravity | 1.44 |

## 3. EXPERIMENTAL ANALYSIS

### 3 .1 Effect of sieved coal bottom ash on compressive strength

**Procedure:**

1. Prepare a concrete mix as mentioned in the proportions suggested Such as: 1: 2: 3 with w/c = 55% by mechanical mixer.
2. Prepare three testing cubes; make sure that they are clean and greased or oiled thinly.
3. Metal molds should be sealed to their base plates to prevent loss of water.
4. Fill the cubes in three layers, tamping each layer with (35) strokes using a tamper, square in cross-section
5. While filling the molds, occasionally stir and scrape together the concrete remaining in the mixer to keep the materials from separating.
6. Fill the molds completely, smooth off the tops evenly, and clean up any concrete outside the cubes. Mark the specimens by a slip of paper on which are written the date and the Specimen identification. Leave the specimens in the curing room for 24 hours.
7. After that open the molds and immerse the concrete cubes in a water basin for 7 days.
8. Before testing, ensure that all testing machine bearing surfaces are wiped clean.
9. Carefully center the cube on the lower platen and ensure that the load will be applied to two opposite cast faces of the cube.
10. Without shock, apply and increase the load continuously at a nominal rate within the range of ( 0.2 N/mm2.s to 0.4 N/mm2.s ) until no greater load can be sustained. On manually controlled machines, as failure is approached, the loading rate will decrease, at this stage operate the controls to maintain, as far as possible, the specified loading rate. Record the maximum load applied to each cube.

Compressive strength of concrete mixed made with and without coal bottom ash of cubes size 150 mm × 150 mm × 150 mm was determined at 7, 28, 56, and 112 days. The test results are given in figure 4.1. The maximum load at failure reading was taken and the average compressive strength is calculated using the following relation.

$$\text{Compressive strength (N/mm}^2\text{)} = \frac{\text{Ultimate load in N}}{\text{Area of cross section (}\;^2\text{)}}$$

Table 4.1.1 Compressive strength gained of sieved bottom ash concrete with age.

| MIX | 7 days<br>In N/mm$^2$ | 14 days<br>In N/mm$^2$ | 28 days<br>In N/mm$^2$ |
|---|---|---|---|
| CC | 27.71 | 33.32 | 42.93 |
| 20SBA+80 S | 27.92 | 33.85 | 44.78 |
| 30SBA+70 S | 28.34 | 34.36 | 45.47 |
| 35SBA+65 S | 28.48 | 34.52 | 45.69 |
| 40SBA+60 S | 26.74 | 32.42 | 38.02 |
| 60SBA+40 S | 23.27 | 28.21 | 32.20 |
| 80SBA+20 S | 20.65 | 24.50 | 31.25 |
| 100 SBA+0S | 19.81 | 23.51 | 22.72 |


4.1.1 Testing of cubes

**3.2 Effect of Sieved coal bottom ash on split tensile strength**

**Procedure:**

1. Prepare three cylindrical specimens in the standard mould by placing fresh concrete in three layers as usual and tamping the same. Cover the mould with wet gunny bags.
2. After 24 hours remove the specimen from the mould and transfer them to the curing tank. Cure the specimen at a temperature of $24^0$C to $30^0$C.
3. Remove the specimen from the curing tank at the age of 28 days. And note down the exact dimensions.
4. Place the cylinder for resting in the compression-testing machine, along its length, keeps the plywood strips between the cylinder and the testing machine bearing surface at top and at bottom of cylinder.
5. Apply load smoothly and gradually.
6. Note the load at which the specimen fails

## 4. CONCLUSIONS

1. The compressive strength for 7, 14 and 28 days was increased up to 35% replacement and after that compressive strengths were decreased from 40% to 100% replacement.
2. The split tensile strength was increased at 7, 14 and 28 days for 10% to 35% replacement

   and after that it was decreased for remaining replacement.
3. The flexural strength was increased for 10 %, 35% replacement and after that it was decreased.
4. Sand quarrying is done to extract sand for construction purposes. It affects the environment to a great extent. Bottom ash disposal in the environment disturbs the eco-system. Hence, this bottom ash concrete can be used in construction of pavement and buildings. Thus bottom ash is disposed in an eco-friendly way and sand quarrying can be reduced. Thus a greener environment can be build.
5. Even though the strength development is less for bottom ash concrete, it can be equated to lower grade of normal concrete and making utilization of waste material justifies the concrete mix-development.
6. Bottom ash used as fine aggregates replacement enables the large utilization of waste product.
7. Hence we are concluded that the coal bottom ash can be use up to 35% of the volume of sand in the concrete to obtain the max strength with the optimum use of coal bottom ash.


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