To Evaluate the Effect of Alccofine and Fly Ash On the Compressive Strength of High Strength Concrete

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ABSTRACT - This study explores the impact of incorporating Alccofine as a supplementary cementitious and filler material on the mechanical properties of high-strength concrete keeping fly ash at 30% such that utilization of the cement should be reduced in a way dependence on natural resources used for extraction of cement get lessen over the period of time to help save environment degradation. Experimental results indicate that a combination of 30% fly ash replacement and 10% Alccofine addition yields the highest compressive strength, suggesting an optimal synergy between these materials. Notably, strength development was significant up to 3 days, accelerated between 3 and 7 days, and progressed at a slower rate from 7 to 28 days. The inclusion of Alccofine also enhanced self-compacting properties, improving filling ability, passing ability, and segregation resistance. Considering Alccofine's lower cost compared to Portland cement, its use not only enhances mechanical performance but also contributes to the economic efficiency of the mix design.

Keywords: Alccofine, Fly ash, Rebound Hammer, M60 grade of concrete.

I. INTRODUCTION

Enhancing concrete strength remains a central focus in concrete technology. High-strength concrete (HSC), typically defined by compressive strengths exceeding 40 MPa, offers superior compressive and tensile strengths, increased stiffness, and enhanced durability compared to normal-strength concrete (NSC). These attributes make HSC particularly advantageous for high-rise buildings, long-span bridges, and structures exposed to aggressive environments. Historically, concrete with a compressive strength of 25 MPa was considered high-strength in the mid-20th century. Advancements in materials and mix design have since elevated achievable strengths, with modern HSC reaching up to 140 MPa in practical applications.

Alccofine is a next-generation micro-fine supplementary cementitious material (SCM) developed in India, engineered to enhance both fresh and hardened properties of concrete. It is available in two primary variants: Alccofine 1203, a low-calcium silicate ultrafine slag-based SCM, and Alccofine 1101, a high-calcium silicate microfine cementitious grout.

Alccofine 1203 is characterized by its ultra-fineness, with a Blaine fineness of approximately 12,000 cm²/g and an average particle size of 4–6 microns. This optimized particle size distribution contributes to improved workability, reduced water demand, and enhanced durability of concrete. Incorporating Alccofine 1203 into concrete mixes can lead to increased early and long-term compressive strength, refined pore structures, and heightened resistance to chemical attacks. Studies have demonstrated that replacing up to 15% of cement with Alccofine 1203 can significantly enhance compressive strength and durability without compromising workability.

Alccofine 1101, with its high-calcium silicate composition, serves as a microfine cementitious grouting material. Its fine particle size allows for deep penetration into soil and rock fissures, making it effective for soil stabilization, rock anchoring, and crack injection applications.

Both variants are produced under controlled conditions to ensure consistent quality and performance. Their unique properties make them suitable for a range of applications, including high-performance concrete, self-compacting concrete, precast elements, and infrastructure projects requiring enhanced durability and strength.

II. MATERIAL AND METHODOLOGY

The investigation focuses on assessing the properties of various materials used in concrete production and their impact on the final product. The materials, including cement, sand, coarse aggregates, fine aggregates, fly ash and alccofine, are meticulously sourced and characterized based on relevant physical properties. This ensures a comprehensive understanding of their behavior within the

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concrete mix. Laboratory testing plays a pivotal role in scrutinizing the properties of these materials. Specifically, the study aims to develop a mix design for M60 grade concrete. This involves conducting tests on the materials to ascertain their suitability and performance in the desired concrete grade. The primary objectives of the study are clearly outlined:

1. Preparation of M60 grade concrete specimens in the laboratory, utilizing conventional materials.

2. Preparation of M60 grade concrete mixes in the laboratory, incorporating fly ash (30% constant) and partial replacement of fine aggregate with alccofine at varying percentages (0%, 4,6, 8 and 10%).

3. Evaluation of the workability and compressive strength of the concrete mixes, comparing both conventional and partial replacement scenarios along with rebound number part of nondestructive testing.

By systematically analyzing the workability and compressive strength of the concrete mixes under different conditions, the study aims to provide insights into the feasibility and efficacy to lessen the load on cement as binder by incorporating fly ash and alccofine in M60 grade concrete production. This research endeavor holds promise for enhancing sustainability in construction practices by utilizing waste materials without compromising performance.

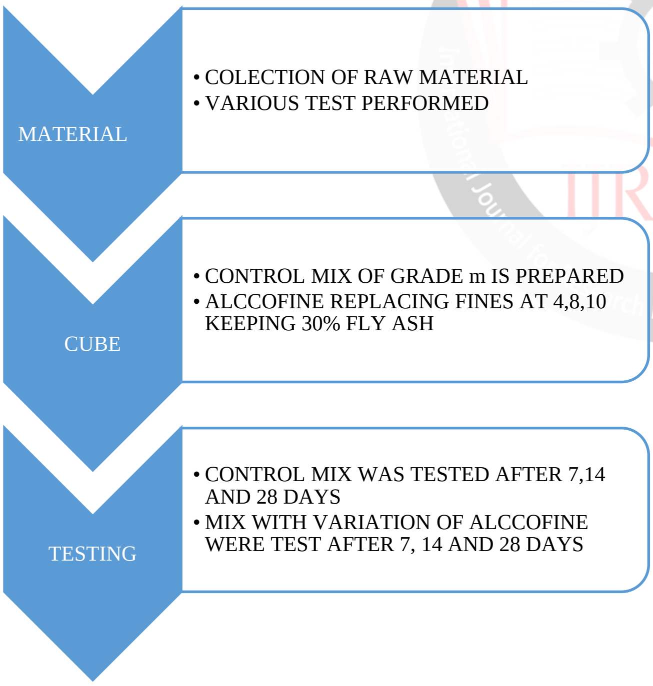

Figure 1 Hierarchy of work

Alccofine 50 kg has been purchased from Ambuja plant for the research work whereas fly ash has been collected from nearby tile maker in appropriate quantity. The various other material such as cement, fine and coarse aggregate, water was brought to the lab. The various test was performed on the collected material as:

A) ALCCOFINE

Alccofine is a brand of microfine materials developed by Ambuja Cements Ltd., comprising two main products: Alccofine 1203 and Alccofine 1101. Alccofine 1203 is an ultrafine slag-based supplementary cementitious material (SCM) with a specific surface area of approximately 12,000 cm²/g and particle sizes (D10: 1–2 µm, D50: 4–5 µm, D90: 8–9 µm). It enhances concrete's strength, durability, and workability, offering early strength development comparable to or exceeding that of silica fume. Alccofine 1101 is a microfine cementitious grouting material used for soil stabilization and rock anchoring, known for its high calcium oxide content and superior performance among Indian admixtures. Both products improve concrete's performance in fresh and hardened stages, making Alccofine a practical substitute for silica fume. It is manufactured by Ambuja Cement Ltd, so the specification is supplied by manufactures as providing its physical and chemical properties as:

Table 1 Physical Properties of Alccofine

Physical Properties	
Fineness (cm2/gm)	>12000
Specific Gravity	2.9
Bulk Density(Kg/m3)	700-900

Table 2 Particle Size Distribution

Particle Size Distribution		
D10	**D50**	**D90**
1.5 micron	5 micron	9 micron

Table 3 Chemical properties

Chemical properties	
CaO	61-64 %
SO_3	2-2.4 %
SiO_2	21-23 %
Al_2O_3	5-5.6 %
Fe_2O_3	3.8-4.4 %
MgO	0.8-1.4 %

B) CEMENT

Cement is a finely ground inorganic binder that, when mixed with water, undergoes hydration—a chemical reaction that causes it to set and harden. This property enables it to bind aggregates like sand and gravel, forming concrete or mortar. The most common type, Ordinary Portland Cement (OPC), is produced by heating limestone and clay to form clinker, which is then ground with gypsum to control setting time. Cement's performance is characterized by properties such as fineness, setting time, soundness, and compressive strength. Its versatility and strength make it essential in construction.

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Table 4 Properties of Cement

Sr.No.	Characteristics	Experimental value	Specified value as per IS:8112-1989
1.	Consistency of cement (%)	33%	30-35%
2.	Specific Gravity	2.99	3.15
3.	Initial setting time (min)	32	>30 As Per IS4031-1968
4.	Final setting time (min)	300	<600 As Per IS4031-1968
5.	Compressive strength (N/mm^2)		
	i) 3 days	27.56	>23
	ii) 7 days	40.57	>33
	iii) 28 days	48.96	>43
6.	Soundness (mm)	2.3	10
7.	Fineness of Cement	6%	10% As Per IS269-1976.

III. RESULT AND DISCUSSION

A. CONCRETE

For this experiment work m60 has been achieved in a way that we kept the quantity of fly ash has been fixed to 30% in the mix. Following test has been performed on fresh as well as hardened state whose result are discussed below:

a) Workability

The workability of the mix prepared is described in table 5.1.

Table 5 Slump value

Sample	%age of fly ash	%age of Alccofine	Slump
Controlled Mix	0	0	95
D1	30	4	103
D2	30	6	110
D3	30	8	114
D4	30	10	120

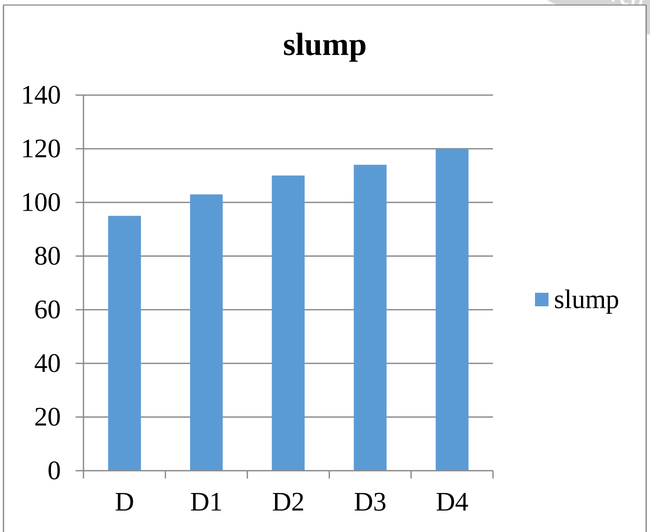

Figure 2 Slump Value

b) Compressive Strength and Rebound Hammer Value

Test specimens of size 150 mm x 150 mm x 150 mm were prepared to evaluate the compressive strength of concrete. The concrete was cast into cubes and cylinders for subsequent testing. To prepare the concrete mix, cement and fine aggregate were first blended dry until a uniform color was achieved.

On the same cube casted, the Rebound hammer test is performed. The Rebound Hammer Test, as per IS:13311 (Part 2)–1992, is a non-destructive method to estimate concrete compressive strength by assessing surface hardness. A spring-driven mass impacts the concrete surface, and the rebound distance is measured as the Rebound Number. This value correlates with compressive strength through calibration curves. The test involves calibrating the hammer on a steel anvil, ensuring the concrete surface is clean and smooth, and taking multiple readings per test point. Factors like surface moisture, carbonation, aggregate type, and concrete age can influence results. While convenient, the method provides approximate strength values and is best used alongside other assessments. The result is discussed as:

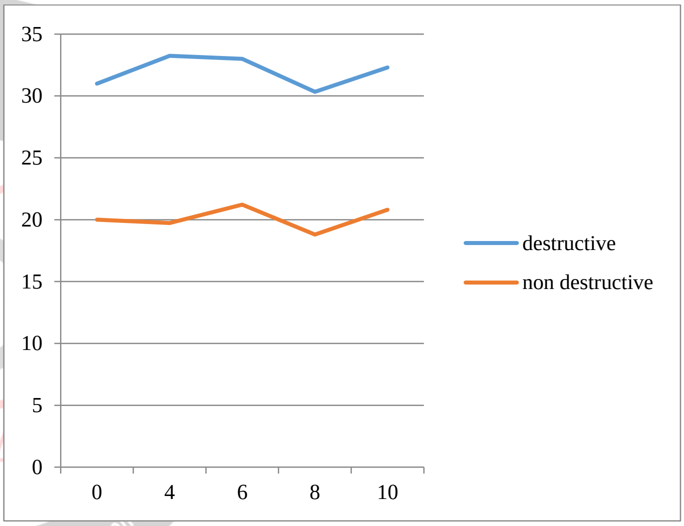

Figure 3 Comparison of strength after 3 days

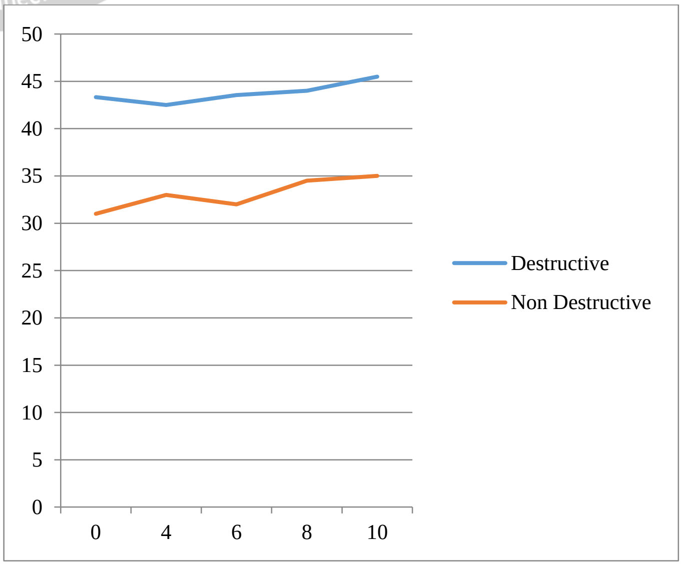

Figure 4 Comparison of strength after 7 days

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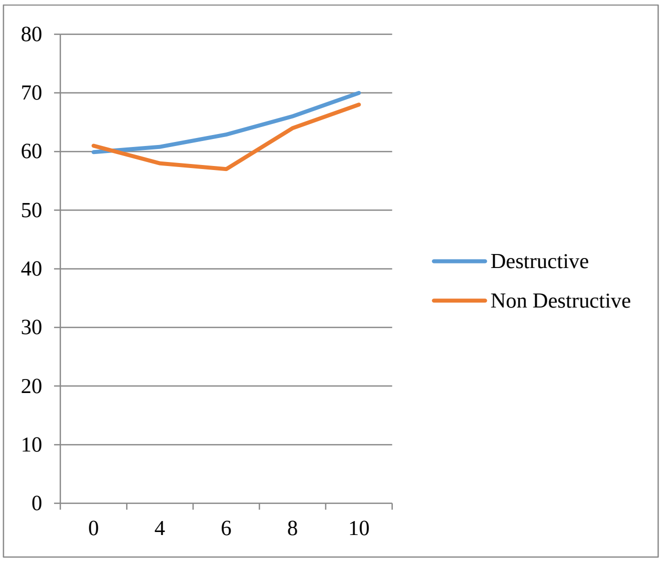

Figure 5 Comparison of strength after 28 days

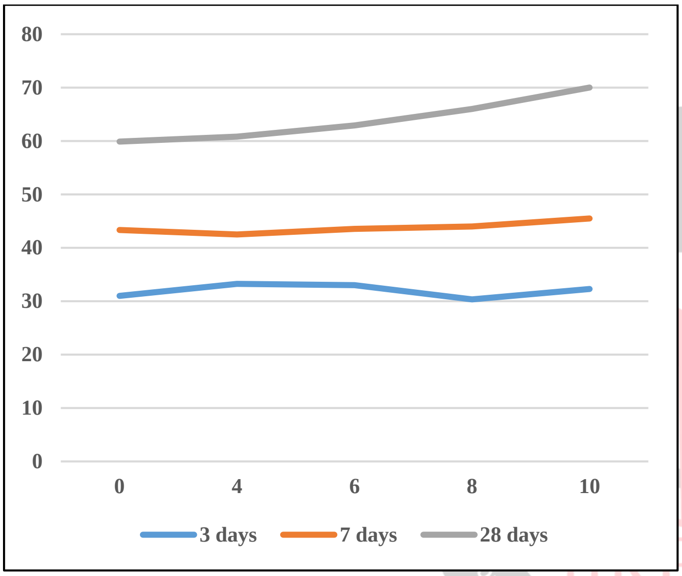

Figure 6 Linear Variation of compressive strength (DT)

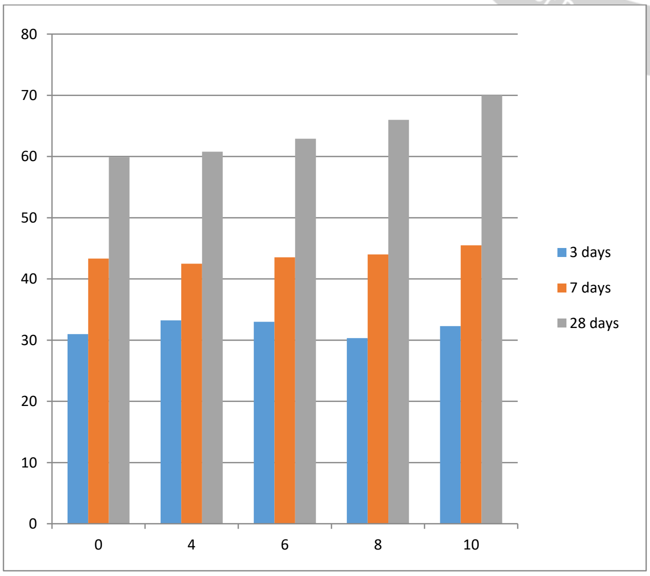

Figure 7 Comparison of compressive strength (DT)

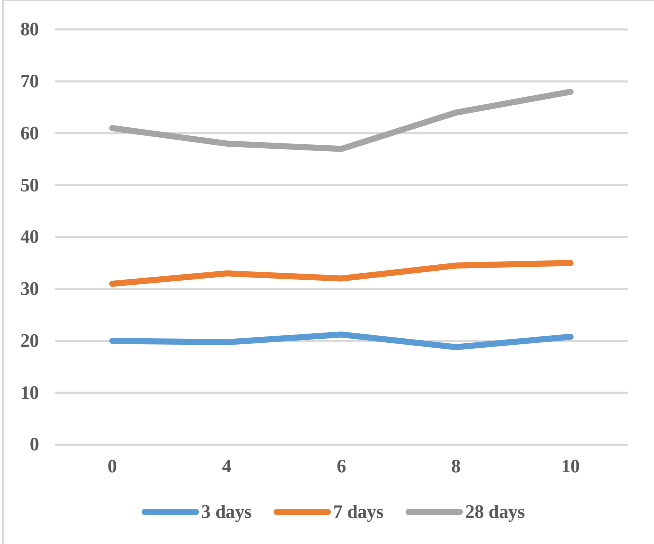

Figure 8 Linear Variation of Rebound Number (NDT)

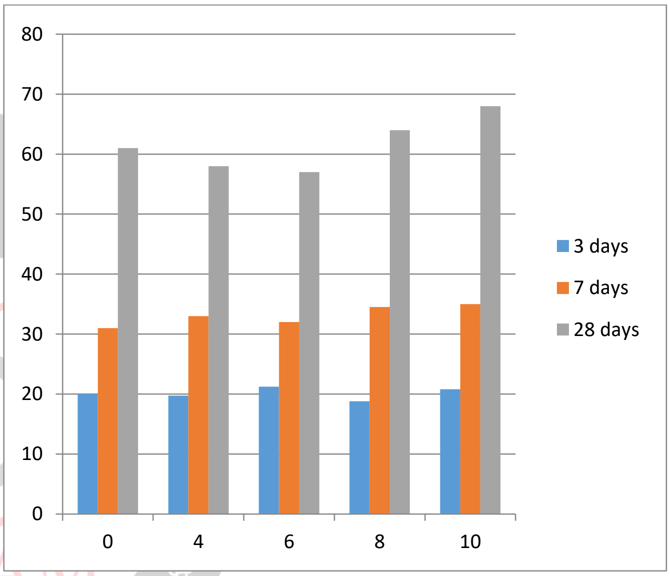

Figure 9 Comparison of Rebound Number (NDT)

IV. CONCLUSION

The strategic use of 30% fly ash combined with up to 10% Alccofine in concrete mixes significantly improves workability, early and long-term compressive strength, and durability, offering a sustainable and efficient approach to concrete formulation.

- Incorporating 30% fly ash and increasing Alccofine content from 4% to 10% progressively enhances concrete workability, as evidenced by slump values rising from 103 mm to 120 mm. This improvement is attributed to fly ash's spherical particles enhancing flowability and Alccofine's fine particles filling voids, reducing internal friction.
- Incorporating 30% fly ash with 4–10% Alccofine enhances 28-day compressive strength from 59.9 MPa (control) to 70 MPa, due to Alccofine's ultrafine particles densifying the concrete matrix.
- Alccofine accelerates hydration, improving early-age strength; mixes with Alccofine show

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comparable or higher strength at 3 and 7 days compared to control.

- An optimal balance of fly ash and Alccofine is crucial; excessive Alccofine may reduce workability due to increased water demand.
- Higher Alccofine content correlates with increased rebound numbers, indicating denser concrete matrices and higher compressive strength.

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