

Evaluating the Optimal Alccofine-1203 Replacement Ratio in M20 Grade Concrete

Hanumesh B M¹, Harish B A^{2,*}, Swapna Channagoudar³

Abstract

The primary objective of this research is to investigate the potential of partially replacing cement with Alccofine 1203 in M20 grade control concrete and to evaluate the resulting effects on the mechanical properties of the concrete. Alccofine 1203, a high-performance mineral admixture known for its ultrafine particle size and high reactivity, was used as a partial cement substitute at varying replacement levels of 5%, 10%, and 15% by weight of cement. Both fresh and hardened properties of the modified concrete mixes, along with the control mix, were evaluated through a series of laboratory tests. To assess the mechanical performance, a total of 72 concrete specimens—comprising 150 × 150 × 150 mm cubes for compressive strength tests and 150 mm diameter × 300 mm height cylinders for split tensile strength tests—were cast and cured. The specimens were tested at curing ages of 7, 14, and 28 days. The experimental results revealed that a 10% replacement of cement with Alccofine 1203 yielded the most favorable results in terms of both compressive and split tensile strength. Strength values improved significantly up to this optimum dosage, beyond which a decline in performance was observed. The study concludes that incorporating Alccofine 1203 in M20 grade concrete not only enhances its mechanical properties but also presents a sustainable alternative to conventional cement. This indicates its potential for broader applications in the construction industry, especially where improved strength and durability are desired.

Keywords: Alccofine 1203, M20 grade concrete, compressive strength (CS), split tensile strength (ST), cement replacement, mineral admixture, mechanical properties

INTRODUCTION

Concrete, a material often used in construction, now has much greater strength and endurance thanks to recent improvements. To produce high-strength concrete that is appropriate for real-world applications, mineral admixtures are necessary. There has been an increase in the adoption of these admixtures as pozzolans worldwide. Mineral admixtures may increase the cohesion, strength,

permeability, and durability of concrete when added in the right amounts, both during the fresh and hardened phases. Several benefits, including lower heat of hydration, increased water tightness, a reduction in alkali-aggregate reaction, better workability, and resistance to sulphate soil assaults and saltwater intrusions, may result from using the right ratios of mineral admixtures to Ordinary Portland Cement (OPC). Alccofine-1203 is a well-crafted product that has been granulated to a precise consistency, giving it a high glass content and great reactivity. Low calcium silicates (belite & alite) and other carefully chosen chemicals are the main components that provide a regulated particle size distribution (PSD). Alccofine-1203 has an estimated Blaine value of 12,000 cm²/g, making it

*Author for Correspondence

Harish B A

¹Assistant Professor, Department of Civil Engineering, GM University-Davanagere, Karnataka, India

²Assistant Professor, Department of Civil Engineering, GM University-Davanagere, Karnataka, India

³Associate Professor, Department of Civil Engineering, SKSVMACET-Laxmeshwara, Visvesvaraya, Technological University-Belagavi, Karnataka, India

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ultra-fine. Depending on the required concrete performance, its distinct chemistry and ultra-fine particle size may be able to drastically cut water consumption by up to 70 %. Alccofine-1203 may also be used as a very powerful workability aid to intensification flow or as a high-range water reducer to raise compressive strength (CS). Alccofine, like pozzolans, uses the calcium hydroxide $[Ca(OH)_2]$ byproduct of concrete hydration to generate more C-S-H gel, which leads to stronger and denser pore structures. The properties of silica fume and alccofine-1203 on the workability, water requirements, admixture requirements, strength, and durability of concrete are investigated in this research.

LITERATURE REVIEW

The effects of substituting alccofine for cement in concrete on its strength and durability have been extensively researched by specialists. Self-compacting concrete (SCC) was created by Kavitha and Felix Kala (2016) [1] by adding alccofine-1203 and ground granulated blast furnace slag (GGBS) to the cement mixture. They assessed the SCC's workability, split tensile (ST) strength, flexural strength (FS), and compressive strength (CS) at different percentages of alccofine-1203 replacement—5 %, 10 %, 15 %, and 20 %—along with 30 % GGBS. According to their research, GGBS and alccofine-1203 together increased the workability and strength attributes of SCC; alccofine-1203's smooth surface and fine texture helped to achieve this better workability. To test the efficacy of SCC with alccofine-1203, Pawar and Saoji (2013) [2] added several volume percentages of the material to the binder, ranging from 0 % to 15 %, while keeping the quantities of cement, fly ash, and aggregates constant. Their results showed that adding alccofine-1203 significantly improved the fresh and hardened characteristics of regular SCC; furthermore, the SCC with 10% alccofine-1203 had better compressive strength (CS) and workability. The strength characteristics of lightweight concrete using coconut shells and alccofine-1203 as a partial replacement for coarse materials were inspected by Sanjeev Kumar et al. (2019) [3]. Alccofine-1203 was utilised for the remaining 6 %, 8 %, 10 %, and 12 % of the cement. Of all the mixes examined, the combination containing 8 % alccofine-1203 had the lowest density and the best compressive strength (CS). In place of cement, different concentrations of alccofine-1203 were used by Gayathri, Ravichandran, and Saravanan (2016) [4] to evaluate the durability of concrete. In comparison to the control mixture and other mixes including arccosine-1203, they found that the concrete mixture containing 15 % alccofine-1203 had the lowest coulombs passing value, the strongest resistance to acid penetration, and the least amount of weight and strength loss. The water absorption and porosity of high-strength concrete (HSC) containing alccofine-1203 were investigated by Sagar and Sivakumar (2021) [5]. The sample containing 20 % fly ash and 10 % alccofine-1203 was found to have the lowest water absorption capacity because of its low pore concentration and thick matrix. In addition to assessing the mechanical and microstructural characteristics of HSC, they looked at the fly ash and alccofine-1203 percentages. After 28 days, they found that the mixture containing 20 % fly ash and 30 % cement had the greatest split tensile strength (ST) (5.81 MPa), flexural strength (FS) (6.22 MPa), and compressive strength (CS) (80.33 MPa) when compared to the other combinations. Finally, Kavya Teja et al. (2020) [6] used 25 % fly ash and various concentrations of alccofine-1203 to study the mechanical characteristics of SCC with partial cement substitution. The specimens with a modulus of rupture and the maximum compressive strength (CS) and split tensile strengths (ST) were found to contain 10 % alccofine-1203 and 25 % fly ash, respectively. They concluded that 10 % alccofine-1203 and 25 % fly ash substitution percentages are the best options for attaining SCC's remarkable strength qualities.

MATERIALS AND MIX DESIGN

For this experiment, all concrete mixes were cast using Ultratech cement 43 grade OPC. There were never any definite lumps in the cement, and it always looked grey with a tint of green. In compliance with IS: 8112-1989 [13], tests for fineness, specific gravity, compressive strength, and early and last setting times were carried out. The sand used in the project was locally produced and had a specific gravity [9] of 2.58 and a fineness modulus of 3.42. It met the grading zone I standards of IS: 383-2016 [10]. The coarse aggregates had a specific gravity [9] of 2.44 and a maximum size of 20 mm. They were freely available in the vicinity. The mineral additive was Alccofine 1203 from Bangalore, Karnataka-based Akash Enterprises. The physical properties of Alccofine 1203 are as follows: bulk density of 680 kg/m³, specific gravity of 2.70, particle size distribution ($d_{10} = 1.8 \mu\text{m}$, $d_{50} = 4.4 \mu\text{m}$, $d_{90} = 8.9 \mu\text{m}$), and

a specific surface area of 12,000 cm²/gm. The chemical composition of Alccofine 1203 is Fe₂O₃ (1.20%), SO₃ (0.13%), SiO₂ (35.30%), MgO (8.20%), Al₂O₃ (21.40%), and CaO (32.20%). Both the preparation and curing of the specimens were done using potable tap water. In concrete technology, exact ingredient proportioning is crucial to ensuring both quality and economy. The first stage in attaining the intended performance characteristics is the selection of component materials, which is followed by the mix design procedure to ascertain the ideal component blend. To create M20 grade concrete [Table 1] [8], this project used a mix design [Table 2] technique based on IS: 10262 – 2009 [7].

Table 1. Blend ratios.

w/c ratio	Water 'W'	Cement 'C'	Fine aggregate 'FA'	Coarse aggregate 'CA'
0.50	(kg/m ³)			
	197	394	698	991.12

Table 2. Concrete mix designation.

Combination designation	Description
M0	M20 Grade Control Concrete
M1	5 % Alccofine + 95 % Cement
M2	10 % Alccofine + 90 % Cement
M3	15 % Alccofine + 85 % Cement

Table 3. Compressive strength (CS) overall findings.

Combination designation	Compressive strength (CS) (N/mm ²)		
	7	14	28
	<i>Days</i>		
M0	26.66	31.25	35.85
M1	30.22	34.07	37.18
M2	38.51	41.47	46.81
M3	33.32	36.88	40.73

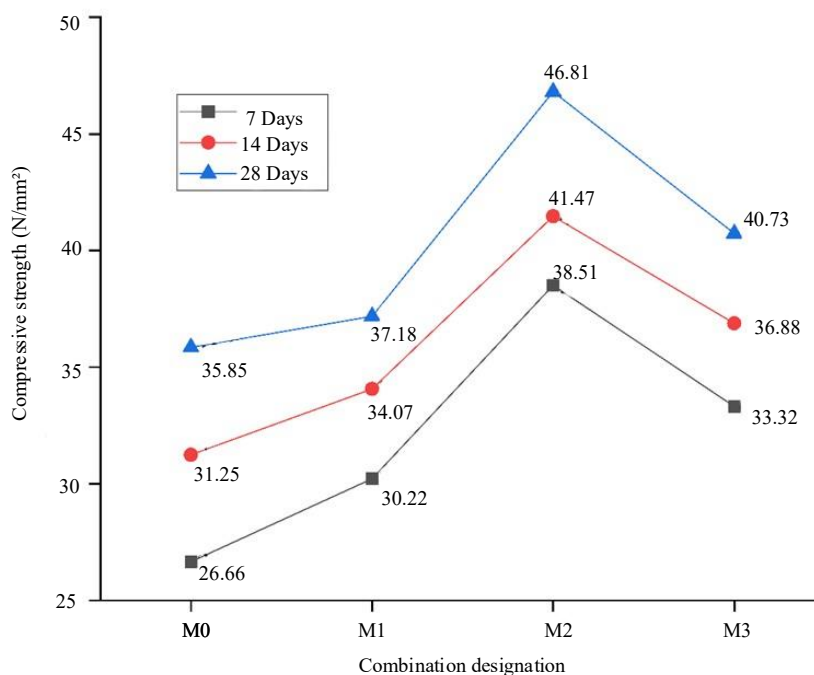
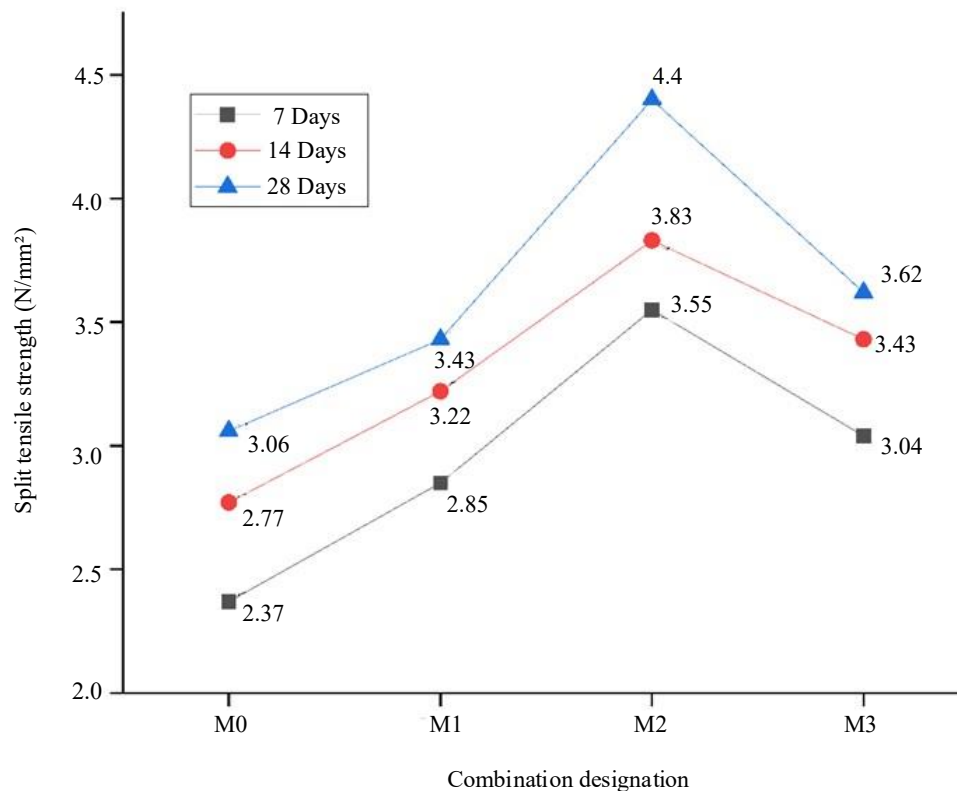


Figure 1. Compressive strength (CS) overall findings.

Table 4. Split tensile (ST) strength overall findings.

Combination designation	Split tensile strength (ST) (N/mm ²)		
	7	14	28
	Days		
M0	2.37	2.77	3.06
M1	2.85	3.22	3.43
M2	3.55	3.83	4.40
M3	3.04	3.43	3.62

**Figure 2.** Split tensile (ST) strength overall findings.

EXPERIMENTAL RESULTS

Compressive Strength (CS) Test Result

After 7, 14, and 28 days of hardening, the compressive strength (CS) [Table 3] [11] of each concrete mix was measured using three 150 x 150 x 150 mm cubes. The total compressive strength (CS) of alccofine concrete produced at different alccofine percentages is shown in the table below. The fluctuation in compressive strength (CS) is seen in Figure 1.

Split Tensile (ST) Strength Test Result

After 7, 14, and 28 days of hardening, the split tensile (ST) [Table 4] [11] strength of alccofine concrete with different alccofine percentages was measured. Cylinders of 300 mm in length and 150 mm in diameter were tested using IS: 5816 – 1999 [12]. An overview of the split tensile (ST) strength data is shown in Figure 2.

OBSERVATIONS AND DISCUSSIONS

Important findings were obtained from an experiment that looked at the effects of partly substituting cement for alccofine on concrete's compressive strengths (CS) and split tensile (ST). At 7, 14, and 28 days, the control concrete's compressive strengths (CS) were 26.66, 31.25, and 35.85 N/mm²,

respectively. As a result of the high pozzolanic character of alccofine, the M₂ mix, on the other hand, showed values of 38.51, 41.47, and 46.81 N/mm² at the same intervals, showing a considerable increase in strength. This property improves void-filling abilities and produces a C-S-H (calcium-silicate-hydrate) gel that is more densely packed. The compressive strength (CS) of M20 grade concrete improved by 44.45 %, 32.70 %, and 30.45 % at 7, 14, and 28 days, respectively, with a 10 % alccofine replacement level. Nevertheless, after the same period, the compressive strength (CS) dropped below a 10 % replacement, which led to the conclusion that the maximum percentage of alccofine replacement for M20-grade concrete is 10 %. At 7, 14, and 28 days, the control concrete's split tensile (ST) strength rose in proportion to the rise in the percentage of alccofine. The M2 mix had split tensile (ST) values of 3.55, 3.83, and 4.40 N/mm², while the control concrete had split tensile (ST) strengths of 2.37, 2.77, and 3.06 N/mm². Due to improved aggregate-cement matrix packing and interfacial bonding, the tensile strength significantly increased by adding alccofine. However, after 7, 14, and 28 days after a 10 % replacement, the split tensile (ST) strength of the M2 mix dropped compared to the control concrete, suggesting a loss in strength. After 7, 14, and 28 days, the M2 mix's split tensile (ST) strength improved by 49.78 %, 38.27 %, and 43.79 %, respectively.

CONCLUSIONS

The following are the findings of a small-scale experimental investigation on the split tensile strength (ST) and compressive strength (CS) of concrete that has some alccofine substituted for cement:

- Replacing cement with alccofine can enhance concrete's compressive strength (CS) by up to 10%. However, beyond a 10% replacement, the compressive strength decreases.
- Similarly, concrete's split tensile strength (ST) can increase by up to 10% with alccofine substitution. But at a replacement level of 10%, the split tensile strength also starts to decline.
- The strength properties of concrete are significantly influenced by the amount of alccofine used due to its strong pozzolanic characteristics. Thus, the substitution level must be carefully optimized to achieve the best performance.

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