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Emerging Trends in the Utilization of Alccofine as a Cement Replacement

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The construction industry is increasingly favoring sustainable materials to produce more environmentally friendly concrete. Alongside environmental considerations, economic viability and performance are key factors driving current research into new alternatives and substitutes for traditional materials. This paper presents a comprehensive evaluation of the strength characteristics of concrete that incorporates Alccofine 1203 as a key ingredient. The study involved experimenting with varying proportions of Alccofine 1203, ranging from 0% to 50%, in M20 grade concrete. The findings indicate that Alccofine 1203 enhances the concrete's strength, particularly in its early stages, compared to conventional concrete mixtures. Additionally, the concrete exhibits improved durability and workability. The curing process was conducted over 7, 14, and 28 days, and the mechanical properties were assessed through Compressive Strength, Modulus of Elasticity, and Flexural Strength tests. The study concludes that the use of Alccofine as a partial replacement for cement offers dual benefits: it is an eco-friendly material that reduces carbon emissions while simultaneously enhancing the workability and mechanical properties of concrete. The optimal results were observed with a 40% replacement of cement by Alccofine 1203, making it a promising material for sustainable construction practices.

Keywords: Alccofine 1203; Cement replacement; Mechanical Properties, Concrete Admixtures, Sustainable Construction.

1. Introduction

Concrete has been a fundamental construction material globally for many years, with cement being one of its most crucial components. As infrastructure development accelerates, the resulting increase in carbon dioxide emissions has become a significant contributor to global warming. In response to the need for more environmentally friendly concrete, researchers have explored various by-products, including fly ash, silica fume, metakaolin, and alccofine, as alternatives or supplements to traditional cement [1].

Among these alternatives, the use of fly ash in concrete production is gaining widespread popularity. This shift is driven by the environmental benefits that fly ash offers, such as reducing greenhouse gas emissions from industrial processes and helping to conserve natural resources. As a result, incorporating fly ash and similar materials into concrete not only mitigates environmental impact but also supports the development of sustainable construction practices [2].

When compared to standard concrete, achieving early strength is often a challenge due to the slower pozzolanic reaction of fly ash within the mix. To overcome this limitation and improve both strength and workability, various admixtures have been considered, with Alccofine 1203 being a notable example. Alccofine 1203 is an ultra-fine Ground Granulated Blast Furnace Slag (GGBS) product characterized by high glass content and significant pozzolanic reactivity [3]. The inclusion of Alccofine 1203 in concrete formulations not only enhances compressive strength but also improves the material's fluidity and overall workability. This admixture can be utilized in two primary ways: as a replacement for cement, which reduces the overall cement content and thereby lowers costs, and as an additive to enhance the desirable properties of high-strength concrete [4].

OBJECTIVE

Identification of optimum percentage of replacement of Cement using industrial by- products i.e., Alccofine 1203 from 0% to 50% for M20 grade of concrete and to investigate the mechanical properties of Alccofine1203 based concrete.

2. Methodology

The process begins with precise measurement of the materials required for the concrete mix, including cement, the Alccofine 1203 admixture, and both fine and coarse aggregates. These materials are carefully weighed to ensure the correct proportions. Once measured, the materials are manually mixed in a sequential manner, with each ingredient being added one at a time. This step-by-step mixing ensures that the components are thoroughly combined, resulting in a uniform and well-blended concrete mix.

After achieving the desired consistency, the fresh concrete is placed into prepared molds. The molds are filled in three separate layers, with each layer being compacted by tamping it 25 times. This compaction process is essential for eliminating air pockets and ensuring that the concrete is densely packed, which contributes to the strength and durability of the final product.

Once the molds are filled and compacted, they are left undisturbed for 24 hours to allow the concrete to set. After this initial setting period, the concrete specimens are carefully removed from the molds and submerged in water for curing. The curing process is critical for the hydration of the cement and the development of the concrete's strength. The specimens are cured for 7, 14, and 28 days, depending on the specific testing requirements.

MATERIALS PROPERTIES

The study involved detailed examinations of various materials used in concrete production. The properties of Ordinary Portland Cement (OPC) 53, which was employed in the study, are summarized in Table 1. This table provides essential data on the cement's characteristics, such as its fineness, setting times, and strength.

The physical properties of the sand and coarse aggregates used are presented in Tables 2 and 3, respectively. These tables offer information on the gradation, shape, and size distribution of the aggregates, which are crucial for determining the quality and suitability of the concrete mix.

The concrete was mixed using a design ratio of 1:1.50:3.00:0.50, where the numbers represent the proportions of cement, fine aggregates (sand), coarse aggregates, and water, respectively. This mix ratio ensures a balanced blend of materials to achieve the desired strength and workability.

Alccofine 1203, used in the study, is a microfine mineral additive known for its ability to reduce water demand, lower the heat of hydration, and improve strength properties across various ages of concrete. The specific properties of Alccofine 1203, including its particle size and reactivity, are detailed in Table 4. This information is crucial for understanding how Alccofine 1203 contributes to enhancing the overall performance of the concrete mix.

Table1 Properties of Cement

Properties	Cement
Specific gravity	3.2
Fineness modulus	3.0
Consistency (%)	30
Initial setting time (min)	30
Final setting time (min)	380

Table 2 Physical Properties of Sand

Sl. No.	Parameter	Value
1	Bulk Density (Kg/m^3)	1450
2	Specific Gravity	2.65
3	Water absorption %	0.6
4	Fineness Modulus	2.75

Table 3 Physical Properties of Coarse Aggregate

Sl. No.	Parameter	Value
1	Bulk Density (Kg/m^3)	1370
2	Specific Gravity	2.68
3	Water absorption %	0.7
4	Fineness Modulus	6.33

Table 4 Properties of Alccofine 1203

Sl. No.	Parameter	Value
1	Particle size (Microns)	4-6
2	Fineness cm^2/gm	12000
3	Specific Gravity	2.9
4	Bulk Density (Kg/m^3)	600-700

Figures 1 and 2 in the study illustrate the materials used for casting, while Figures 3 and 4 provide visual documentation of the casting process itself. These figures likely help to provide a clear understanding of the experimental setup, the materials involved, and the procedure followed to ensure consistent and accurate results. The detailed casting process, combined with the use of standardized molds, ensures that the concrete samples produced are suitable for rigorous testing and analysis, thereby allowing for a thorough evaluation of the effects of Alccofine 1203 on concrete properties.

Fig 1. Materials for Casting

Fig 2. Alccofine 1203

Fig 3. Casting of Cubes

Fig 4. Casting of Cylinders and Prisms

EXPERIMENTAL INVESTIGATION

The research involved replacing cement with Alccofine 1203 in varying proportions, up to 50% by weight, to assess its impact on concrete properties. The mix design was carefully developed following the guidelines of IS:10262-2019, a standard used for concrete mix proportioning in India.

For the experimental study, a total of 54 concrete cubes, 12 prisms, and 12 cylinders were cast. The molds used for casting these specimens were of specific dimensions: the cubes measured 100 x 100 x 100 mm, the prisms were 100 x 100 x 500 mm, and the cylinders had a diameter of 150 mm and a height of 300 mm.

TESTING

COMPRESSIVE STRENGTH:

Compressive strength test is carried out using Compressive Testing machine. It is one of the major tests in determining the mechanical behavior of concrete. The concrete cubes are tested up to failure. Figure 5 shows the Compressive testing of cubes.

Figure 5 Compressive Strength Testing

MODULUS OF ELASTICITY:

Cylinder specimens of 150 mm diameter and 300 mm height were compressed tested using a typical compression testing machine. Dial gauge was used to measure the change in length of the specimen. The load is gradually added until the specimens fail. The maximum load and the accompanying length change were measured. Figure 6 and 7 show the specimens used for finding modulus of elasticity of concrete and testing of specimen.

Figure 6 Specimens for Modulus of Elasticity Test

Figure 7 E- Concrete Testing

FLEXURAL STRENGTH TEST:

Flexural strength test was carried out using CBR Testing Machine. The following formula for the evaluation of the flexural strength (F_{cr}) is obtained. $F_{cr} = PL/ bd^2$ (N/mm^2). Figure 8 and 9 show the specimens cast and Flexural strength Testing.

Figure 8 Prisms for Flexural Test

Figure 9 Specimens under Flexure

3. Results and Discussion

The results obtained for partial replacement of Cement using Alccofine 1203 concrete are discussed in detail below:

COMPRESSIVE STRENGTH:

Test is carried out as per IS: 516-1959 [7] and the results are shown in Table 5. Figure 10 shows the growth of compressive strength from 7 to 28 days of Alccofine based concrete with conventional concrete. Early strength is achieved in alccofine concrete and optimum results are observed at 40% replacement of cement with alccofine.

Table 5 Compressive Strength Test Results

Sl.No	Specimen ID	7 days (MPa)	14 days (MPa)	28 days (MPa)	Remarks
1	C100AC0	22.35	23.25	27.25	CC
2	C90AC10	25.50	28.90	35.0	Alccofine 1203
3	C80AC20	25.90	27.0	37.0	
4	C70AC30	26.0	35.40	40.0	

5	C60AC40	40.90	42.40	44.0	
6	C50AC50	32.0	34.0	37.0	

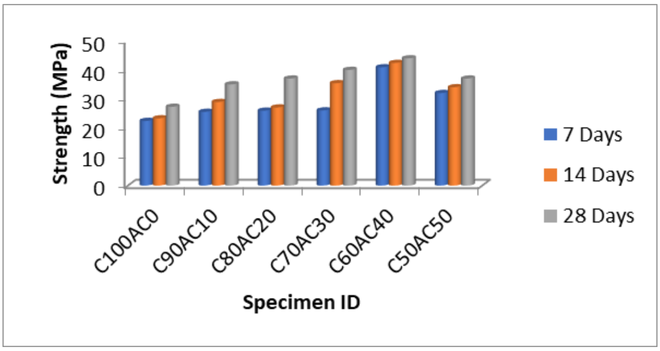

Figure 10 Compressive strength of Alccofine Based Concrete

MODULUS OF ELASTICITY:

E-for Concrete values are obtained and compared with conventional concrete. It is observed that 40% shows optimum result of 1.32 x10^{-4} N/mm^2. Table 6 shows EC values and Figure 11 is graphical representation of Modulus of Elasticity values of concrete.

Table 6 Modulus of Elasticity of Concrete

Sl.No.	Type of Concrete	Percentage of Replacement	Ec
1	Conventional	0	1.14 x10^{-4} N/mm^2
2	Alccofine	10	1.16 x10^{-4} N/mm^2
3		20	1.18 x10^{-4} N/mm^2
4		30	1.19 x10^{-4} N/mm^2
5		40	1.32 x10^{-4} N/mm^2
6		50	1.16 x10^{-4} N/mm^2

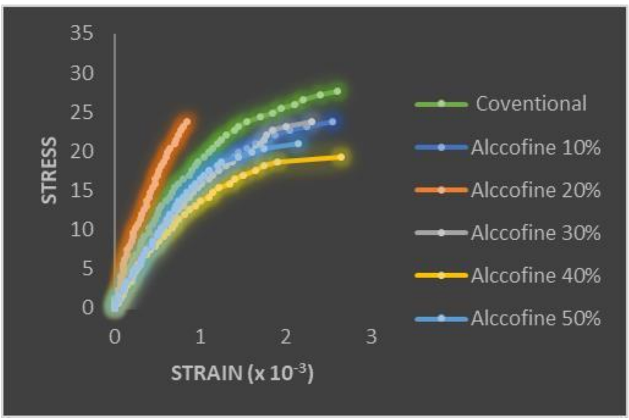

Figure 11 Comparison of Modulus of Elasticity of Concrete

FLEXURAL STRENGTH TEST:

Table 7 shows the Flexural Strength test and Figure 12 shows the graphical representation of

Flexural Strength Results. A maximum flexural strength of 12.2 MPa is found in 40% Alccofine replaced concrete.

Table 7 Flexural Strength Test Results

Sl.No.	Specimen Id	28 Days (MPa)
1	CC100AC0	11.9
2	CC90AC10	9.3
3	CC80AC20	11.3
4	CC70AC30	11.8
5	CC60AC40	12.2
6	CC50AC50	9.8

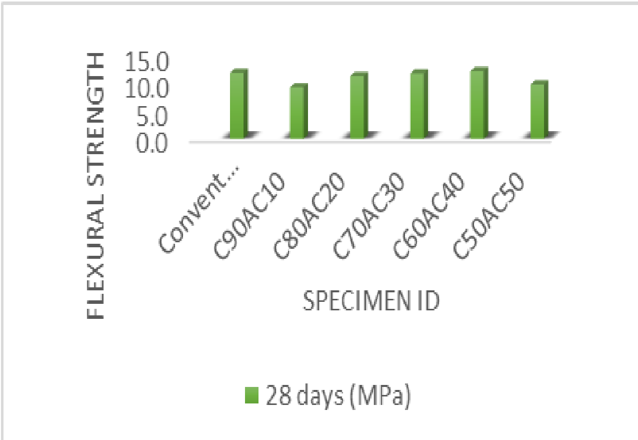

Figure 12 Flexural Strength of Concrete

4. Conclusions

The experimental investigation into concrete mixed with Alccofine has led to several significant conclusions:

1. Enhanced Compressive Strength: Concrete incorporating Alccofine exhibits higher compressive strength compared to conventional concrete. This improvement underscores the effectiveness of Alccofine as a supplementary material in concrete production.

2. Strength Development Over Time: The compressive strength of Alccofine-based concrete (specifically, the C100AC40 mix, which includes a 40% replacement of cement with Alccofine) was measured at 7, 14, and 28 days. The results showed impressive strengths of 40.90 MPa, 42.40 MPa, and 44.0 MPa, respectively. These values are notably higher than those observed in other concrete mixes tested during the study, indicating superior early and long-term strength development.

3. Flexural Strength and Modulus of Elasticity: The study also found that the concrete mix with 40% Alccofine replacement demonstrated the highest flexural strength compared to conventional concrete. This trend was consistent with the Modulus of Elasticity, suggesting that Alccofine not only enhances compressive strength but also improves the overall mechanical performance of the concrete.

4. Significant Strength Gain: The most striking finding is that the 28-day compressive strength of the concrete with 40% Alccofine replacement was 61% higher than that of conventional cement concrete. This substantial increase highlights the potential of Alccofine to greatly enhance the structural integrity and durability of concrete, making it a valuable component in high-performance construction applications.

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