Experimental Investigation of Alccofine Based M40 Grade Concrete with Granite Dust

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Abstract - Concrete remains the most widely used construction material in civil engineering; however, the depletion of natural resources and the environmental burden associated with cement production have created a growing need for sustainable alternatives. Rapid urbanization and infrastructure expansion have intensified the scarcity of key raw materials such as cement, natural sand, and quality aggregates. In response to these challenges, this study investigates the feasibility of incorporating granite dust and Alccofine as partial replacements for cement in high-performance M40 grade concrete. Granite dust, a readily available industrial byproduct of granite processing, is utilized to reduce waste generation and environmental pollution. Alccofine, a highly reactive ultrafine material derived from Ground Granulated Blast Furnace Slag (GGBFS), contributes significant pozzolanic activity, enhancing both strength development and microstructural performance.
The experimental program explores granite dust replacement levels of 10%, 20%, 30%, 40%, and 50%, combined with Alccofine proportions of 5%, 10%, 15%, and 20%. Conplast SP550 is incorporated as a superplasticizer to ensure adequate workability. Mechanical properties—including compressive, split tensile, and flexural strength—are evaluated at multiple curing periods and compared with conventional M40 concrete. Additionally, non-destructive tests such as the rebound hammer and ultrasonic pulse velocity provide supplementary validation of the mechanical behavior and quality of the developed mixes. The findings identify the optimum blend of granite dust and Alccofine that achieves superior strength characteristics while promoting sustainability in construction. This study demonstrates that both materials can effectively enhance concrete performance and serve as environmentally responsible alternatives in high-performance concrete applications.

Key Words: Granite dust; Alccofine; High-performance concrete; Mechanical properties; Sustainable construction.

1.INTRODUCTION

This document shows the suggested format and appearance of a Concrete is the most widely used construction material in the world, second only to water in terms of consumption. Its versatility, durability, and ability to be moulded into any desired shape make it indispensable for infrastructure development, buildings, transportation systems, and industrial structures. Conventional concrete is composed of cement, coarse and fine aggregates, and water, forming a composite structure in which aggregates are bound together by a hydrated cement matrix [1]. As nearly 70–75% of concrete volume consists of aggregates, the availability of high-quality natural aggregates is critical for construction activities. However, rapid urbanization and extensive infrastructure development have led to the depletion of natural resources, creating an urgent need for sustainable alternative materials [2]. Cement production presents an additional environmental challenge. Globally, cement manufacturing contributes approximately 7–8% of CO_2 emissions, primarily due to calcination of limestone and the high-energy requirements of clinker production at temperatures up to 1450°C [3]. This has prompted researchers to explore supplementary cementitious materials (SCMs) such as fly ash, ground granulated blast furnace slag (GGBFS), rice husk ash, geopolymers, and bio-based binders to reduce carbon emissions and improve durability [4]. Among these, Alccofine—a micro-fine slag-based material—has gained considerable attention due to its high pozzolanic reactivity, ability to enhance early and later-age strength, and its role in producing high-performance and self-compacting concretes [5].
Similarly, granite dust, a byproduct of quarrying and stone-cutting operations, offers potential as a partial replacement for fine aggregates or cement. Its use not only reduces environmental pollution from waste disposal but also enhances packing density, reduces permeability, and improves mechanical performance when used in appropriate proportions [6]. Integrating these sustainable materials in concrete aligns with global efforts to reduce carbon footprint, promote waste utilization, and achieve long-term durability in modern construction. Therefore, the combined use of Alccofine and granite dust presents a promising avenue to develop high-performance, eco-friendly concrete suitable for diverse engineering applications.

1.1 Scope of the Study

The present investigation focuses on studying and evaluating the impact of incorporating Alccofine, derived from Ground Granulated Blast Furnace Slag (GGBFS), to enhance the performance of concrete. The study involves optimizing the proportions of granite dust (10%, 20%, 30%, 40%, and 50%) and Alccofine (5%, 10%, 15%, and 20%) in M40 grade concrete, with Conplast SP550 used as a superplasticizer to ensure the required workability. Standard cube specimens of size 150 mm × 150 mm × 150 mm are cast and tested for compressive strength at curing ages of 7, 14, 28, and 56 days. Similarly, standard cylinders of size 150 mm × 300 mm are prepared and tested at 7, 14, 28, and 56 days to determine split tensile strength. Based on these results, the optimum concrete mixes are identified, and non-destructive testing methods, including the Rebound Hammer test and Ultrasonic Pulse Velocity test, are performed on the selected mixes. Overall, the partial replacement of cement with granite dust and Alccofine demonstrates significant environmental and economic advantages, highlighting its potential for sustainable concrete production.

1.2 Objectives of the Study

The present study utilizes Alccofine sourced from Chennai, Tamil Nadu, as a cement replacement material, and granite dust obtained from a granite processing industry located in Tekkali, Srikakulam, Andhra Pradesh. Optimal dosage ranges of both Alccofine and granite dust are selected based on preliminary concrete mix studies. The primary aim of this investigation is to evaluate the performance of concrete mixes incorporating Alccofine and granite dust and compare their behavior with that of conventional concrete. The specific objectives of the study are as follows:

- To optimize the percentage replacement of cement with Alccofine by conducting compressive strength tests on M40 grade concrete specimens at various curing ages.
- To optimize the percentage replacement of cement with granite dust by performing compressive strength tests on M40 grade concrete specimens at different curing periods.
- To determine the mechanical properties of M40 grade concrete containing the optimum proportions of granite dust and Alccofine as partial cement replacements, and to compare the obtained strength results with those of conventional concrete.
- To evaluate the compressive strength of M40 grade concrete with optimum granite dust and Alccofine content through rebound hammer testing and compare the results with conventional concrete.
- To compare the ultrasonic pulse velocity values of M40 grade concrete containing optimum granite dust and Alccofine content with those of conventional concrete.
- To compare the flexural strength of M40 grade concrete beams incorporating optimum granite dust and Alccofine content with that of conventional concrete beams.

2. Materials and Methodology

2.1 CEMENT

Ordinary Portland cement (OPC) of 53 grade (priya cement) was used. fineness, specific gravity, standard consistency, initial setting time, final setting time were the tests conducted on cement.

2.1.2 Aggregate

Depending upon their size, the aggregates are classified as (i) Fine Aggregative (ii) coarse aggregates.

a) Coarse aggregate: The aggregate passing from 20mm sieve and retained on 4.75mm sieve are termed as coarse aggregate. The mixture of 20mm and 10mm size aggregate are used. Water absorption, specific gravity are the tests conducted on coarse aggregate.

b) Fine aggregate: -The aggregate passing from 4.75mm and retained on 150µm sieve are termed as fine aggregate. Fine aggregate was taken from Vamsadara River (Srikakulam). Particle size distribution, specific gravity are the tests conducted on fine aggregate. The sieve analysis as shown in table 1

2.1.3 Alccofine

Alccofine is a high-performance supplementary cementitious material (SCM) used in concrete to enhance strength, durability, and workability. It is an ultrafine, low-calcium silicate material with high reactivity, making it ideal for high-strength and high-performance concrete applications. Alccofine improves early strength development, reduces permeability, and enhances resistance to chemical attacks, making it suitable for infrastructure projects like bridges, tunnels, and marine structures.

2.1.4 Granite dust

Granite dust is a fine by product obtained from the crushing and processing of granite stone. It is commonly used as a supplementary material in concrete and construction applications to improve strength, durability, and workability. Granite dust enhances the mechanical properties of concrete, reduces environmental impact by utilizing waste material, and can be used as a partial replacement for cement or fine aggregates. The properties as shown in table2

Table 2 Properties of Granite Dust

PROPERTIES	
Type	Granite powder
Maximum Size	90micron
Specific Gravity	2.57
Water Absorption	3.62
Moisture Content	Nill
Fineness Modulus	<0.075mm

Table 3 Sieve analysis of River sand

IS Sieve Size (mm)	Weight Retained	% Weight Retained	Cumulative % Weight Retained(W_1)	% Passing
4.75	86	8.6	8.6	91.4
2.36	142	14.2	22.8	77.2
1.18	128	12.8	35.6	64.4
600	156	15.6	51.2	48.8
300	205	20.5	71.7	28.3
150	283	28.3	100	0

Physical properties	
Form	Powder
Odour	Odourless
Colour	Grey
Density	2.7 – 2.9
Bulk density	Approx. 700kg/m3
% Volatiles	0 g/l
Solubility in water	Insoluble
Solubility in other solvents	Slightly soluble

Fig.1 Methodology Flow Chart

3.Mixing of Concrete

The present study uses M40 grade concrete, designed as per the relevant IS codes. The mixing proportions of cement, water, fine aggregate, coarse aggregate, Alccofine, and granite dust are obtained from the approved mix design and used for casting the required specimens. The calculated quantities for each batch are thoroughly hand-mixed to achieve a uniform consistency before moulding them into cubes and cylinders for strength testing.

3.1 Casting of Specimens

The materials used for casting concrete cubes include cement, fine aggregate, coarse aggregate, and water. After completing the preliminary material tests and finalizing the mix proportions, concrete cubes are cast following standard procedures. The moulds are filled in three approximately equal layers (about 33 mm each). Compaction is carried out using a compacting bar, ensuring uniform distribution of strokes across the surface of each layer. Every layer is compacted fully to eliminate voids and achieve proper density.

3.2 Mix Details Used in the Study

The nomenclature of the concrete mixes used in this investigation is as follows:

- **M1:** Cement + River sand + Coarse aggregate + Water
- **M2:** Cement + 5% Alccofine + River sand + Coarse aggregate + Water
- **M3:** Cement + 10% Alccofine + River sand + Coarse aggregate + Water
- **M4:** Cement + 15% Alccofine + River sand + Coarse aggregate + Water
- **M5:** Cement + 20% Alccofine + River sand + Coarse aggregate + Water
- **M6:** Cement + 10% Granite dust + River sand + Coarse aggregate + Water
- **M7:** Cement + 20% Granite dust + River sand + Coarse aggregate + Water
- **M8:** Cement + 30% Granite dust + River sand + Coarse aggregate + Water
- **M9:** Cement + 40% Granite dust + River sand + Coarse aggregate + Water
- **M10:** Cement + 50% Granite dust + River sand + Coarse aggregate + Water
- **M11:** Cement (65%) + 15% Alccofine + 20% Granite dust + River sand + Coarse aggregate + Water
- **.Results and Discussions**

4.1 Compressive Strength

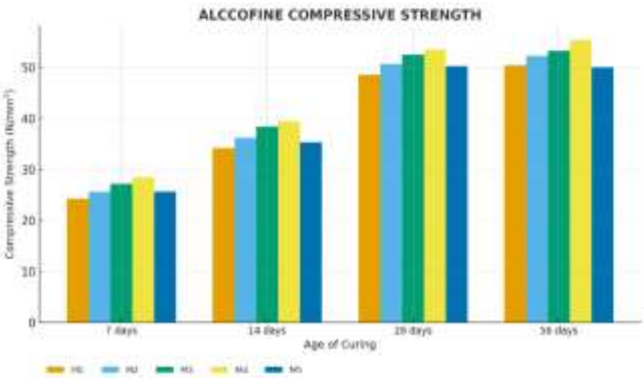

Figure 2 Compressive strength for Alcofine variations mixes

Across all curing ages, mixes M2, M3, and M4 consistently show an increase in compressive strength when compared to M1, with M4 demonstrating the highest improvement throughout. At 7 days, M2, M3, and M4 show an increase of 5.61%, 12.23%, and 17.56%, respectively, while M5 records an increase of 5.87%. A similar trend is observed at 14 days, where M2 increases by 5.96%, M3 by 12.25%, and M4 by 15.39%, with M5 showing a smaller increase of 3.22%. At 28 days, M2, M3, and M4 again show improved strengths with increases of 4.39%, 8.15%, and 10.39%, respectively, whereas M5 records an increase of 3.57%. By 56 days, M2, M3, and M4 continue to perform better than M1 with increases of 3.61%, 5.68%, and 9.90%, respectively. However, M5 shows a slight decrease of 0.63% compared to M1 at this age. Overall, M4 provides the maximum improvement at all curing ages, followed by M3 and M2, highlighting the benefits of Alccofine incorporation in these mixes.

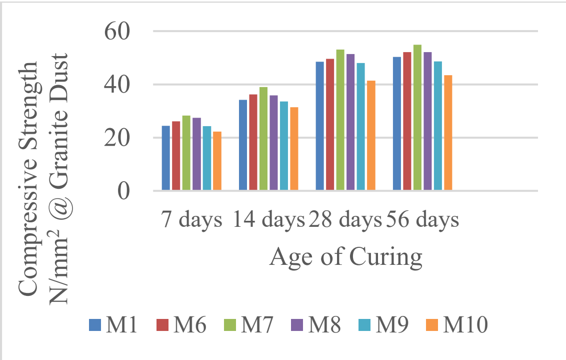

Figure 3 Compressive Strength of M40 Grade Concrete with Optimum Content of Alccofine and Granite Dust

4.2 Split Tensile strength

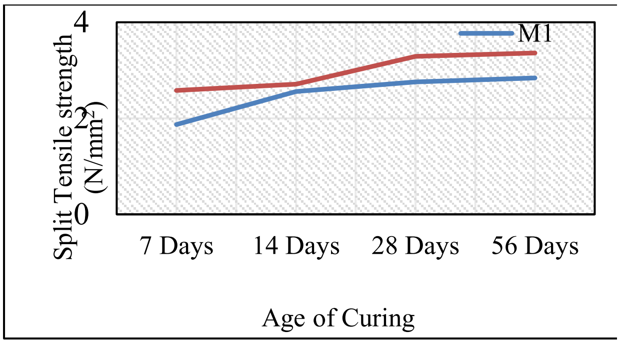

Figure 4. Variation of Split Tensile Strength of M1 Concrete Mix at Different Curing Ages (7, 14, 28, and 56 Days).

5.flexural strength of m40 grade concrete with optimum content of alccofine and granite dust

Material selection & characterization – Ordinary Portland cement, Alccofine, granite dust, coarse aggregates, and water. Mix design – Preparation of M40 grade concrete mixes with varying percentages of Alccofine ,SP550 and granite dust. Testing – Flexural strength tests performed at 7, 14, and 28 days in accordance with concrete mixes are shown in figure5

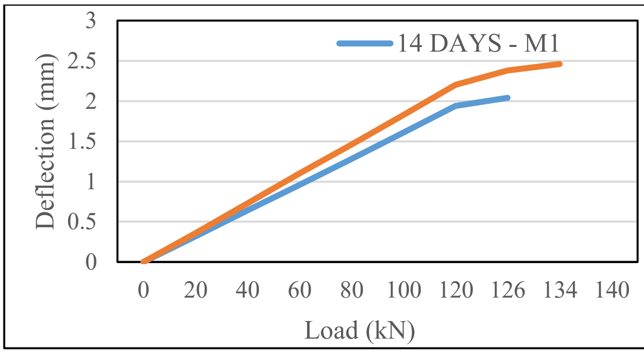

Figure5 Load deflection behavior of M40 grade concrete mix with Alccofine and Granite Dust at 7 days curing

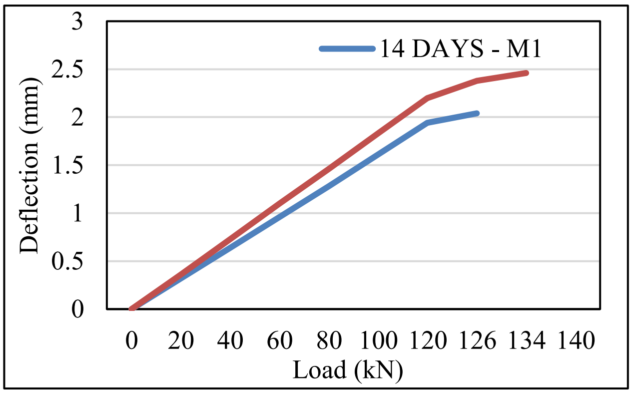

Figure5 Load deflection behaviour of M40 grade concrete mix with Alccofine and Granite Dust at 14 days curing

From the Figure it is observed that the flexural strength of concrete mix M11 has exhibited maximum bending and shear cracks when compared to mix M1 at 14 days curing period.

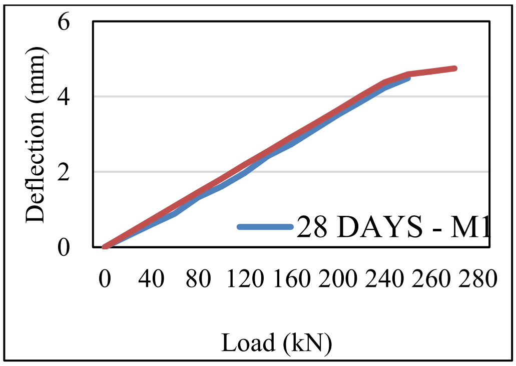

Figure 6 Load deflection behaviour of M40 grade concrete mix with Alccofine and Granite Dust at 28 days curing

The flexural strength results of M40 grade concrete incorporating Alccofine and Granite Dust (Mixes M1 and M11) reveal a consistent improvement in load-carrying capacity and deflection behaviour with age. Across all curing periods—7, 14, and 28 days—the load–deflection curves show that Mix M11 consistently exhibits higher deflection .

values and achieves greater flexural strength than Mix M1 at identical load levels. This enhanced behaviour is attributed to the combined effect of Alccofine and Granite Dust, which refine the microstructure, improve particle packing, and enhance the paste–aggregate interface. At 7 days, M11 displays superior bending and shear resistance, indicating faster early-age strength gain due to the high reactivity of Alccofine. A similar trend is observed at 14 and 28 days, where M11 continues to outperform the control mix with increased crack-resisting capacity and higher ultimate flexural strength. Overall, the integration of these sustainable mineral additives significantly enhances the flexural behaviour of M40 concrete, demonstrating improved ductility, stiffness, and structural performance as confirmed by the load–deflection characteristics.

6. CONCLUSIONS

1. The optimum content of Alccofine is attained at 15 % replacement of cement for M40 grade concrete resulting in highest compressive strength when compared to other varying percentages of mixes.

2. 20% replacement of cement with granite dust has shown more improvement in strength when compared to other percentage replacements.

3. Utilization of the Alcidine and Granite dust has improved the compressive strength at early ages and also resulted in development of new innovative concrete.

4. The new innovative concrete developed from the optimum mixes of alccofine and granite dust has exhibited remarkable strength improvement properties in terms of compressive and split tensile strengths.

5. The increase in compressive and split tensile strengths of final optimum concrete mix are by 12.20% and 13.47% respectively when compared with the conventional concrete.

6. The increase in compressive strengths of final optimum concrete mix is by 8.3% respectively when compared with the conventional concrete from rebound hammer test.

7. The increase in ultrasonic pulse velocity of final optimum concrete mix is by 5.43% respectively when compared with the conventional concrete.

8. The increase in flexural strength of final optimum concrete mix is by 6.32% respectively when compared with the conventional concrete.

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