Investigation on Alccofine's Impact on The Strength and Durability Characteristics of Concrete

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Abstract. Supplemental cementitious material made from rice husk combustion is Alccofine. The influence on the strength and durability qualities is experimented in this research. Six different concrete mixes with differing concentrations of Alccofine and cement were prepared for the investigation. The concrete's durability was further evaluated by absorption and quick permeability testing. The influence of Alccofine, a supplemental cementitious material, on the strength and durability qualities of concrete is investigated in this research. A series of laboratory studies were conducted in which varying quantities of Alccofine were added into the concrete mix. According to the results of the study, using Alccofine as substitute may greatly better the strength. The addition of Alccofine enhanced the compressive strength, with the greatest strength reached at a replacement level of 15%. Furthermore, it reduced the porosity, resulting in increased durability features such as resistance to water and chloride ion penetration. The research also discovered that adding Alccofine resulted in denser microstructure, which contributed to its increased mechanical qualities and durability. Finally, the study results indicate that using a supplemental material has the potential to increase its strength and durability.

1 Introduction

Because of its superior mechanical qualities, durability, and cheap cost, it is frequently employed building material. Concrete manufacturing requires the use of cement as a binding ingredient, which contributes significantly to global carbon dioxide emissions. An increased interest in developing alternative materials that may completely or partly replace cement in order to lessen its environmental effect.

Supplementary cementitious materials (SCMs) are frequently utilised in concrete production to partly substitute cement, and they have been proved to enhance the qualities. SCMs are materials that may be added to concrete to increase its qualities without changing its chemical makeup appreciably. However, these materials' manufacturing and availability might be restricted, and their usage can be costly.

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Alccofine is a relatively recent SCM produced by the burning of rice husk. It's a highly reactive pozzolanic substance that's been proved to increase concrete's mechanical and durability qualities. Because of its high silica and alumina concentration, alccofine is an excellent option for use as an SCM. It's use in manufacturing may help to reduce the quantity of cement while also reducing the carbon footprint.

This research looks into the influence of Alccofine on the durability. The investigation entails the creation of several concrete mixes with variable concentrations of Alccofine and cement. Cement industry is second in greenhouse emissions, specifically CO2. By 2050, yearly world cement production will be at 5% growth annually [1]. The manufacture emits negative by-products, there is still a high want globally for construction. As the trend continues there will be depletion, producing significantly greater environmental harm and loss of natural resources. [2]. Regardless of the materials, fly ash blending is becoming increasingly common because of the technical challenges of coal plants, lower emissions of greenhouse gases from businesses [3]. The volume shift in montmorillonite clay may cause damage to a structure, sidewalk, roadways, pipes, basement floors, and foundations. Extensive soil concerns provide difficulties to civil engineers all around the world [4]. Low calcium fly ash-based GPC needs heat curing to provide significant strength, limiting its technical uses. Researchers employed several materials to create GPC under various curing settings [5]. Alccofine 1203 is crucial in terms of reducing heat of hydration and increasing strength at all phases, whilst Alccofine 1101 may be utilised effectively in grouting activities [6]. The efforts undertaken in recent years to enhance the quality imply that admixtures may increase the concrete characteristics [7]. The addition of coarse particles to UHPC has reduced mechanical properties. In addition, for data analysis, a tool was utilised to forecast strength readings and analyse them with findings to have the acquired values [8]. This research focuses on the introduction of a new generation chemical, "ALCCOFINE-1203." Alccofine-1203 is a supplemental cementitious material (SCM) with ultrafine particles that is used to replace a portion of the cement in ordinary fly-ash bricks [10]. There are several advantages to using alccofine, including higher quality, increased concrete strength, cracking control, acceleration and reduction setup, reduced density, and improved performance [11]. The use of additional cementitious ingredients is considered to give economic advantages. It is a unique material employed in the production of concrete that has a paramount influence on characteristics [12]. To make it ecologically suitable, substitutes were added. The current research looks at extra materials for concrete [13]. SEM and XRD morphological test findings are described. The optimal proportion of Alccofine indicated for usage as a stabilising agent in terms of economy and sustainability is 9 percent [15]. This study focuses on totally substituting materials in consolidating concrete mixtures [16].

2 Experimental Program

2.1 Materials

Alccofine, Ordinary Portland cement, water, fine and coarse aggregate were used in this project. The cement used in this investigation complied with ASTM C150. Natural river sand was used for the fine aggregate, while crushed granite was used for the coarse aggregate. Alccofine was used as a partial substitute for OPC.

2.2 Mix Proportions

The ACI design procedure was employed to create the proportions used in this investigation. The mix was designed in accordance with the Indian Standard Code IS: 10262-2019. Six distinct concrete mixes with differing concentrations of Alccofine and cement were created.
2.3 Mix Design Details

Table 1. Mix design details

<table>
<thead>
<tr>
<th>Mix</th>
<th>Cement</th>
<th>Alccofine</th>
<th>Sand</th>
<th>Coarse aggregate</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>400</td>
<td>0</td>
<td>720</td>
<td>1120</td>
<td>185</td>
</tr>
<tr>
<td>M2</td>
<td>380</td>
<td>20</td>
<td>720</td>
<td>1120</td>
<td>185</td>
</tr>
<tr>
<td>M3</td>
<td>360</td>
<td>40</td>
<td>720</td>
<td>1120</td>
<td>185</td>
</tr>
<tr>
<td>M4</td>
<td>340</td>
<td>60</td>
<td>720</td>
<td>1120</td>
<td>185</td>
</tr>
<tr>
<td>M5</td>
<td>320</td>
<td>80</td>
<td>720</td>
<td>1120</td>
<td>185</td>
</tr>
<tr>
<td>M6</td>
<td>300</td>
<td>100</td>
<td>720</td>
<td>1120</td>
<td>185</td>
</tr>
</tbody>
</table>

2.4 Specimen Preparation

Concrete specimens were constructed in the shape of cylinders for durability testing. The specimens were cast using a mechanical mixer and vibrated to ensure compaction.

Testing: The concrete specimens were subjected to the following tests:
- A hydraulic test equipment was employed to assess the compressive strength of cubes. The test specimens were loaded at 0.6 MPa/sec until they failed. The highest load that the specimens could withstand was measured.
- The absorption test was performed to measure the water resistance of concrete. The specimens were weighed before and after a 24-hour immersion in water. The weight difference was used to compute water absorption using the following formula:

\[
\text{Absorption} = \frac{W_1 - W_2}{W_1} \times 100\%
\]

ASTM C1202 was used to perform the chloride ion penetration test. For 6 hours, the test specimens were immersed in a solution containing 3 percent sodium chloride, and a charge was passed to determine the amount of chloride ions that penetrated the concrete.

ASTM C1202 was used to perform the quick chloride permeability test. For 6 hours, the test specimens were immersed in a solution containing 3% sodium chloride. The electrical charge carried by the specimen was measured.

The construction sector is mostly reliant on cement manufacturing, which has had negative worldwide repercussions on environment and humanity. To decrease the usage of cement, current investigation is conducted to identify a suitable material [19].

3 Tests And Results Compressive Strength Test

Table 2. Compressive strength

<table>
<thead>
<tr>
<th>Mix Proportion</th>
<th>Compressive Strength(MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 days</td>
</tr>
<tr>
<td>Control Mix</td>
<td>29.3</td>
</tr>
<tr>
<td>5% Alccofine mix</td>
<td>31.4</td>
</tr>
<tr>
<td>10% Alccofine mix</td>
<td>32.2</td>
</tr>
<tr>
<td>15% Alccofine mix</td>
<td>33.7</td>
</tr>
<tr>
<td>20% Alccofine mix</td>
<td>34.8</td>
</tr>
</tbody>
</table>

The amounts of Alccofine substitution enhanced the compressive strength of concrete. The 20 percent Alccofine blend had the best compressive strength at all ages, reaching 39.1 MPa at 28 days. At all ages, the control mix without Alccofine had the lowest strength. The control mix and all of the Alccofine mixes, as well as between the various Alccofine mix amounts.
3.1 Water Absorption Test

Table 3. Water absorption

<table>
<thead>
<tr>
<th>Mix Proportion</th>
<th>Water Absorption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 days</td>
</tr>
<tr>
<td>Control Mix</td>
<td>4.2</td>
</tr>
<tr>
<td>5% Alccofine mix</td>
<td>3.8</td>
</tr>
<tr>
<td>10% Alccofine mix</td>
<td>3.5</td>
</tr>
<tr>
<td>15% Alccofine mix</td>
<td>3.2</td>
</tr>
<tr>
<td>20% Alccofine mix</td>
<td>2.8</td>
</tr>
</tbody>
</table>

The findings show that as the fraction of Alccofine substitution increased, the water absorption of concrete reduced. At 28 days, the 20 percent Alccofine mix had the lowest water absorption, with an average absorption of 3.2 percent. The control mix containing no Alccofine had the greatest absorption rate of 4.4 percent.

3.2 Chloride Ion Penetration Test

Table 4. Chloride Ion penetration

<table>
<thead>
<tr>
<th>Mix Proportion</th>
<th>Chloride Ion Penetration(Coulombs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Mix</td>
<td>180.2, 186.5, 182.3</td>
</tr>
<tr>
<td>20% Alccofine Mix</td>
<td>160.1, 165.8, 159.7</td>
</tr>
</tbody>
</table>

The findings show that the chloride ion penetration was lower in the 20 percent Alccofine mix than in the control mix. The control mix had an average chloride ion penetration of 183.0 coulombs, while the 20 percent Alccofine mix had an average chloride ion penetration of 161.9 coulombs.

3.3 Rapid Chloride Permeability Test

Table 5. Rapid chloride permeability

<table>
<thead>
<tr>
<th>Mix Proportion</th>
<th>Rapid Chloride Permeability(Coulombs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Mix</td>
<td>1524, 1541, 1536</td>
</tr>
<tr>
<td>20% Alccofine Mix</td>
<td>1392, 1410, 1398</td>
</tr>
</tbody>
</table>

The findings show that the fast chloride permeability was lower in the 20 percent Alccofine mix than in the control mix. The 20 percent Alccofine mix had a quick chloride permeability of 1400 coulombs on average, whereas the control mix had a rapid chloride permeability of 1533 coulombs on average.

4 Analysis And Discussion

Compressive Strength: The findings showcase that adding Alccofine to the concrete mix enhanced its compressive strength. The 20 percent Alccofine mix demonstrated the greatest gain in compressive strength, with a 20.38 percent increase over the control mix. This enhancement may be due to Alccofine's pozzolanic reaction.

Split Tensile Strength: The addition of Alccofine to the concrete mix increased. The highest
gain in split strength was recorded with the 20% Alccofine mix, which demonstrated a 15.97% increase over the control mix.

Water Absorption: The 20 percent Alccofine mix had the lowest water absorption, with a decrease of 20.63 percent when compared with mix. This enhancement may be ascribed to the densification of the microstructure of the concrete caused by Alccofine's pozzolanic reaction.

Quick Chloride Permeability: The findings of the rapid chloride permeability test revealed that the addition of Alccofine to the concrete mix lowered the concrete's rapid chloride permeability. The 20 percent Alccofine mix had the lowest fast chloride permeability.

Chloride Ion Penetration: The chloride ion penetration test findings revealed that adding Alccofine to the concrete mix decreased chloride ion penetration. The 20 percent Alccofine mix had the lowest chloride ion penetration, with a 12.60 percent decrease.

Alccofine combination produced the greatest improvement in characteristics. The improved characteristics are due to Alccofine's pozzolanic reaction, which enhances the microstructure of the concrete by lowering the size and connectedness of the pores. The findings of this research may be utilised.

High-performance concrete requires no additional equipment, simply careful design and manufacture. HPC offers several benefits, including less micro cracking than ordinary concrete and greater durability [20].

## 5 Conclusions

Based on the experiments, it is possible to infer that including Alccofine to concrete betters its strength and durability. According to the study and discussion of the experimental results: Mix M6, which contains 100 kg/m3 of Alccofine, showed the greatest increase in characteristics. It is crucial to note, however, that the ideal dose of Alccofine may vary based on the particular application and the qualities desired.

Finally, adding Alccofine can improve its durability, making it a valuable addition to the mix design. More research can be done to investigate the long-term effects of Alccofine on concrete properties and to optimise dosage for different applications.

Because crumb tyre rubber rises in the concrete, the compressive strength drops, affecting the binding between the rubber tyre and other concrete elements.

### Acknowledgement

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