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Effect of Addition of Alccofine on Coal Bottom Ash Concrete Properties

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ABSTRACT- The effect of addition of ultra-fine material i.e. Alccofine on the properties of coal bottom ash assisted concrete has been studied in this study. Alccofine is added in steps in the 40% bottom ash concrete to revive the properties of bottom ash concrete. A proportion of 5 to 20% has been added as an alternative to cement. Results showed that replacement of cement with Alccofine has improved the compressive strength of the concrete.

KEYWORDS- Concrete, Sustainability, Green Environment, Waste Management, Compressive Strength.

I. INTRODUCTION

Around the world, concrete that is sustainable and reasonably priced has been used to construct a range of structures, both structural and non-structural. [1][2][3]. The use of fine aggregates in concrete has been restricted due to restrictions on ille-gal sand mining and rising costs for its acquisition. However, because it is a necessary component of concrete, it must be replaced as little as possible with other viable options.

Numerous industrial and agricultural wastes have been mixed into various types of concrete over the years to reduce their negative environmental effects and cost [4]. These wastes could be used as aggregate or a stabilizer in cementitious materials [5].[6]. One of the many potential industrial wastes that are easily accessible globally and can be used as fine aggregate in concrete compositions is coal bottom ash (CBA). CBA is one of the wastes generated by coal-fired power plants, according to [3]. In order to produce electricity, a sizable amount of coal must be burned in specific boilers, which results in a significant volume of different types of ashes. The larger particles that are removed from the bottom of the furnace are referred to as CBA. CBA, which is composed of a complex mixture of metal carbonates and oxides, makes up around 10–20% of the coal ash produced as waste during the operation of coal-fired power plants [7]. The ozone layer depleting potential of cement manufacture, on the other hand, raises severe concerns about its continued use as a building material [8]. Nearly a ton of carbon dioxide is emitted into the environment during the production of clinker [9], contributing around 5-7% of the greenhouse gas emissions caused by the use of fuel and the breakdown of calcium carbonate into calcium oxide and carbon dioxide.

The use of industrial wastes as an alternative to cement was first the main focus in order to reduce carbon footprints and the overuse of natural resources in cement production. However, given the current situation, efforts have been undertaken to identify environmentally friendly prospective substitutes for obtaining natural aggregates. Any concrete mix must have aggregates, which make up around 70% of the total mass of concrete and are typically mined from riverbeds. Due to growing construction activity to suit human requirements during the past few decades, exploitation of these natural aggregates has reached its peak. Therefore, it becomes crucial to find alternatives that can reduce the exploitation of natural resources while yet offering concrete-like qualities. It is only feasible to use industrial waste materials as a substitute for fine aggregates if they share the same physical properties as natural aggregate and are chemically inert [10].

It is no longer necessary to dispose of CBA waste in landfills when CBA is used in place of conventional natural fine aggregates, and it also offers a different source of natural raw materials, both of which add to CBA's sustainability advantages. The detrimental environmental effects associated with the extraction and processing of natural fine aggregates are eliminated as a result. Additionally, it has been discovered that the aesthetics of the surroundings are influenced by where natural fine particles are located. When it comes to soil stabilization, the long-term benefits of CBA use in the construction industry have also been well studied [11]. It's critical that people are informed about CBA's qualities and how they affect the properties of various types of concrete because it is increasingly being used as a sustainable alternative to the conventional natural fine aggregate in cementitious materials. As it has been demonstrated to be a workable material to be used in place of fine aggregate in the manufacturing of concrete, CBA can therefore be employed in concrete applications [12], [13].

However, a number of methods have been developed to develop an effective substitute for cement, including the use of fly ash [14][15] blast furnace slag [16][17], silica fume [18][19], Alccofine [20-22]and metakaolin [23-24] as supplementary cementitious materials.

A synthetic cementitious substance called Alccofine 1203 can be used to partially replace cement. Because it is an ultra-fine slag material, there is no increased need for water, and the pozzolanic reactions, which include both primary and secondary reactions, are good. However, it was also noted that the workability of the concrete mix decreased [25]. Studies have indicated that when Alccofine is used in conjunction with fly ash as a supplementary element in the concrete, improved mechanical qualities can be achieved. Furthermore, it should go without saying that Alccofine 1203 can function differently depending on the type of replacement and that this is a topic for additional study.

This study aims to decrease the concurrent usage of natural sand and cement by partially substituting these materials with bottom as, a waste product obtained from a power plant dump site, and Alccofine, a highly dense fine powder. The government of India's waste to wealth generation programs are the focus of this study program. Additionally, as the manufacture of alcofine emits less carbon dioxide than the production of cement, replacing cement with alcofine will result in lower overall CO2 emissions, which is how this research helps to create a sustainable and environmentally friendly atmosphere.

This study looked at how the characteristics of coal bottom ash assisted concrete were affected by the inclusion of ultra-fine material, specifically Alccofine. To restore the characteristics of bottom ash concrete, accofine is gradually added to the 40% bottom ash concrete. In place of cement, a fraction of 5 to 20% has been added. Results indicated that switching from cement to alumina enhanced the concrete's compressive strength.

II. MATERIALS

A. Alccofine

Alcofine is purchased at the cement store in Ambuja. The manufacturing facility for Alccofine is situated in Goa (India), in the Pissurlem Industrial Estate. Glenium - 51, a modified polycarboxylic ether-based superplasticizer, was employed in this work. Glenium was purchased from Chandigarh-based BASF INDIA LIMITED.

B. Categorization of Materials

Cement paste and aggregates (coarse and fine aggregates) make up the majority of the two ingredients that make up concrete. The mechanical and adhesion characteristics of the cement and aggregate surfaces determine the ultimate strength of concrete. Utilized is OPC con-fining to BIS:8112-1989 standard. Table 1 lists the specific gravities of cement, coarse and fine aggregates, CBA, and alumina. BIS: 2386 (Part I and II)-1963 criteria have been used to evaluate the fineness modules of coarse and fine aggregates. 20 mm coarse aggregates have been employed in this study project. The Guru Gobind Singh Thermal Power Plant in Ropar, Punjab, has gathered CBA. To eliminate the larger particles, a sieve with a mesh size of 4.75 mm was used to sift the CBA and sand.

Table 1: Concrete component characteristics

Sr. No.	Constituents	Specific gravity	Fineness modules
1.	Cement	3.13	-
2.	Coarse aggregates	2.66	6.68
3.	Fine aggregates (river sand)	2.63	2.53
4.	Coal Bottom ash	1.71	1.37
5.	Alccofine 1203	2.98	-

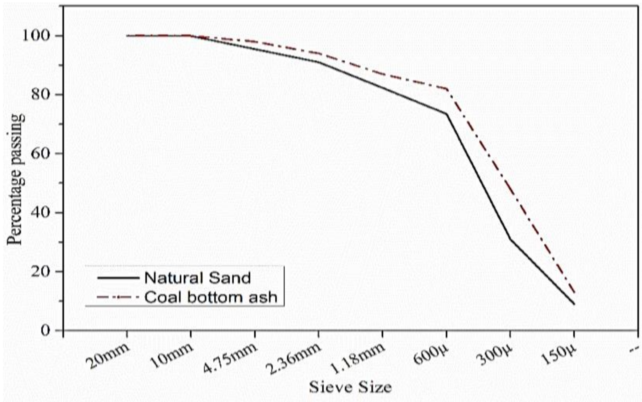

Figure 1: Particle size distribution of natural sand and coal bottom ash

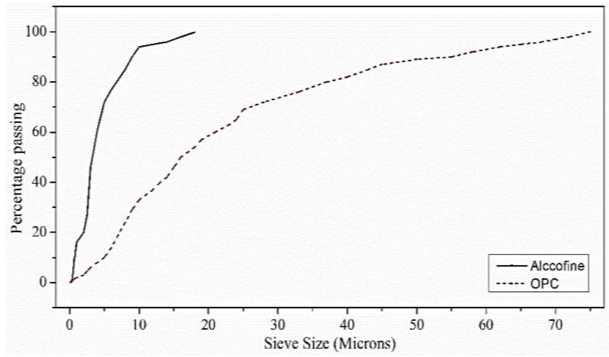

Figure 2: Particle size distribution of OPC and Alccofine 1203

Cement's chemical composition is listed in Table 2, and the chemical makeups of CBA and Alccofine 1203 are listed in Table 3. Figure 1 shows the distribution of natural sand and CBA particle sizes. The chart shows that CBA has finer particle size for all sieve sizes when compared to natural sand. Additionally, Figure 2 shows that Alccofine has significantly smaller particle size for all filter diameters when compared to OPC.

Table 2. Properties of cement

Chemical composition			Physical properties		
Composition	Test result	BIS value	Property	Test result	BIS value
Lime saturation factor (l_{sf})	0.877	$0.66 < l_{sf} < 1.02$	Fineness (m^2/kg)	278.6	>225
Ratio of Alumina and Iron oxide	1.51	> 0.66	Initial setting time (min)	125	>30
Loss on Ignition (%)	1.93	< 5.0	Final setting time (min)	175	<600

Table 3: Chemical Composition of Constituents

Compound	Percentage (CBA)	Percentage (Alccofine)
SiO_2	35.13	35.05
Al_2O_3	25.63	24.34
MgO	0.54	9.66
CaO	0.46	28.86
Fe_2O_3	7.92	1.97

III. RESULTS AND DISCUSSIONS

A. Compressive Strength of Bottom Ash Concrete

The test results make it abundantly evident that when the replacement amount of fine aggregate with CBA increased at all ages, the compressive strength decreased. For the MB5 mix, the maximum drop in compressive strength has been determined to occur at a replacement of 50% fine aggregates. Figure 3 shows the strength variations of concrete mixes for all sand replacement concentrations at various curing ages. The trend is similar to that of the controlled mix (MB0).

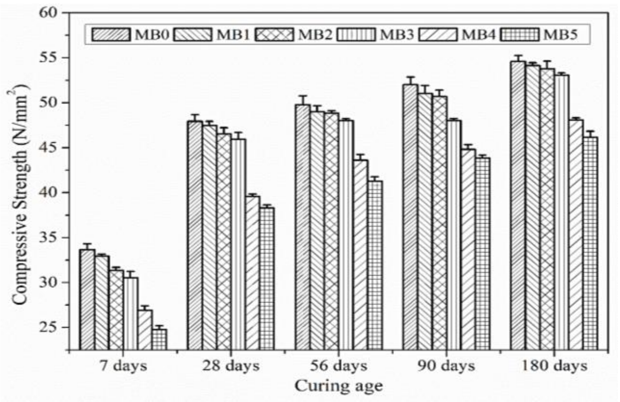

Figure 3: Effect of coal bottom ash on the compressive strength of concrete

The compressive strength of CBA concrete gradually decreases with the addition of CBA to the concrete mix, even after fine particles have been replaced with CBA during all curing ages. After that, a sharp decline in compressive strength can be noticed (Figure 3) for all curing ages when fine aggregates are replaced with CBA by between 30% and 40%. These test results for the concrete mix design are comparable to those from [25-27], in which the authors reported a reduction in compressive strength for the mix design.

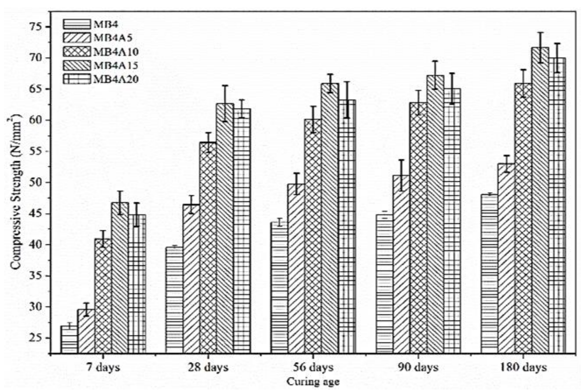

Figure 4: Effect of coal bottom ash and Alccofine on the compressive strength of concrete

B. Compressive Strength of Alccofine Assisted Bottom Ash Concrete

The graph of Figure 4 shows the results of the compression strength analysis. Compressive strength has been observed to significantly increase at all curing ages with the addition of Alccofine 1203 to coal bottom ash concrete. It has been discovered that the Compressive strength reaches its highest value when 15% of cement is replaced with Alccofine 1203 and 40% of fine aggregates are replaced with coal bottom ash.

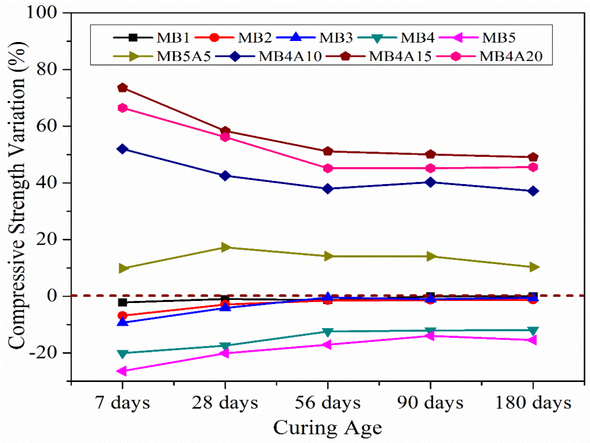

Figure 5: Percentage variation in compressive strength

Figure 5 shows that for all the mixtures (apart from MB4A5) and all curing ages, the percentage improvement in compressive strength is rather considerable. The percentage increase in compressive strength for MB4A15 is around 72% at 7 days, 59% at 28 days, 52% at 56 days, 49% at 90 days, and 48% at 180 days.

Improved properties of Alccofine assisted CBA mixtures can be attributed to the rounded shape of ultrafine material with optimal particle size and unique chemical composition, which can be examined as important contributing factors. The improvement in strength of Alccofine assisted CBA concrete may be attributed to the continual hydration and filling of porosity with CSH gel produced by the pozzolanic activity of Alccofine.

As a result, it can be seen that Alccofine 1203 assisted coal bottom ash concrete has improved workability and compressive strength at all ages due to the special properties of Alccofine material, which include finer particle size distribution and inbuilt CaO that further form dense pore structure. Additionally, compared to coal bottom ash, Alccofine 1203 inclusion in MB4 concrete mix has lowered the dose of super-plasticizer and enhanced the compressive strength of the concrete.

IV. CONCLUSIONS

In this study, the usage of industrial wastes, such as CBA ash as a cost-effective replacement for fine aggregate and Alccofine as a partial replacement for cement, has been challenged. From the current investigation, the following results have been drawn:

- All CBA concentrations (10% to 50%) show a significant loss in strength qualities when compared to the controlled concrete mix.

- Alcofine additive, which has smaller pore structure and less void space than concrete, has considerably helped the material's capacity to regain its workability and strength attributes. Particularly, MB4A15 concrete mix has demonstrated better qualities; as a result, it is advised in this study to utilize Alccofine in cement.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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