ISSN: 2633-4828 Vol. 5 No.4, December, 2023

International Journal of Applied Engineering & Technology

EXPLORING THE FEASIBILITY OF QUARRY DUST AS A SUSTAINABLE SUBSTITUTE FOR SAND IN CONCRETE MIXTURES: A STUDY ON COMPRESSIVE STRENGTH

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ABSTRACT

In construction projects, concrete plays a vital role, with large stones being commonly used. However, the increasing cost of natural river sand due to transportation expenses and concerns about environmental impact necessitate the exploration of alternative materials. Quarry dust, a byproduct of quarrying, has emerged as a promising substitute for sand in concrete mixtures, offering potential cost savings. This study investigates the feasibility of using quarry dust as a partial or complete replacement for sand in M20 grade concrete mixtures. Various tests and laboratory analyses, including slump and compressive strength tests, were conducted to examine the hardening behavior and properties of concrete incorporating quarry dust. Concrete specimens were cast and tested at different ages (14 and 28 days) to assess compressive strength development. The results indicate that the compressive strength of concrete containing quarry dust increases over time, suggesting its suitability as a sand replacement in concrete mixtures. This study contributes to understanding the performance differences of various stone compositions over time, thus informing material selection in construction projects.

Keywords: Concrete, quarry dust, sand replacement, compressive strength, construction materials, environmental impact

INTRODUCTION

Quarry dust, a byproduct of the quarrying process, has garnered attention as a potential substitute for traditional fine aggregate in concrete production. As the demand for concrete rises, so does the need for sustainable alternatives to mitigate environmental impact and reduce costs. This paper delves into the characteristics of quarry dust, its utilization in concrete, and its implications on construction practices and environmental sustainability.

Characteristics and Composition of Quarry Dust

Quarry dust is predominantly composed of finely crushed stone particles obtained during the quarrying process. Its chemical composition and physical properties make it suitable for incorporation into concrete mixtures. By understanding its granular composition, particle size distribution, and mineralogical properties, engineers can optimize its use in concrete production.

Challenges in Traditional Concrete Production

The conventional method of concrete production heavily relies on natural river sand, which is becoming scarce and expensive due to transportation costs and environmental concerns. Moreover, the depletion of river sand reserves poses a threat to ecosystems and biodiversity. Hence, the exploration of alternative materials like quarry dust becomes imperative to ensure the sustainability of the construction industry.

Environmental Impact and Sustainability

The environmental implications of concrete production cannot be overlooked. Quarry dust offers a sustainable solution by repurposing waste material generated from quarrying operations. By reducing the extraction of natural resources and minimizing waste accumulation, the utilization of quarry dust promotes environmental conservation and sustainable development.

Role of Quarry Dust in Concrete Mix Design

Incorporating quarry dust into concrete mixtures requires meticulous mix design to ensure optimal performance. The proportion of quarry dust to cement, aggregate, and water significantly influences the compressive strength, workability, and durability of concrete. Through experimental analysis and testing, researchers can determine the ideal blend of materials to achieve desired properties.

Impact on Compressive Strength and Durability

Compressive strength is a crucial parameter in assessing the structural integrity and load-bearing capacity of concrete. Research studies evaluating the impact of quarry dust on compressive strength reveal promising results, indicating enhancements in strength characteristics compared to conventional concrete mixtures. Furthermore, durability assessments shed light on the long-term performance and resistance to environmental factors such as moisture, chemical attacks, and abrasion.

Economic Considerations and Cost Effectiveness

Apart from environmental benefits, the utilization of quarry dust offers economic advantages by reducing production costs associated with concrete manufacturing. The availability of quarry dust as a locally sourced material minimizes transportation expenses, making it a cost-effective alternative to traditional fine aggregate. Moreover, its abundance as a byproduct of quarrying operations ensures a steady supply for construction projects.

Engineering Applications and Construction Practices

The application of quarry dust extends beyond conventional concrete production, encompassing various engineering applications such as road construction, pavement stabilization, and soil improvement. Its versatility and compatibility with existing construction practices make it a viable option for infrastructure development projects.

Regulatory Framework and Industry Standards

As the construction industry transitions towards sustainable practices, regulatory bodies and industry standards play a pivotal role in endorsing the use of alternative materials like quarry dust. Collaborative efforts between government agencies, research institutions, and construction companies are essential to establish guidelines, specifications, and quality control measures for incorporating quarry dust into concrete mixtures.

Methodology

MATERIALS PROPERTIES: -

Table1: Properties of Cement Used

Compound	Pozzolana Portland Cement (%)
SiO_2	28 % - 32 %
Al_2O_3	7 % - 10 %
Fe_2O_3	4.9 % - 6 %
CaO	41 % - 43 %
MgO	1 % - 2 %
SO_3	2.4 % - 2.8 %
Loss on Ignition	3 % - 3.5 %

Table 2: Properties of Obtained Quarry Dust

Sr No.	Characteristics	Values
1	Effective Particles Size	
	D10	0.44 mm
	D30	0.55 mm
	D60	0.63 mm
2	Specific Gravity	2.65
3	Bulk Density	1.7 kg/m^3
4	Water absorption	0.50%

Table 3: Properties of Fine Aggregates

Sr No.	Characteristics	Values
1	Type	Crushed

2	Specific Gravity	2.66
3	Fineness Modulus	6.83
4	Water absorption	0.56

Table 4: Properties of Coarse Aggregates

Sr No.	Characteristics	Values
1	Specific Gravity	2.45
2	Fineness Modulus	2.56
3	Water absorption	0.85%
4	Bulk Density	1.4 kg/m^3

The procedure for testing the compressive strength of concrete cubes is a fundamental aspect of concrete research and quality assessment. This section outlines the detailed steps involved in conducting cube tests to evaluate the compressive strength of concrete specimens over different curing periods.

Selection of Cube Size and Materials

The cube test typically involves testing concrete blocks of standard sizes, such as 15cm x 15cm x 15cm or 10cm x 10cm x 10cm, depending on the size of aggregates used. For this project, the 15cm x 15cm x 15cm cube mold was chosen. The concrete mix for M20 grade, with a ratio of 1:1.5:3 (cement:sand:aggregate), was prepared for testing.

Material Preparation and Mixing

Weight batching was employed to measure the materials accurately. Cement, sand, and aggregate were weighed according to the specified ratio and gathered on a clean surface. Dry mixing was performed manually using a shovel until all materials were uniformly blended. Crushed sand was then added to the mixture, maintaining the water-to-cement ratio, and mixed until a homogeneous slurry of the desired consistency was achieved.

Mould Preparation and Pouring

The cube molds were thoroughly cleaned and oiled to ensure even surface finish. The prepared concrete mixture was poured into the molds using a trowel, filling them evenly. Care was taken to tamp the concrete at regular intervals to remove air voids and excess water. Tamping was performed using a tamping rod with a minimum of 25 strokes per layer.

Surface Finishing and Curing

After tamping, the surface of the concrete cubes was smoothed using a trowel to achieve a uniform finish. The excess water and air bubbles were removed by tapping the molds on a plain surface. The filled molds were then left undisturbed for one day to allow the concrete to set. Subsequently, the cubes were removed from the molds and placed in a curing tank for further curing at intervals of 7, 14, and 28 days.

Curing Process

Curing is essential for the hydration and hardening of concrete. The cubes were submerged in water within the curing tank to maintain adequate moisture levels and promote proper curing. Care was taken to ensure that the cubes remained undisturbed throughout the curing period to prevent any alterations to their structural integrity.

Testing Procedure

After the respective curing periods, the cubes were removed from the curing tank and allowed to dry on the surface. The dried cubes were then subjected to compressive strength testing using a compression testing machine. The smooth sides of the cubes were placed on the testing apparatus, and a gradual and uniform load was applied until the specimen failed. The load was increased continuously at a regular rate until failure occurred.

Data Analysis and Results

The compressive strength of each cube specimen was recorded at the end of the curing periods (7, 14, and 28 days). The mean compressive strength was calculated based on the results obtained from multiple cube specimens. Data analysis was conducted to assess the impact of curing duration on the compressive strength of the concrete cubes.

Quality Control and Assurance

Throughout the testing process, stringent quality control measures were implemented to ensure the accuracy and reliability of the results. Standardized procedures and protocols were followed to minimize variations and discrepancies in the testing procedure. Any deviations or anomalies were documented and addressed promptly to maintain the integrity of the experiment.

4 RESULT AND OBSERVATION

Table 5: Compressive Strength In 7 Days

Sr. No.	Sample	Weight	Compressive Strength (N/mm2)	Average Compressive strength (N/mm2)
1	Natural sand	8.34 kg	13.3	13.55
		8.40 kg	13.8	
2	Partially	8.30 kg	14	14.15
		8.38 kg	14.3	
3	Quarry Dust	8.34 kg	14.8	14.95
		8.36 kg	15.1	

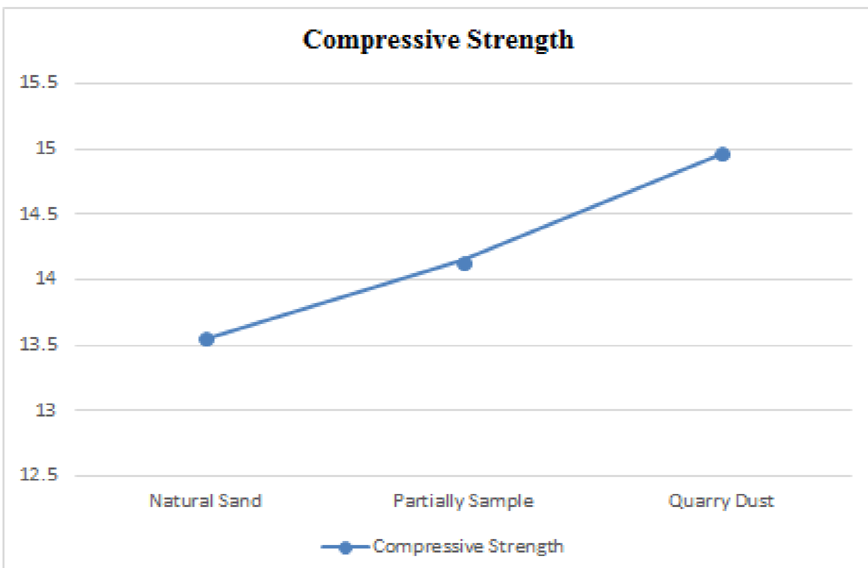

Figure 1: Compressive Strength In 7 Days

Table 6: Compressive Strength In 14 Days

Sr. No.	Sample	Weight	Compressive Strength (N/mm2)	Average Compressive strength (N/mm2)
1	Natural sand	8.34 kg	15.55	14.44
		8.40 kg	13.33	
2	Partially	8.30 kg	16.89	15.78
		8.38 kg	14.67	
3	Quarry Dust	8.34 kg	17.78	16.67
		8.36 kg	15.56	

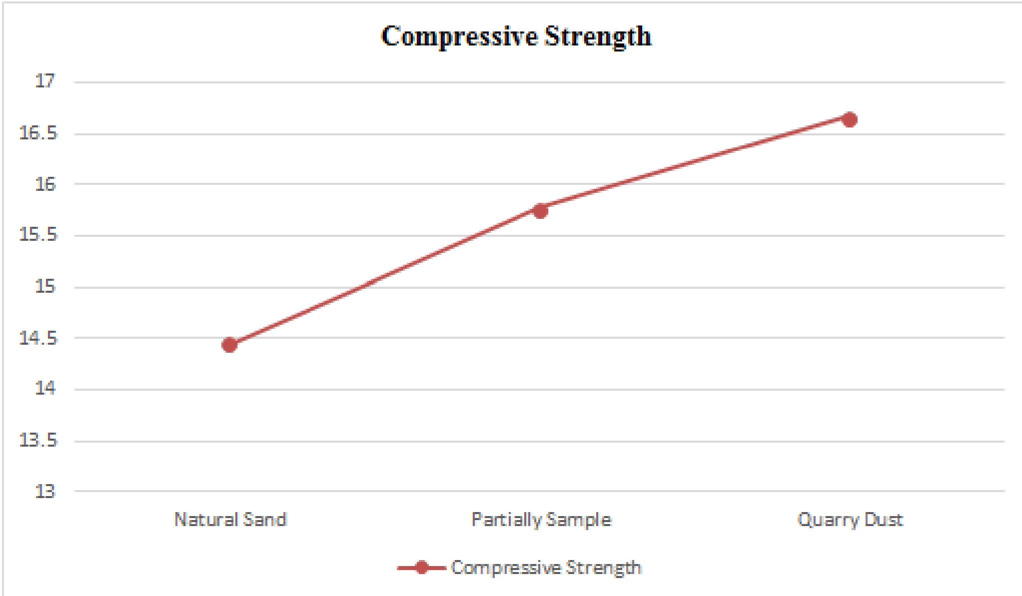

Figure 2: Compressive Strength In 14 Days

Table 7: Compressive Strength In 28 Days

Sr. No.	Sample	Weight	Compressive Strength (N/mm2)	Average Compressive strength (N/mm2)
1	Natural sand	8.34 kg	22.5	21.78
		8.40 kg	21.34	
2	Partially	8.30 kg	23.56	23.11
		8.38 kg	22.67	
3	Quarry Dust	8.34 kg	25.56	25
		8.36 kg	24.45	

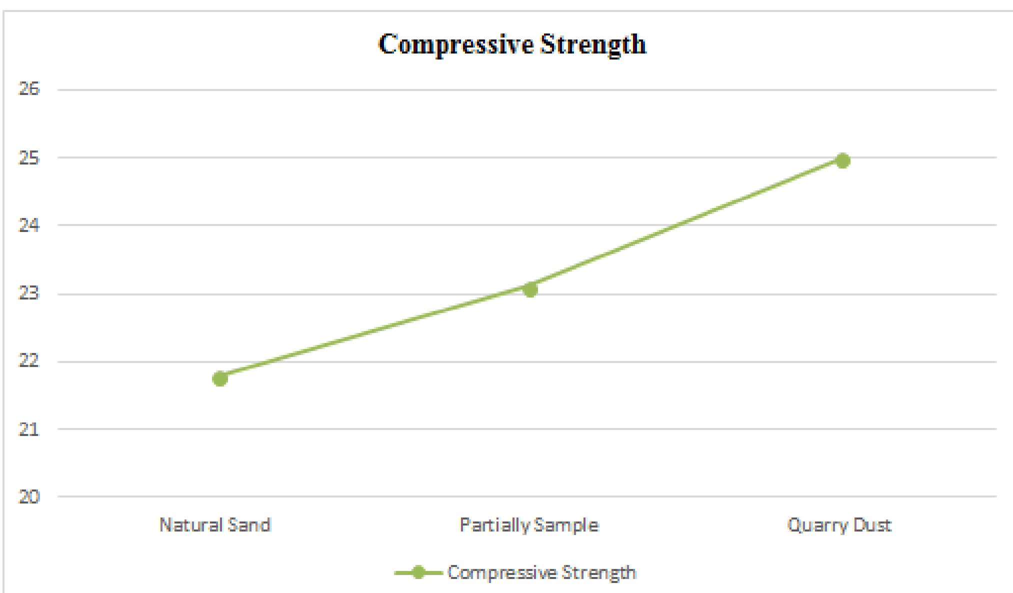

Figure 3: Compressive Strength In 28 Day

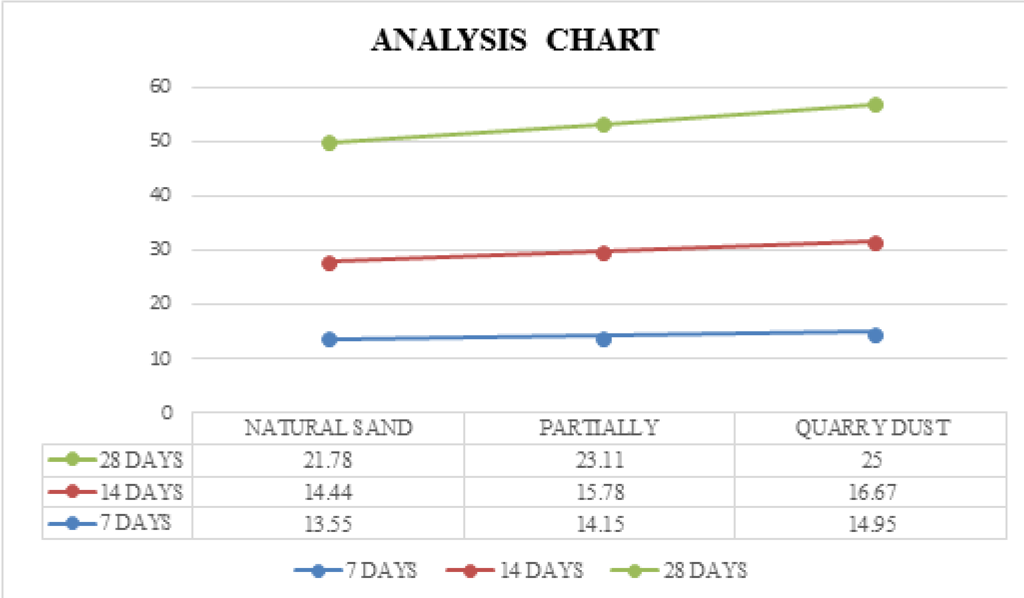

Figure 5: Overall Analysis

CONCLUSION

The compressive strength of M20 grade concrete was tested using varying percentages of quarry dust as a replacement for natural sand over 7, 14, and 28 days. The results showed that at 50% replacement (7 days), the average compressive strength was 14.15 N/mm² compared to 13.55 N/mm² for natural sand, while at full replacement, it was 14.95 N/mm². At 50% replacement (14 days), the average compressive strength was 15.78 N/mm² compared to 16.67 N/mm² for natural sand, while at full replacement, it equaled 16.67 N/mm². At 50% replacement (28 days), the average compressive strength was 23.11 N/mm² compared to 21.78 N/mm² for natural sand, while at full replacement, it reached 25 N/mm².

These findings suggest that quarry dust can effectively substitute natural sand in concrete without compromising its strength, albeit with slight fluctuations observed in compressive strength at different ages of concrete. Notably, as the concrete ages, its compressive strength tends to increase, especially when fully replacing natural sand with quarry dust. Maximum compressive strength was achieved at 30% replacement level over 28 days.

In summary, the study demonstrates the viability of using quarry dust as a substitute for natural sand in M20 grade concrete, with optimal results observed at a 30% replacement level over different ages of concrete.

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