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Assessing the Differences in Concrete Performance without and with Sand Substitution using Granite Dust & Marble Dust

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Abstract - *For the past 15 years, it has been evident that the availability of natural sand has significantly decreased. This scarcity of natural sand not only poses environmental challenges but also necessitates alternative solutions. This practice is particularly relevant for sectors like concrete production, where additional profits can be generated by utilizing materials like marble and granite dust in a manner akin to river sand.*

To enhance concrete properties, it is essential to manufacture marble dust (MD) and granite dust (GD) in a way that not only mirrors river sand but also contributes to increased strength without compromising workability. Various construction projects, ranging from roads to the production of building materials like light aggregates, bricks, and tiles, can benefit significantly from the incorporation of MD and GD.

Our research paper delves into the experimental findings regarding "Quarry sand" and provides detailed insights into concrete compositions utilizing Quarry sand. The study involved conducting tests on M30 Grade concrete, both with and without the inclusion of Granite Dust and Marble Dust, following a 28-day curing period.

Granite dust and marble dust were systematically assessed as partial substitutes for sand in conventional M30 grade concrete, with varying replacement percentages—15%, 25%, 40%, and 50%. The discussion section of our paper highlights that replacing 15% of the sand with granite dust yields the strongest bond. While there is a slight decrease in compressive strength at a 25% replacement with granite dust, the maximum strength is attained when substituting 25% of the sand with marble dust.

Therefore, it is evident from our findings that the use of granite and marble dust as replacements for 25% of the natural sand in concrete formulation results in high-quality concrete. All concrete mixes incorporating marble and granite dust exhibit superior strength. These results underscore the potential of granite and marble dust as sustainable alternatives in concrete production.

Key Words: *Compressive Strength, Split strength, marble Dust, Granite Dust.*

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I. INTRODUCTION

Concrete stands out as a highly practical and widely utilized building material across the globe, owing to its versatility, cost-effectiveness, and easy accessibility of its components. Quality is a paramount consideration in the construction sector, and concrete's core ingredients, namely water, coarse aggregate, and cement, are naturally occurring materials. Cement is produced in factories, while riverbeds commonly serve as sources for fine aggregate, with river sand being the predominant choice.

Sand, constituting approximately 35% of concrete volume, plays a crucial role in determining the quality of the concrete, and its origin significantly impacts its characteristics.

Marble dust, sourced from marble industry deposits in the Elazig region, is a by-product of marble sawing and shaping. The wet marble sludge necessitated drying before sample preparation.

Integrating these marble wastes within the industry itself offers dual benefits—it reduces the over-mining of sand resources and safeguards the environment by mitigating the impact of marble landfills. This sustainable approach not only addresses waste management but also contributes to the responsible use of natural resources in the construction sector.

Advantage of Grainte Dust
The use of granite dust in concrete production offers several advantages:

1. Improved Strength: Granite dust, when used as a partial replacement for sand in concrete mixtures, can enhance the compressive, flexural, and split tensile strengths of the resulting concrete. This contributes to the overall durability and load-bearing capacity of the concrete structures.

2. Reduced Environmental Impact: Utilizing granite dust as a replacement material in concrete can be an environmentally friendly practice. By recycling granite waste into a construction material, it helps in reducing the amount of waste in landfills and conserving natural resources.

3. Cost Efficiency: Granite dust, often considered a waste product in the granite industry, can be a cost-effective alternative to traditional sand. Its availability and potential lower cost make it an attractive option for concrete producers, contributing to cost efficiency in the production process.

4. Enhanced Workability: Granite dust can improve the workability and cohesiveness of the concrete mix. It may lead to better finishing characteristics and ease of placement during construction.

5. Reduced Shrinkage: The incorporation of granite dust in concrete mixes has been reported to reduce shrinkage, which is beneficial in minimizing the risk of cracks and improving the long-term durability of the concrete.

6. Aesthetic Appeal: Depending on the source, granite dust may also impart unique aesthetic qualities to the concrete, adding variations in color and texture that can enhance the visual appeal of finished structures.

It's important to note that while there are advantages, proper testing and consideration of the specific application are necessary to ensure that the concrete with granite dust meets the required performance standards and specifications.

Advantage of Marble Dust

The use of marble dust in concrete production offers several advantages:

1. Enhanced Strength Properties: Marble dust, when used as a partial replacement for sand in concrete mixes, can contribute to improved compressive and flexural strengths. This can result in concrete structures with enhanced load-bearing capacity and durability.

2. Waste Utilization and Environmental Benefits: Utilizing marble dust in concrete production provides a sustainable solution for the disposal of marble waste, reducing environmental impact by diverting waste from landfills and promoting resource efficiency.

3. Improved Workability: Marble dust can enhance the workability of concrete mixes, making them more cohesive and easier to handle during construction. This can lead to better finishing characteristics and improved placement efficiency.

4. Reduced Permeability: Incorporating marble dust in concrete has been reported to reduce permeability, which is beneficial for structures exposed to aggressive environmental conditions. Lower permeability can contribute to increased durability and resistance to chemical attack.

5. Aesthetic Appeal: Depending on the source, marble dust may impart unique aesthetic qualities to the concrete, such as variations in colour and texture. This can enhance the visual appeal of finished structures, making it a desirable choice in architectural applications.

6. Cost Efficiency: Marble dust, often considered a byproduct of the marble industry, can be a cost-effective alternative to traditional sand. Its availability and potential lower cost contribute to cost efficiency in concrete production.

7. Alkali-Silica Reaction Mitigation: The use of marble dust has been suggested to mitigate the risk of alkali-silica reaction in concrete, a chemical reaction that can lead to the formation of cracks and reduce the durability of concrete structures.

It's important to note that the incorporation of marble dust in concrete should be carefully evaluated based on specific project requirements and local standards. Testing and quality control measures are essential to ensure that the concrete meets the desired performance characteristics**.**

II. OBJECTIVE OF STUDY

The primary objective of this thesis is to explore and assess the strength of concrete by replacing a portion of the conventional sand with granite and marble dust. The key goals include:

1. **Modification of Concrete Mixes M30:** The thesis aims to alter Concrete Mixes M30 by incorporating Granite Dust and Marble Dust as substitutes for natural sand. This modification is central to understanding how the inclusion of these dust materials influences the overall composition and properties of the concrete.

2. **Investigation of Concrete Characteristics:** A crucial aspect of the research involves a comprehensive investigation into the various characteristics exhibited by concrete when granite and marble dust are utilized.

3. **Comparison with Ordinary Concrete**: The study seeks to establish a comparative analysis between the results obtained from concrete mixes incorporating granite and marble dust and those from ordinary concrete. This comparative assessment is vital for understanding the effectiveness of the dust materials as partial substitutes for natural sand and determining whether the modified concrete meets or exceeds the performance of traditional concrete mixes.

By addressing these objectives, the thesis aims to contribute valuable knowledge to the field, providing insights into the feasibility and benefits of using granite and marble dust in concrete formulations, and ultimately, enhancing our understanding of sustainable and innovative practices in the construction industry.

III. METHODOLOGIES

The research is structured into 2 distinct stages, namely Stage I and Stage II, each contributing to the overall objective. The approach involves replacing a portion of the sand with specific dust types in each stage. Various types of concrete specimens, such as cubes, beams, cylinders, and cubes with embedded roadways, are cast, followed by a series of physical tests.

Stage I: Granite Dust Replacement

Table 1.1 outlines the details of Stage I, where granite dust is introduced as a replacement for sand in varying proportions—15%, 25%, 40%, and 50%. Five distinct batches, encompassing different ratios, are produced, including a reference batch with conventional concrete mix proportions. Cubes, beams, and cylinders are cast to facilitate the assessment of concrete properties, specifically focusing on 28-day compressive strength, flexural strength, split tensile strength, bond strength, and the stress-strain curve.

Table 1.1: Stage I - Granite Dust Replacement Ratios

Granite Dust Replacement Ratio	Concrete Mix Batches
15%	Batch 1
25%	Batch 2
40%	Batch 3
50%	Batch 4
Conventional Mix (0%)	Batch 5

Stage II: Marble Dust Replacement

Moving to Stage II, Table 1.2 illustrates the utilization of marble dust as a substitute for sand at ratios of 15%, 25%, 40%, and 50%. Similar to Stage I, five batches are produced, including a control batch with traditional concrete mix proportions.

Table 1.2: Stage II - Marble Dust Replacement Ratios

Marble Dust Replacement Ratio	Concrete Mix Batches
15%	Batch 6
25%	Batch 7
40%	Batch 8
50%	Batch 9
Conventional Mix (0%)	Batch 10

By systematically examining these stages and their respective replacements, the research aims to provide a comprehensive understanding of the impact of granite and marble dust on various concrete properties, aiding in the formulation of sustainable and effective concrete mixtures.

IV. RESULTS

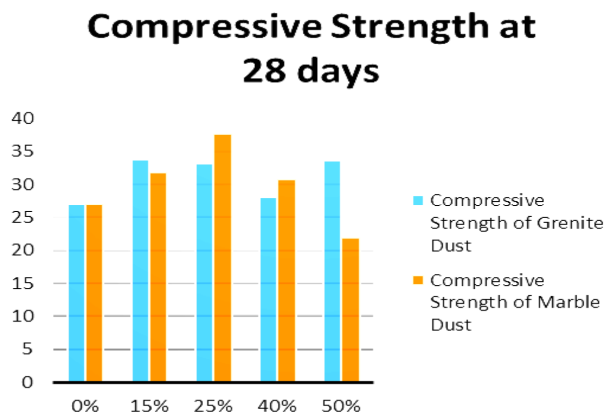
This thesis work, sand is partially substituted with Granite Dust at varying percentages of 0%, 15%, 40%, and 50%. A total of 15 cubes, 15 beams, 10 cylinders, and 5 cubes with a 12mm diameter steel rod are cast for experimentation. Moving on to Stage-II, sand is replaced with Marble Dust at different percentages (0%, 15%, 40%, and 50%), and a similar set of specimens are prepared, consisting of 15 cubes, 15 beams, 10 cylinders, and 5 cubes with a 12mm diameter steel rod. Subsequently, a series of tests are conducted in accordance with Indian Standards. These include compression tests on cubes, flexural strength tests on beams, split tensile strength tests on cylinders, bond strength tests on cubes with embedded rods, and finally, stress-strain curve tests on concrete cylinders.

Table 1.3 Compressive Strength Result for 28 days (Stage 1)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Mix-01	C+S+CA	Cube-1	593	26.36	26.99
		Cube-2	627	27.87	
		Cube-3	602	26.76	
Mix-02	C+S(85%)+GD(15%) +CA	Cube-1	775	4.44	33.76
		Cube-2	746	33.16	
		Cube-3	758	33.69	
Mix-03	C+S(75%)+GD(25%) +CA	Cube-1	739	32.84	33.11
		Cube-2	730	32.44	
		Cube-3	766	34.04	
Mix-04	C+S(60%)+GD(40%) +CA	Cube-1	694	30.84	28.00
		Cube-2	574	25.51	
		Cube-3	622	27.64	
Mix-05	C+S(50%)+GD(50%) +CA	Cube-1	701	31.16	33.64
		Cube-2	814	36.18	
		Cube-3	756	33.60	

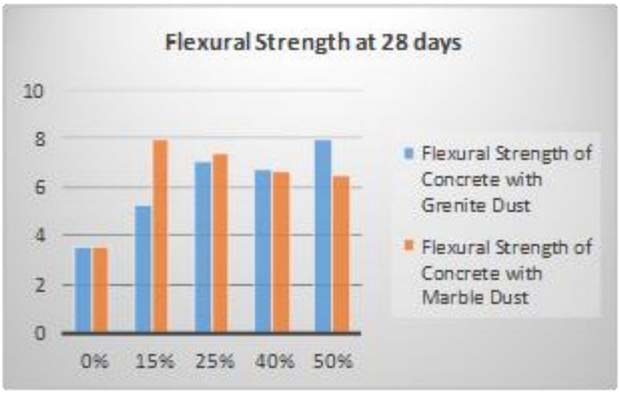
Table 1.4 Compressive Strength Result for 28 days (Stage 2)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Mix-01	C+S+CA	Cube-1	593	26.36	26.99
		Cube-2	627	27.87	
		Cube-3	602	26.76	
Mix-02	C+S(85%)+MD(15%)+CA	Cube-1	896	39.82	31.78
		Cube-2	587	26.09	
		Cube-3	662	29.42	
Mix-03	C+S(75%)+MD(25%)+CA	Cube-1	859	38.18	37.61
		Cube-2	834	37.07	
		Cube-3	846	37.60	
Mix-04	C+S(60%)+MD(40%)+CA	Cube-1	696	30.93	30.70
		Cube-2	690	30.67	
		Cube-3	686	30.49	
Mix-05	C+S(50%)+MD(50%)+CA	Cube-1	491	21.82	21.94
		Cube-2	497	22.09	
		Cube-3	493	21.91	



Graph 1 Compressive strength at 28 days, measured in N/mm²

The analysis of the graphs reveals that the maximum compressive strength is attained when sand is partially replaced with 15% Granite Dust. In this scenario, the strength increases by 20.05% in comparison to conventional concrete. Similarly, in the case of Marble Dust substitution at 25%, the maximum compressive strength is observed, showing a significant increase of 28.23% compared to conventional concrete.

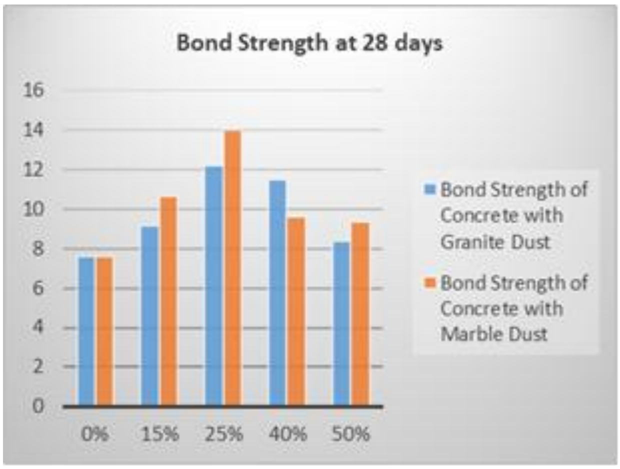


Graph 2 Flexural Strength at 28 days, measured in N/mm²

Analysis of the graphs reveals that the peak flexural strength occurs with a 50% replacement of sand with Granite Dust, leading to a significant 55.40% enhancement compared to traditional concrete. Likewise, a 15% replacement of sand with Marble Dust demonstrates the highest flexural strength, exhibiting an identical 55.40% improvement over conventional concrete.

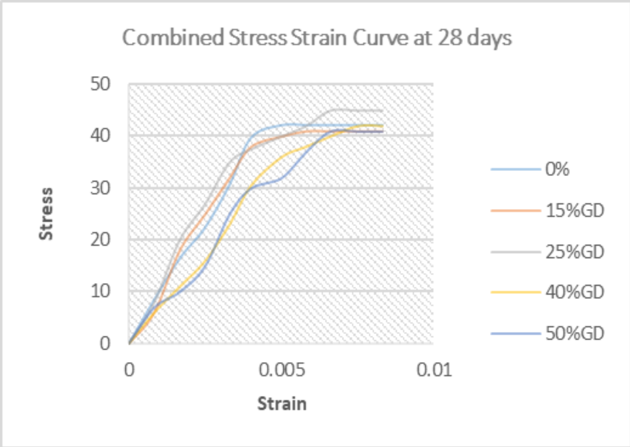
Graph 3 Split Strength at 28 days, measured in N/mm²

Upon analysing the graphs, it is evident that the highest split tensile strength is obtained with a 25% replacement of sand with Granite Dust, yielding a strength increase of 7.08% compared to conventional concrete. Similarly, a 25% replacement of sand with Marble Dust exhibits the maximum split tensile strength, demonstrating a more substantial improvement of 8.88% over traditional concrete.

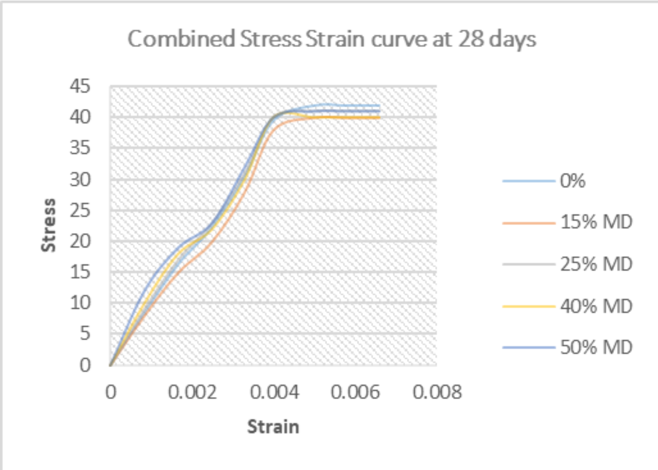


Graph 4 Bond Strength at 28 days, measured in N/mm²

Examining the graphs indicates that the peak bond strength is attained with a 25% replacement of sand with Granite Dust, leading to a strength increase of 38% compared to conventional concrete. Similarly, when sand is partially replaced with 25% Marble Dust, the maximum bond strength is observed, showcasing a higher improvement of 45% over traditional concrete.



Graph 5 Stress-Strain Curve depicting the combined behavior of concrete with Granite Dust.



Graph 6 Stress-Strain Curve illustrating the combined response of concrete with Marble Dust.

V. CONCLUSION

The discussion reveals several key findings:

1. Compressive Strength: The optimal strength is achieved by replacing 15% of the sand with granite dust. While there is a slight decrease in compressive strength at a 25% replacement with granite dust, the maximum strength is attained when 25% of the sand is replaced with marble dust.

2. Flexural Strength: Maximum flexural strength is obtained by replacing 15% of the sand with marble dust, surpassing the strength achieved with a 50% replacement of granite dust. However, the strength remains quite commendable at the 25% replacement level.

3. Bond Strength: The bond strength reache its peak at a 25% replacement, regardless of whether granite dust or marble dust is used to replace some of the sand.

4. **Split Tensile Strength:** Similar to bond strength, the split tensile strength also reaches its maximum when 25% of the sand is replaced with either granite dust or marble dust.

5. Stress-Strain Curve: The stress-strain curve of the concrete, when sand is partially replaced by granite or marble dust in various percentages, is comparable to that of regular concrete. This suggests that the structural behavior of the concrete remains consistent and predictable.

In summary, the data strongly supports the claim that replacing 25% of the sand with either granite or marble dust leads to the generation of high-quality concrete. All concrete formulations incorporating marble and granite dust exhibit superior strength when compared to the reference mix with 0% replacement of natural sand. These findings underscore the potential of granite and marble dust as effective substitutes for sand, offering a sustainable approach to enhance concrete performance in various applications.

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