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Experimental Investigation of Using Granite Powder as an Partial Replacement for Fine Aggregate in Concrete

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ABSRTACT

This study investigates the potential of granite powder, a by product of granite cutting and polishing industries, as a partial replacement for fine aggregate in concrete. The primary objective is to evaluate the feasibility of using granite powder to enhance the mechanical and durability properties of concrete while addressing environmental concerns associated with waste disposal and sand depletion. Concrete mixes were designed with varying replacement levels of fine aggregate (15%, 20%, 25%) by granite powder, following standard mix design guidelines. Tests were conducted to determine the workability (slump test) and hardened concrete test (compressive strength). Results revealed that incorporating granite powder up to 20% significantly improved the compressive strength, achieving an increase of up to 13% compared to the control mix. The workability of concrete decreased with higher replacement levels. The findings suggest that granite powder can serve as a sustainable and effective partial replacement for fine aggregate in concrete, offering environmental, economic, and performance-related benefits. This study encourages the adoption of granite powder in practical applications to reduce the environmental footprint of the construction industry and promote the utilization of industrial waste.

INTRODUCTION

Engineers face challenges in adopting innovative materials and techniques to improve conventional concrete efficiently. Globally, the construction and environmental sectors are increasingly concerned about the growing accumulation of industrial waste in solid, liquid, and

gaseous forms. Among the 25 states in India, Tamil Nadu holds approximately 70% of the nation's granite reserves. Granite blocks are extracted from quarries using various cutting methods and transported to processing facilities.

Granite, known for its exceptional strength, is widely used as a construction material. Recently, it has been utilized in powdered form as a partial substitute for natural sand in concrete production. During industrial processing, such as sawing and polishing, granite stones are refined into high-value decorative materials. This process generates a by-product comprising fine granite particles mixed with water, resulting in a granite colloidal waste.

OBJECTIVES

1. To utilize granite powder effectively for sustainability.

2. Mix proportions of granite powder 15%, 20% and 25%.

3. To enhance concrete strength and testing methods.

4. To reduce aggregates usage and cost.

MATERIALS USED

Coarse aggregate

Granite powder

Cement

M sand

CUBE TEST

MATERIALS AND MIX PROPOTIONS

- Cement: Ordinary Portland Cement (OPC) 43 or 53 grade.
- Fine Aggregate: Natural sand partially replaced with granite powder at 15%, 20% and 25%.
- Coarse Aggregate: Crushed stone of size 12.5 mm.
- Water-Cement Ratio: 0.5 (kept constant across all mixes).
- Granite powder in fine particles.

Concrete cubes of standard dimensions (150 mm × 150 mm × 150 mm) were cast for each mix proportion.

We used for cube testing ratios is,

Cement - 1 part

Granite Powder & Fine Aggregate - 2 part

Coarse Aggregate - 1 part

Water - 1 part

MIX DESIGN OF CONCRETE FOR M20

Design mix of concrete for 20Grade are made as per IS 10262:2009. Water cement ratio and minimum cement content is taken as per IS 456: 2000. Size of nominal maximum of aggregates is 12.5 mm used. Minimum water content as per IS 10262:2009

TESTING OF MATERIALS

SPECIFIC GRAVITY TEST:

Specific gravity of fine aggregates is found to be 2.5. And as per IS 2386 (part3):1963, the specific

gravity of coarse aggregate should be 2.2 to 3.2.

SIEVE ANALYSIS TEST:

Fineness modulus of Fine Aggregate is 4.82%. The soil belongs to zone II of classification (IS383).

WATER ABSORPTION TEST

% of water absorption of fine aggregate = 1.2%.

SPECIFIC GRAVITY TEST:

Specific gravity of coarse aggregate is found to be 2.71 and as per IS 2386 (part3):1963, the specific gravity of coarse aggregate should be 2.6 to 2.9.

SIEVE ANALYSIS TEST:

Fineness modulus of Coarse Aggregate is 5.18%. The soil belongs to zone II of classification (IS383).

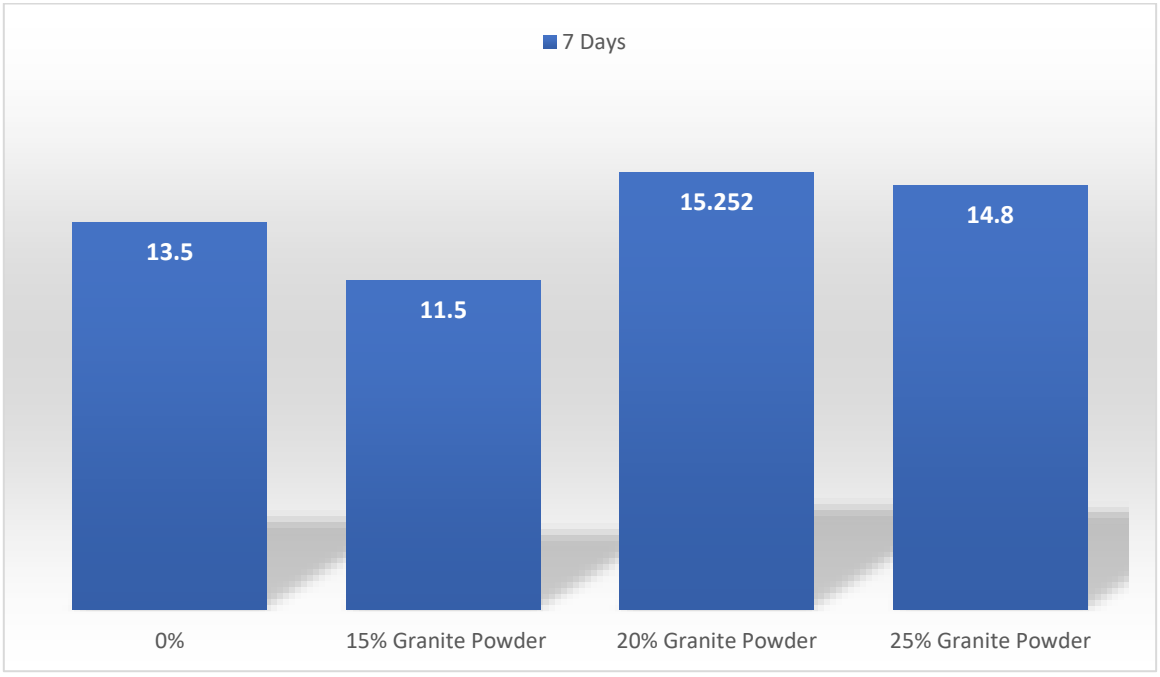
WATER ABSORPTION TEST:

% of water absorption of coarse aggregate = 0.72 %

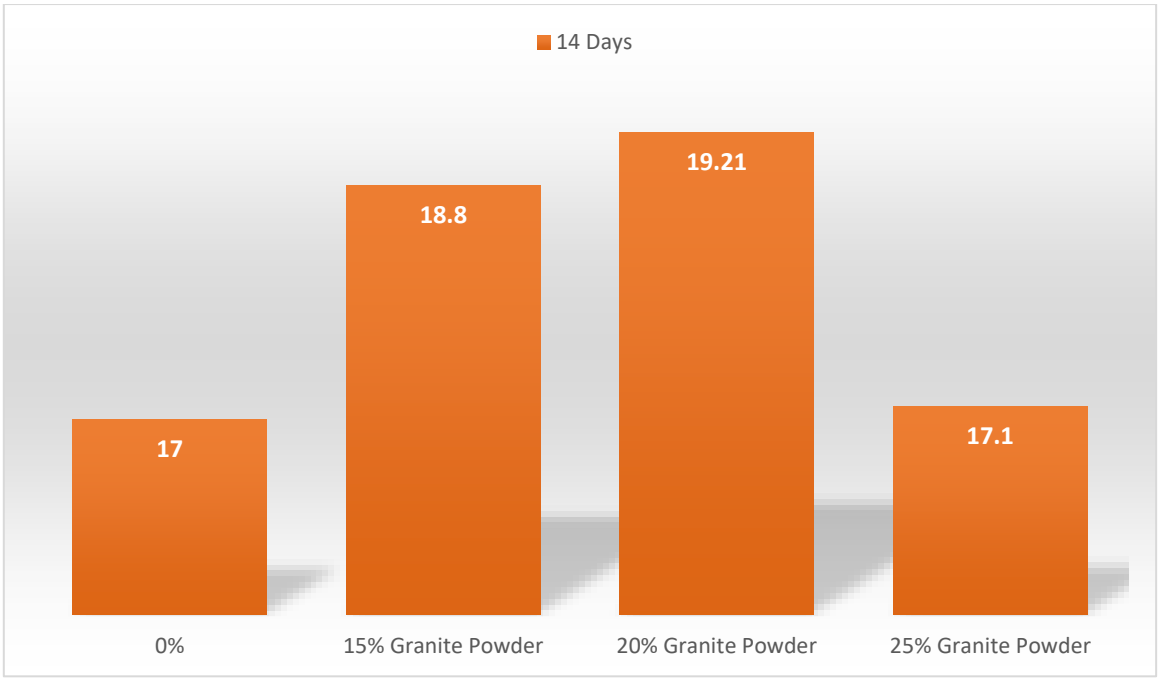
TEST OF HARDENED CONCRETE

Compressive Strength Test

MIXTURE	DURATION			
	7 DAYS		14 DAYS	
	LOAD (KN)	STRENGTH (N/mm^2)	LOAD (KN)	STRENGTH (N/mm^2)
Normal Concrete	303.75	13.5	382.5	17
Concrete with 15% EPS	258.75	11.5	423.0	18.8
Concrete with 20% EPS	343.23	15.252	432.225	19.21
Concrete with 25% EPS	333.0	14.8	384.75	17.1



7 Days – Strength (N/mm^2)



14 Days – Strength (N/mm^2)

CONCLUSION

Granite powder as a partial replacement for fine aggregate in concrete has proven to be a sustainable and effective material, offering improved mechanical and durability properties when used in optimal proportions. Studies have shown that replacing fine aggregate with granite powder at levels between 15-25% enhances compressive, tensile in the concrete matrix. Additionally, the reduced water absorption and enhanced resistance to chloride permeability contribute to improved durability, making it suitable for use in aggressive environments. However, excessive replacement (above 25%) can negatively impact workability and strength due to increased fines disrupting the matrix. By reducing dependency on natural sand and utilizing industrial waste, granite powder supports eco-friendly construction practices while maintaining material performance. Thus, it presents a promising solution to sustainable construction challenges, balancing environmental benefits with economic and structural advantages.

The specimen casted with 20 % replacement of granite fines to fine aggregate gives higher strength when compared to control specimen with the compressive strength of 13% increased. The specimen cast with 25% replacement of fine aggregate by granite fines gives better compressive strength of 13% increased,

Results and Observations

1. 15% Granite Powder: The control mix achieved baseline compressive strength values at 7, 14 days.
2. 20-25% Granite Powder:
    - Strength increased significantly, with 20% replacement yielding the highest compressive strength. The filler effect of granite powder enhanced the matrix density.

- 13% increase in 14-day compressive strength was observed at 20% replacement compared to the control mix.

3. Trend Analysis: Strength improvements were most noticeable at 7 and 14 days, indicating that granite powder's benefits are most effective during early and long-term curing.

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