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An Experimental Investigation on Bella Stone Dust as Partial Replacement of Fine Aggregate in Concrete

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Abstract: *The increasing demand for natural sand in concrete production has led to environmental degradation and depletion of natural resources. In response to this challenge, the present study investigates the potential use of Bella Stone Dust as a partial replacement for fine aggregate in concrete. Bella Stone Dust, a by-product generated during the crushing of stones, poses disposal issues and environmental hazards if not managed effectively. This research aims to evaluate the suitability of Bella Stone Dust as an alternative material in concrete mixes. A comprehensive experimental program was conducted in which Bella Stone Dust partially replaced fine aggregate at varying percentages of 0% to 100% by weight. The M-30 grade concrete tested for workability and concrete specimens were tested for compressive strength and split tensile strength at 7, and 28 days of curing. The results indicated that up to a certain percentage, the inclusion of Bella Stone Dust enhanced the mechanical properties of concrete, with the optimum performance observed at a specific replacement level..*

Keywords: Bella Stone Dust, Sustainable Construction, Environmental Impact, Fine Aggregate Replacement

I. INTRODUCTION

Bella Stone Dust, a by-product of stone crushing operations, has gained attention as a potential substitute for fine aggregates in concrete. This material not only helps in reducing the environmental impact of traditional sand mining but also contributes to the conservation of natural resources. The use of Bella Stone Dust in concrete could provide a solution to the growing environmental concerns associated with the excessive use of natural sand.

This study aims to investigate the effects of Bella Stone Dust as a partial replacement for fine aggregate in concrete, specifically focusing on its influence on two key mechanical properties: compressive strength and split tensile strength. The replacement levels of Bella Stone Dust will range from 0% to 100% in intervals of 10%. By conducting experiments at varying replacement levels, this research seeks to determine the optimal proportion of Bella Stone Dust that yields desirable concrete properties while maintaining sustainability.

Through a series of controlled experiments, the compressive strength and split tensile strength of concrete samples will be measured and analysed. The findings of this study are expected to contribute valuable insights into the feasibility of using Bella Stone Dust as a partial replacement for fine aggregates, offering a sustainable alternative to conventional concrete mixes.

Bella Stone Dust is a finely crushed material obtained as a by-product during the mechanical crushing of hard stones in stone crushers. It is typically generated in large quantities during the production of Bella Stone. Due to its fine particle size, similar to that of natural sand, Bella Stone Dust has emerged as a potential alternative to conventional fine aggregates in concrete. Its physical properties—such as angular shape, good fineness, and high silica content—make it suitable for enhancing the interlocking and packing density in concrete mixes. Moreover, its local availability and low cost add to its attractiveness as a sustainable construction material. The utilization of Bella Stone Dust in concrete not only helps reduce dependency on natural river sand but also supports effective waste management in stone crushing industries.

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II. Concrete Methodology

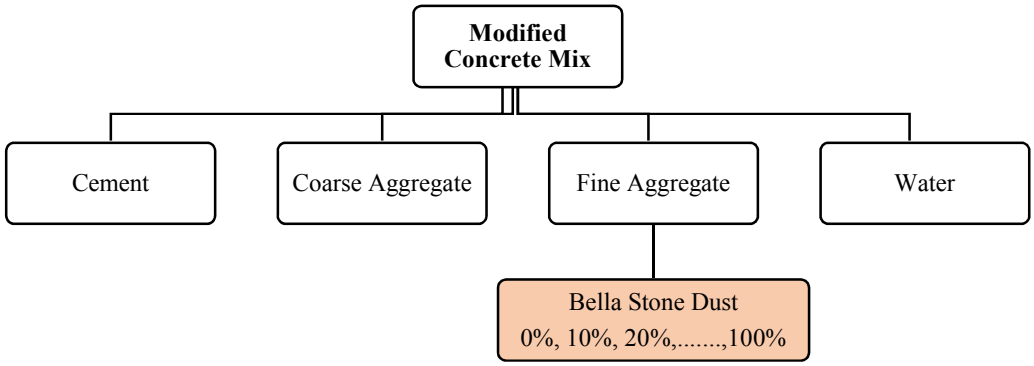

Figure 1 Work Flow Chart

Table 1 Physical Properties of Experimental Material

Sr. No.	Test	Coarse Aggregate	Fine Aggregate	Bella Stone Dust
1	Specific Gravity	2.80	2.68	2.72
2	Water Absorption	0.45 %	1.24 %	2.1 %
3	Fineness Modulus	-	2.69	2.13
4	Sieve Analysis	-	Zone - II	-

Table 2 M-30 Concrete Mix Design

Material	Weight in kg/m^3
Cement	412
Water	194
Coarse Aggregate 20 mm (60 %) 10 mm (40 %)	**1212** 726 486
Fine Aggregate	662
W/C ratio	0.42
Target Mean Strength	38.25 N/mm^2

III. Experimental Results

Slump Test

The slump test is used for the measurement of a property of fresh concrete as per IS: 1199 - 1959. From the test, it was observed that replacement with Bella Stone Dust as fine aggregate concrete slump was decreased.

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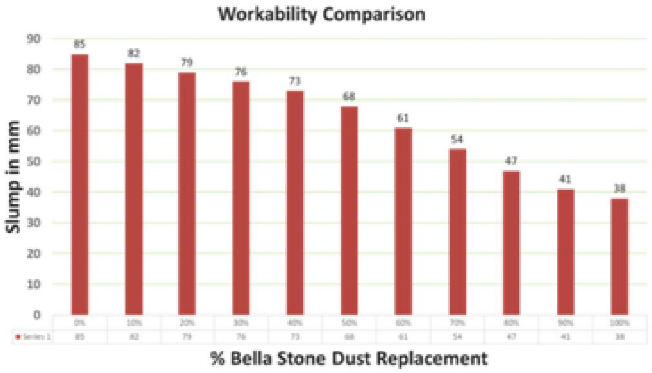

Figure 2 Workability Test Result

Figure 3 Slump Measuring

The slump value consistently decreases from 85 mm (0%) to 38 mm (100%) as the percentage of Bella Stone Dust increases. This trend indicates a reduction in workability with higher replacement levels. Bella Stone Dust has a rougher texture and angular shape compared to natural sand, which increases internal friction in the mix.

Compressive Strength Test

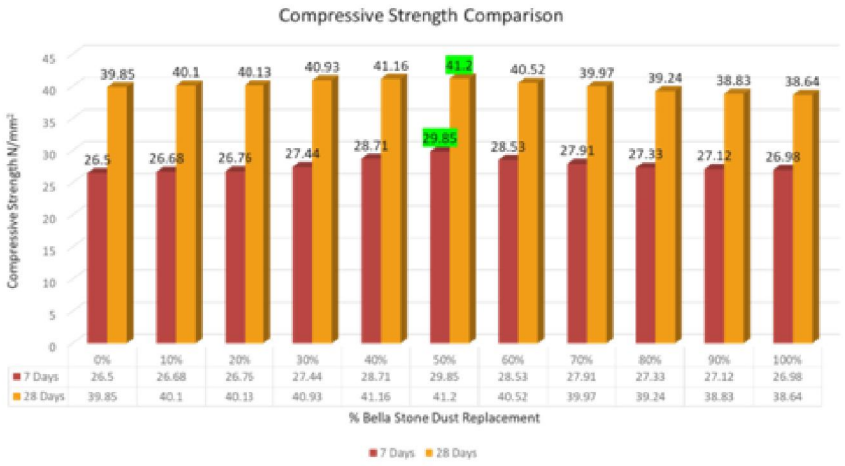

Figure 4 Compressive Strength at 7 days and 28 days

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Figure 5 Testing of Cube

Compressive Strength at 7 Days

The compressive strength increases with Bella Stone Dust replacement up to 50%, showing the highest gain of 12.64% over the control mix (0% replacement).

Beyond 50%, strength begins to decrease but still remains above the control up to 100% replacement.

The trend suggests Bella Stone Dust enhances early-age strength up to 50% replacement, likely due to better particle packing and improved internal matrix structure.

Compressive Strength at 28 Days

The compressive strength gradually increases from 0% to 50% replacement, with the maximum gain of 3.39%.

Beyond 50%, the strength begins to decline, and at 100% replacement, the compressive strength is 3.03% lower than the control mix.

The results show that Bella Stone Dust can successfully replace fine aggregate up to 50% without compromising strength, and even slightly improving it.

Split Tensile Strength Test

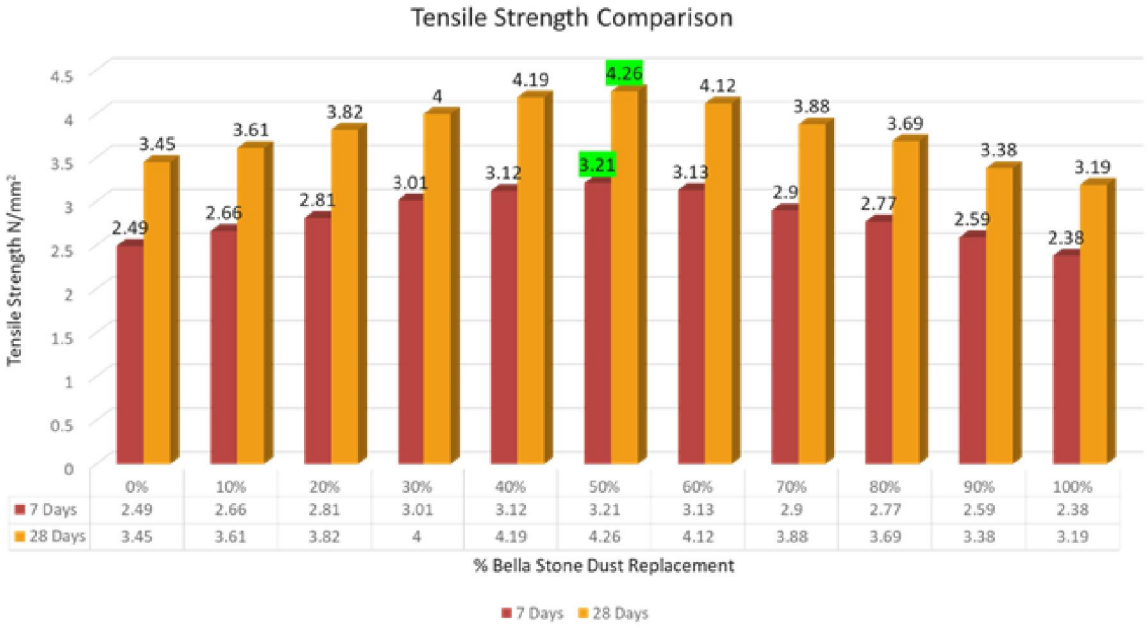

Figure 6 Split Tensile Strength at 7 days and 28 days

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Figure 7 Testing of the Cylinder

Split Tensile Strength at 7 Days

The split tensile strength increases steadily up to 50% replacement, peaking at 3.21 N/mm², which is 28.92% higher than the control mix.

After 50% the strength begins to drop gradually.

At 100% replacement, the strength drops below the control mix by 4.42%.

The trend indicates that Bella Stone Dust positively influences early tensile strength up to a certain threshold (50%).

Split Tensile Strength at 28 Days

The tensile strength consistently improves with replacement up to 50%, where the maximum strength of 4.26 MPa is recorded 23.48% higher than the control mix.

A gradual decrease is observed beyond 50%.

At 100% replacement, the tensile strength drops 7.54% below the control.

IV. Conclusion

The optimal performance in both compressive and tensile strength was observed at 50% replacement of fine aggregate with Bella Stone Dust.

The improvement is likely due to enhanced particle packing, better filler effect, and improved interfacial bonding.

Higher replacement levels (>50%) may introduce excessive fines, affecting workability and weakening the matrix structure, resulting in reduced strength.

Bella Stone Dust can effectively replace natural fine aggregate up to 50% in M30 grade concrete without compromising strength characteristics.

It offers a sustainable and economical alternative, enhancing both compressive and tensile strength, especially at early ages.

Therefore, it is recommended to use Bella Stone Dust as a partial replacement of fine aggregate in structural concrete applications, up to a replacement level of 50%, as it enhances the mechanical properties of concrete while maintaining acceptable workability.

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