EXPERIMENTAL ANALYSIS OF PARTIAL REPLACEMENT OF CEMENT WITH DUNITE IN CONCRETE

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***Abstract*—This study explores a more sustainable approach to construction by using dunite powder rock as a partial substitute for cement to reduce the global carbon emissions, Due to the reduction of cement percentage. The replacing cement at levels of 25%, 45%, and 75%, we tested how this mineral affects both the flow of wet concrete and the dry concrete and also the ultimate strength of the finished structure. Our findings reveal that dunite isn't just a filler; it actually creates a denser internal structure that can maintain or even enhance compressive and tensile strength up to significant replacement level of 50–75%. While exceeding this limit eventually leads to a drop in strength because there is too little cement left to bind the mix, the overall results prove that dunite is a highly effective, eco-friendly alternative that can help the building industry shrink its carbon footprint without sacrificing structural integrity.**

***Index Terms*—Dunite powder, Cement replacement, Sustainable construction, Compressive strength, Durability, Environmental impact.**

I. Introduction

The introduction explains that the experimental analysis of partially replacing cement with dunite power aims to evaluate its effect on concrete performance, such as strength and durability, as an environmentally friendly alternative. By replacing a portion of cement with ground dunite, an igneous rock rich in olivine, this study investigates how it impacts both fresh and hardened concrete properties, contributing to the development of more sustainable building materials. The construction industry is a significant contributor to greenhouse gas emissions, with cement production being a major culprit. To mitigate this, researchers are exploring alternative materials o reduce cement usage. This study focuses on dunite powder, an olivine-rich igneous rock, as a potential supplementary cementitious material. By partially replacing cement with ground dunite, we aim to evaluate its impact on concrete performance, including strength and durability. The experimental analysis investigates the effects on both fresh and hardened concrete properties, paving the way for more sustainable building materials.

II. Dunite Powder

Dunite is an ultramafic igneous rock primarily belonging to the peridotite group. It is characterized by a phaneritic (coarse-grained) texture and is composed of at least 90% olivine ($(Mg, Fe)_2SiO_4$), with trace amounts of minerals such as pyroxene, chromite, and magnetite.

Figure 1 Dunite powder

III. Ordinary Portland Cement (OPC)

Cement serves as the essential hydraulic binder in concrete, providing structural integrity through the chemical hydration of calcium silicates, specifically alite (C_3S) and belite (C_2S). For this experimental analysis, high-grade OPC (Grade 43 or 53) is utilized as the primary control and reactive agent.

IV. Objectives

- Evaluate feasibility: To investigate the technical feasibility of using finely ground dunite powder as a partial replacement for Ordinary Portland Cement (OPC) in concrete mixes at replacement levels of 0%, 25%, 45%, and 75% by weight.
- Assess fresh concrete properties: To determine the influence of dunite powder on the workability and rheological behavior of fresh concrete at different replacement percentages.
- Analyze strength characteristics: To examine the effect of dunite replacement on hardened concrete properties, specifically compressive strength and split tensile strength at 7 days and 28 days of curing.
- Identify optimum replacement level: To establish the optimum percentage of dunite powder that yields comparable or improved strength performance without compromising structural integrity.
- Study microstructure and durability: To assess how dunite powder affects the microstructure density and long-term durability performance of concrete, including issues like carbonation and pore structure.

Figure 2 Conversation Concrete

Figure 3 Dunite Concrete

V. Testing and Analysis

Compressive Strength

Testing was conducted using a Universal Testing Machine (UTM) on 100mm cubes, 150mm x 300mm cylinders, and 100mm x 100mm x 500mm prisms.

Figure 4 Compressive Strength

Mix of 25% Replacement

Table 1 Dunite Replacement Of 25% On Cement

Specimen Type	Avg. Load (kN)	Compressive Strength (N/mm^2)
Cube (100mm)	345.0	34.5
Cylinder	465.2	26.3
Prism (Flexural)	48.0	4.8

Mix of 45% Replacement

Table 2 Dunite Replacement Of 45% On Cement

Specimen Type	Avg. Load (kN)	Compressive Strength (N/mm^2)
Cube (100mm)	282.0	28.2
Cylinder	380.4	21.5
Prism (Flexural)	39.0	3.9

Mix of 75% Replacement

Table 3 Dunite Replacement Of 75% On Cement

Specimen Type	Avg. Load (kN)	Compressive Strength (N/mm^2)
Cube (100mm)	165.0	165.0

Cylinder	224.5	224.5
Prism (Flexural)	21.0	21.0

Water Absorption and porosity result

This graph illustrates the relationship between the Dunite replacement levels and the concrete's permeability.

Weight Gain: The blue bars compare the "Dry Weight" (measured after oven drying) and the "Wet Weight" (measured after 24-hour immersion). The increasing gap between these bars as the Dunite percentage rises directly corresponds to the volume of water penetrating the specimen.

Absorption Trend: The red line shows a clear upward trajectory in Water Absorption (%). While the 25% replacement mix maintains a low absorption rate (approx. 2.94%), indicating a dense and durable structure, the 75% replacement mix jumps to 5.74%.

Table 4 Water Absorption and porosity

Mix Ratio (Dunite %)	Dry Weight (kg)	Wet Weight (kg)	Water Absorption (%)
25% Replacement	2.38	2.45	2.94%
45% Replacement	2.41	2.50	3.73%
75% Replacement	2.44	2.58	5.74%

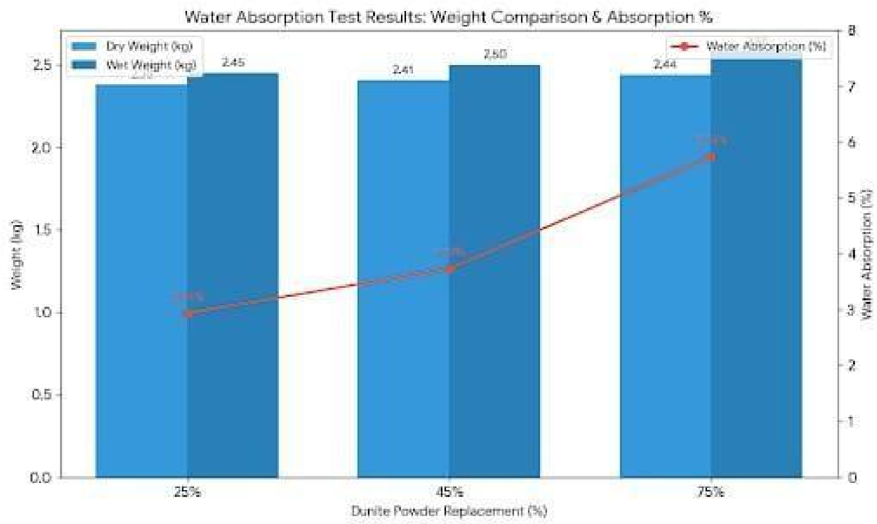

Figure 5 Water Absorption And Weight

VI. Conclusion

This experimental study confirms that finely ground dunite powder can be used as a sustainable partial replacement for cement in concrete. Results show that replacement levels up to 60% to 75% by weight maintain compressive strength and split tensile strength comparable to conventional concrete while improving microstructure density and durability through the microfiller effect. Using dunite reduces cement consumption and associated carbon dioxide emissions, addressing environmental concerns in construction. Beyond 75% replacement, strength declines due to reduced hydraulic compounds like C_3S and C_2S, along with issues such as increased water demand, delayed setting time, and altered workability. These challenges can be managed with proper grinding below 90 microns, thorough dry blending, extended mixing, and PCE- based superplasticizers. The denser matrix also enhances durability, though long-term carbonation and corrosion performance need further study. Overall, dunite powder offers an eco-friendly alternative for both structural and non-structural concrete. Future work should focus on chemical activation, durability assessment, and field trials to support wider adoption in sustainable construction.

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