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EFFECT OF BOTTOM ASH AS REPLACEMENT OF FINE AGGREGATES IN CONCRETE

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ABSTRACT

Concrete is a composite material containing hydraulic cement, water, coarse aggregate and fine aggregate. The resulting material is a stone like structure which is formed by the chemical reaction of the cement and water. Concrete and the addition of some other materials may change the properties of concrete. The present experimental study was conducted for following general purpose of testing of new sustainable building processes and modern production systems, it's aim is not only at saving natural raw materials and reducing energy consumption, but also to recycle industrial by-products. The objectives of this study was to investigate the effect of use of coal bottom ash as partial replacement of fine aggregates in percentages (10%, 20% and 30%), on concrete properties such as compressive strength, flexural strength. Bottom ash use in concrete is becoming more important in view of the fact that sources of natural sand as fine aggregates are getting depleting gradually, and it is of most significance that substitute of sand must be examined.

Keywords: Bottom Ash, Coal Bottom Ash, Concrete, Compressive, Replacement to SandStrength, Waste Material.

I.INTRODUCTION

Concrete is the crucial material for the construction industry used for construction of high rise buildings and various infrastructures. Infrastructural development, particularly in developing countries like India, is more. Concrete is a mixture of cement, fine aggregate, coarse aggregate and water and river sand is the main raw material used as fine aggregate in the production of concrete. The natural sources of river sand are getting depleted gradually. Concrete has moderately high compressive strength, but conducts lower tensile strength, and as such is usually reinforced with materials that are strong in tension (often steel or other fibrous material). The density of concrete varies, but is around 2,400 kg/m3. The elasticity of concrete is constant when low stress levels are applied but starts decrease at higher stress levels as the crackinggets developed. Also, concreteposses a very low coefficient of thermal expansion. It is subjected to long-duration forces prone to creep. Tests can be made to ensure the properties of concrete correspond to specifications for the application.The management of

coal bottom ash produced by coal thermal power station is a major problem in many parts of the world. However, the generation of ash tends to increase every year. Although some coal fly and bottom ash is used in a range of applications, particularly as a substitute for cement in concrete. Large amount remain unused and thus required disposal. At present, coal fly ash is used in civil engineering for production of cement, concrete, cube and artificial aggregate. Safe disposal of the ash without adversely affecting the environment and the large storage area required are major concerns. This paper presents the experimental investigation carried out to study the effect of use of bottom ash as a part replacement of fine aggregates (sand). Although, bottom ash is being generally used as replacement of cement, as an admixture in concrete, and in manufacturing of cement, the study on the use of bottom ash,which is a coarser material thatsettles in furnace bottom in modern large thermal power plants and constitute about 20% of total ash content of the coal fed in the boilers, has been very limited.

1.1 Bottom Ash

Bottom ash is a by-product from burning coal which is generated at the thermal power plants. Bottom ash particles are much coarser than the fly ash. It is a coarse, angular material having porous surface texture predominantly sand-sized. This material is composed of silica, alumina, and iron with small amounts of calcium, magnesium, and sulphate Grain size typically ranges from fine sand to gravel in size. Bottom ash contains high carbon content and exhibits high shear strength and lowcompressibility. These engineering properties make bottom ash an ideal material in design construction. Bottom ash also exhibits a relatively high permeability and grain size distribution that allows the design engineer to use it in direct contact with impervious material. Bottom is an economic material because it has revealed to have, not only good engineering property but also to have constructability benefits. It is also used as concrete aggregate or for several other civil engineering applications where sand, gravel and crushed stone are used.

II. LITERATURE REVIEW ON BOTTOM ASH

Abernethy *et al*. (Year 1969) investigated the common constituents present in the bottom ash by taking more than 600 ash samples from commercial coals in the United States of America. They found that coal ash was composed of silica (SiO_2), ferric oxide (Fe_2O_3), and alumina (Al_2O_3), primarily consisting of smaller quantities of calcium oxide (CaO), potassium oxide (K_2O),), sodium oxide (Na_2O), magnesium oxide (MgO), titanium oxide (TiO_2), phosphorous pent oxide (P_2O_5), and sulphur trioxide (SO_3). In bituminous coal, three major components (SiO_2, $Fe_2O_3$and Al_2O_3) accounted for about 90% of the total components.

Seals *etal*. (Year 1972) presented from West Virginia Thermal Plant. The results of standard Proctor maximum densities varied between 11.6 and 18.4 kN/m3 while the optimum water content ranged from 12 to 34%. They provedby comparing that at low stress levels, the compressibility of bottom ash was having same relative density to natural granular soils.

Cheriaf*etal*(Year 1999) reported the morphological characteristics of bottom ash. He scanned electron micrograph in terms of the shape and surface characteristics of the particles. Bottom ash particles were angular and irregular in shape and had rough surface.

Jaturapitakkul*et al.* (Year2003) studied the potential of using bottom ash, as pozzolanic material, from the Mae Moh power plant in Thailand. He found bottom ash ,which was used in concrete due to its pozzolanic reaction, improved its quality by grinding until when the particle size retained on sieve 325 which was less than 5% by weight.

Bottom ashes before and after being ground were investigated and compared for their physical and chemical characteristics. The bottom ashes were used to replace Portland cement in mortar and concrete mixtures. He found that the particle of bottom ash was large, porous and a regular shapes. The grinding process reduced the particle size as well as porosity of bottom ash. Compressive strengths of mortar containing 20 to 30% of bottom ash as cement replacement were much less than that of cement mortar at all edges, but use of ground bottom ash produce higher compressive strength than the cement mortar after 60 days. He used bottom ash at 20% replacement of cement to make concrete, the concrete with higher cement content produce higher percentage of compressive strength. He concluded that ground bottom ash could be used Bottom ash as a good pozzolanic material.

III. MATERIALS AND TESTS

3.1 Cement:

Cement is a constituent of concrete which binds all the material in concrete. Cement is produced by calciningat high temperature. It is a mixture of calcareous, siliceous, aluminous substances and crushing the clinkers to a finepowder. Cement is the most expensive materials in concrete and it is available in different forms and grades. When cement ismixed with water, a chemical reaction takes place. Due to this reaction, cements paste sets and hardens to a stone mass.

Test Results of Standard Consistency Test: Standard consistency of cement is defined as that water content at which the needle of the apparatus fails topenetrate the specimen by 5mm from bottom of the mould.

Water Content (in %)	Penetration Depth (From Bottom of Mould)
28	37.5
30	27
32	7

3.2 Fine Aggregates:

The material used as fine aggregate in this project is river sand at Sarangkheda from River Tapi. The sand was sieved and passed through 4.75mm I.S. Sieve

SR.	Properties	Test Results
1	Specific Gravity	2.54
2	Size	4.75mm

3.3 Coarse Aggregates:

The aggregate whose particles are of size which gets retained on I.S Sieve No.480 (4.75mm) is termed as coarseaggregate. The coarse aggregate used in thisexperimental investigation are of 20mm, 10mm, angular in shape. The aggregates are free fromdust before used in the concrete.

3.3.1 Properties of coarse aggregate:

SR.	Properties	Test Results
1	Specific Gravity	2.21
2	Size	>4.75mm

3.4 Bottom Ash (As a Part Replacement to Sand In Concrete):

In this project we use bottom ash as a part replacement of fine aggregates. Bottom ash is part of the non-combustible residueof combustion in a furnace or incinerator. In an industrial context, it usually refers to coal combustion and comprisestraces of combustibles embedded in forming clinkers and sticking to hot side walls of a coal-burning furnace during itsoperation. The portion of the ash that escapes up the chimney or stack is, however, referred to as fly ash. The clinkersfall by themselves into the bottom hopper of a coal-burning furnace and are cooled. The above portion of the ash isreferred to as bottom ash too.

3.4.1 Physical Properties of Bottom Ash

Bottom ashes consist of angular particles with a very porous surface texture. The ash is usually a well graded material, although variations in particle size distribution may be encountered in ash samples taken from the same power plant at different times. Bottom ash is usually sand - sized, usually with 60 to 85% passing a 4.75 mm sieve, 10 to 60% passing a 0.42 mm sieve, 0 to 10% passing through 0.075 mm sieve, and a top size usually ranging from 19 mm to 38.1 mm.Bottom ash particles range insize from a fine gravel to a fine sand with very low percentages of silt and clay sized particles.

3.4.2 Chemical Properties of Bottom Ash

Bottom ash and boiler slag are made essentially out of silica, alumina, and iron, with smaller percentages of calcium, magnesium, sulphates, and other compounds. Bottom ash or boiler slag derived from lignite or sub-bituminous coals have a higher percentage of calcium than that from anthracite or bituminous coals. Due to the salt content and, in some cases, the low pH of bottom ash and boiler slag, these materials could display corrosive properties.

3.5TESTS ON FRESH CONCRETE

3.5.1 Slump test:

Slump test is used for measuring consistency of concrete which can be employedeither in laboratory or at site of work. It is not suitable method for very wet or very dry concrete. It is usedconveniently as a control test and gives an indication of the uniformity of concrete from batch to batch.

Percentage of Part Replacement of Sand with Bottom Ash	Slump Test
10%	69
20%	62
30%	58

3.5.2 Compaction factor test:

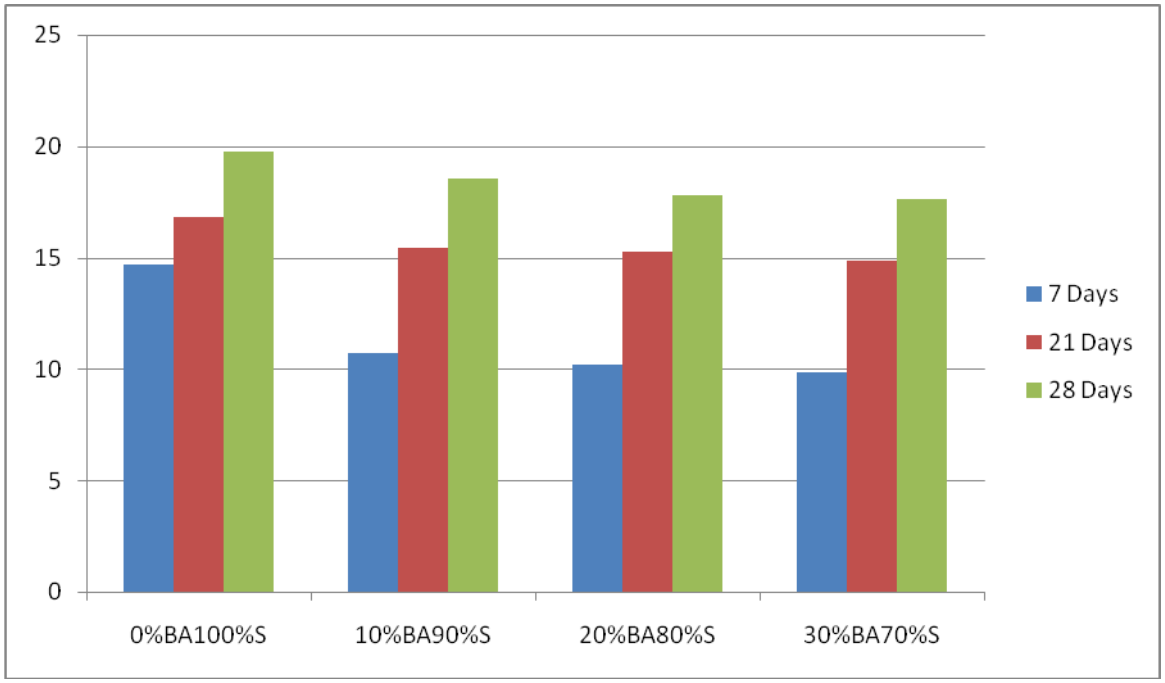
Amount of work done by allowing the concrete to fall through is a standard height. The degree of compactioncalled the compaction factor is measured by the ratio of density of actually achieved in the test to the density of thesame concrete fully compacted.

$$Compaction\ Factor = \frac{\text{weight of partially compacted concrete}}{\text{weight of fully compacted concrete}}$$

Percentage of Part Replacement of Sand with Bottom Ash	Compaction Factor
10%	0.75
20%	0.69
30%	0.65

3.5.3 Compressive Strength gained by Sieved Bottom Ash Concrete

	0%BA100%S	10%BA90%S	20%BA80%S	30%BA70%S
7 Days	14.67	10.69	10.22	9.87
21 Days	16.84	15.44	15.24	14.86
28 Days	19.74	18.56	17.78	17.64



IV.CONCLUSION

From above investigation we found that the maximum compressive strength of mix proportion is 18.56 N/mm2, 15.44 N/mm2, and 10.69 N/mm2at 7 days, 14 days and 28 days respectively. From the experimental studies it is found that, workability varies when different percentage of components are added. Increase in sand increases the compressive strength and decreases when 100% is done.Compressive strength of sand replaced bottom ash concrete will be lower than normal concrete specimens at all the ages. The workability of concrete decreased with the increase in bottom ash content due tothe increase in water demand. The density of concrete decreased with the increase in bottom ash content due to thelow specific gravity of bottom ash as compared to fine aggregates.

Water absorption is more Bottom Ash Concrete compared to conventional concrete

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