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Research Article

EXPERIMENTAL STUDY ON THE PARTIAL REPLACEMENT OF CEMENT WITH QUARRY DUST FOR CEMENT MORTAR

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Abstract

The aim of the work is to explore the possibility of partially replacing the cement with quarry dust in the production of cement mortar with the aim of promoting sustainability in construction works. In the course of carrying out the research, the quarry dust was used as a replacement of the cement at 0%, 10%, 20%, and 30%. From the findings of the research, the workability of the mortar reduces as the percentage of quarry dust increases, while the compressive strength of the mortar increases as the percentage of quarry dust increases, with the best results at 10%.

Keywords: Dimension stability; Water absorption; Compressibility strength; Efflorescence test; Environment; Solid waste management.

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1. INTRODUCTION

Due to its strength and economic development, along with the quality of life, mortar has been accepted as the base of the infrastructure of a country. Over 5% of CO₂ emissions into the atmosphere are caused by the manufacturing of Portland cement. Green materials with pozzolanic activity can replace some of the cement (OPC) in order to reduce its disadvantages. Different types of dust-containing green materials, such as fly ash and ground nut shell ash, are tested as partial replacements of cement. Success has been achieved in India. In the proposed research, quarry dust will replace some of the cement. Concrete is the most versatile and variable building material and the engine of infrastructure development in any country [1-2]. The use of quartz quarry dust (QQD) as a partial substitute for fine aggregates in cement mortar has been studied by Ngayakamo and Ikotun (2026). The workability, bulk density, water absorption, and compressive strength of mortar mixes with 0–20% QQD substitution were assessed. According to the results, 10% QQD replacement improves performance by lowering water absorption from 6.4% to 5.7% and raising 28-day compressive strength from 10.8 MPa to 18.5 MPa. Because

of increased particle angularity and void formation, higher replacement levels decreased strength and workability. The viability of use quarry dust as fine aggregate in the production of cement blocks was investigated by Sundaralingam et al. (2022). Four distinct quarry dust composition levels—0, 33.3%, 66.7%, and 100%—were used to make and test cement blocks. Mechanical properties (compressive and flexural strength) and durability features (sorption, evaporation, wet and dry cycle, resistance to salt, alkaline and acid solution) were determined throughout the tests. The test findings showed that when quarry dust was used entirely in place of river sand as fine aggregate, mechanical properties and resistance to wet and dry cycles increased. The cubes exposed to harsh environmental circumstances showed greater rates of strength degradation than those under normal environmental conditions when the amount of quarry dust increased. According to Ansari et al. (2023), ready-mixed concrete facilities should scale the environmental impact of various concrete kinds (or grades) on the sustainability scale (economic, social, and environmental sustainability). The findings demonstrated that, with a comparable compressive

strength to M20 ready-mixed concrete, sun-dried water treatment sludge and sun-dried stone dust may successfully replace cement (15% by weight) in the concrete. It is estimated that the EF of typical M20 RMC is 0.02295 gha/m³. Concrete using sun-dried water treatment sludge has an EF that is 13.14% lower than that of traditional ready-mixed concrete. After reviewing the literature, AL-Kharabsheh et al. (2022) found that up to 40–50% substitution of QD as a fine aggregate can be used in concrete without negatively affecting durability and strength. Furthermore, less research has been done in this field, despite the fact that QD has cementitious qualities and can be utilized as a cement substitute to some extent. In order to improve the gradation of natural river sand by adding normalized quarry dust, Akmal et al. (2023) carried out extensive trials. River sand was largely substituted with quarry sand to create concrete mixes with strengths of 21 MPa, 28 MPa, and 35 MPa. The characteristics of hardened concrete and workability were assessed. 40% river sand and 60% normalized quarry dust were combined to improve river sand. For 28 MPa concrete, the enhanced sand gradation concrete's compressive and flexural strengths rose by 10–25% and 9–17%, respectively, in comparison to the control concrete. According to a cost research, 28 MPa concrete created with improved natural river sand gradation was 8.6% less expensive than concrete made with coarse pit sand. The mechanical, durability, and microstructure characteristics of ECC composed of waste quarry dust (WQD) and crumb rubber (CR) have been studied by Helal et al. (2024). They made use of leftover glass, granite, and ceramic powder. These WQD were used to partially replace cement at doses of 10%, 20%, and 30%, while CR was utilized to partially replace sand at the same dosages. In comparison to the control ECC, the results demonstrated that the application of untreated CR enhanced flexural strength by 25.1% while decreasing compressive and tensile strengths by 28.1% and 11.2%, respectively. Although flexural strength dropped by 13.4%, adding 20% physically treated CR increased compressive strength by up to 20.1% and tensile strength by up to 24.4%. In order to create a sustainable composite, Taiwo et al. (2022) used rice husk ash (RHA) and quarry dust (QD). Conventional composite samples were made with cement and river sand, while non-conventional composite samples were made with different percentages of QD and RHA (5%, 10%, 15%, 20%, and 25% wt/wt). According to the study, when creating sustainable building materials, QD and RHA might be utilized to partially replace river sand and cement, respectively. In order to determine whether it is feasible to incorporate industrial wastes into high-strength concrete, Teja Prathipati et al. (2022) evaluated the mechanical properties of HSC blended with industrial wastes. An attempt has been made to use fly ash and quarry dust, respectively, in varying amounts to partially substitute cement and fine aggregate in the concrete. In addition to durability characteristics such water absorption, porosity, density, acid strength loss, and acid mass loss, the concrete's

workability, compressive strength, and flexural strength were examined and documented. The findings suggest that adding fly ash and quarry dust to high strength concrete up to 30% each has improved mechanical performance. Thus, it can be said that adding industrial wastes like fly ash and quarry dust up to 30% in place of cement and aggregate in the HSC can be a sustainable substitute for the traditional HSC. Shaheen et al. (2023) Using stone dust as a fine aggregate substitute for natural sand, the current study assesses the physico-mechanical and petrographic characteristics of concrete and stone dust. Sand (traditional) and stone dust (alternative) were compared as fine aggregates using a number of physical characteristics tests, petrographic and geochemical studies (X-ray fluorescence), and physico-mechanical testing on the concrete. In accordance with American Concrete Institute (ACI) guidelines, many trial mixes of M25 grade concrete were created using different proportions of natural sand in place of stone dust. In comparison to a concrete mix that used 100% natural sand, medium-grade concrete that substituted stone dust for sand at different ratios shown increases in compressive strengths of up to 40 and 29% and flexural strengths of up to 53 and 32% for 7- and 28-day curing periods, respectively. In order to optimize the mechanical strength characteristics of green concrete, Alaneme et al. (2022) used the Adaptive Neuro-Fuzzy Inference System (ANFIS), which has an adaptive framework that combines fuzzy logic and neural network principles. In order to attain sustainability and eco-efficient building materials, the benefits of using soft computing techniques assist in managing various limitations related to recycling and reusing waste materials and their derivatives. The ANFIS model was developed using sixty-two datasets taken from the tests assessing the mechanical characteristics of green concrete with different replacement ratios of sawdust ash (SDA) and quarry dust (QD) for cement and fine aggregates, respectively, ranging from 0 to 50%. The results of the mechanical strength response demonstrate that SDA and QD can be useful admixtures for concrete, with notable improvements noted at 0.5% and 0.225% substitution by cement and fine aggregates, respectively. According to Chandramouli et al. (2022), replacing 40% of the fine aggregate with quarry dust yields the greatest results. Strength starts to decrease at 60% and is higher than that of regular concrete. The quantifiable compressive strength was used to determine the amount and kind of concrete used when sand was substituted with quarry dust. In the experimental investigation, natural sand is replaced with quarry dust in percentages of 0%, 20%, 40%, and 60%. The percentage of hook-end steel fibers in the concrete was between 0.5% and 0.75%. 40% quarry dust was found to boost strength after tests on cube and cylinder specimens. The physical and mechanical characteristics of concrete created by partially and completely replacing regular Portland cement and fine aggregates with periwinkle shell ash and quarry dust (5%, 10%, 15%, 20%, and 100%), respectively, were investigated by Njoku et al. (2025). For the concrete mixture, a 1:2:4 water

to cement ratio of 0.60 was used. In contrast to the partially replaced concrete, which had a compressive strength of 18.8–15.1 N/mm², the concrete without the waste materials had an optimal value of 22.9 N/mm². The compressive strengths of the concrete samples with complete substitutions of quarry dust and periwinkle shell ash are less than 13.8 N/mm². In their study, Samuel and Okafor (2025) substituted ceramic tile dust (CTD) for quarry dust (QD) in hot asphalt mix. A polynomial model equation was created to predict the Indirect Tensile Strength (IDT) of asphalt mix that included CDT as a full or partial replacement for QD filler. The pozzolanic feature of CTD has been linked to improved IDT of the final asphalt mix, according to laboratory test results. The F-test and analysis of variance had F-values of 1.170 and 0.1020, respectively, and their corresponding F-critical values were 2.484 and 4.1960. Both of their P-values were higher than 0.05, indicating a negligible lack of fit. With the highest value being 5.81%, the model residuals at the 15 checkpoints were generally modest.

Researchers have found that replacing cement with quarry dust up to about 10–15% improves compressive strength due to better particle packing and its pozzolanic properties. However, increasing the replacement percentage

beyond this limit results in reduced workability and strength. In addition, quarry dust contributes to minimizing environmental pollution and reducing overall construction expenses. Quarry dust, which is a by-product of stone crushing, can be utilized in various mortar applications such as masonry work plastering, and floor leveling, while also supporting sustainability and cost efficiency.

2. MATERIALS AND METHOD

In mortar, quarry dust is used to partially replace cement at percentages of 0%, 10%, 20%, and 30%. Conventional specimens are also created for the proportion of 1:6 without the use of quarry dust. Compression tests are conducted to analyze the characteristics of mortar. Mortar cubes with cement and cubes with partially added quarry dust are cast and tested to evaluate their compressive strengths. The standard procedure for using quarry dust in cement mortar is to substitute some of the sand with quarry dust, usually in a 1:3 cement to sand ratio, and then combine it with water to get the right consistency. Depending on the required characteristics of the mortar, the precise ratio and water content can be changed. The detailed experimental procedure is given in Figure 1.

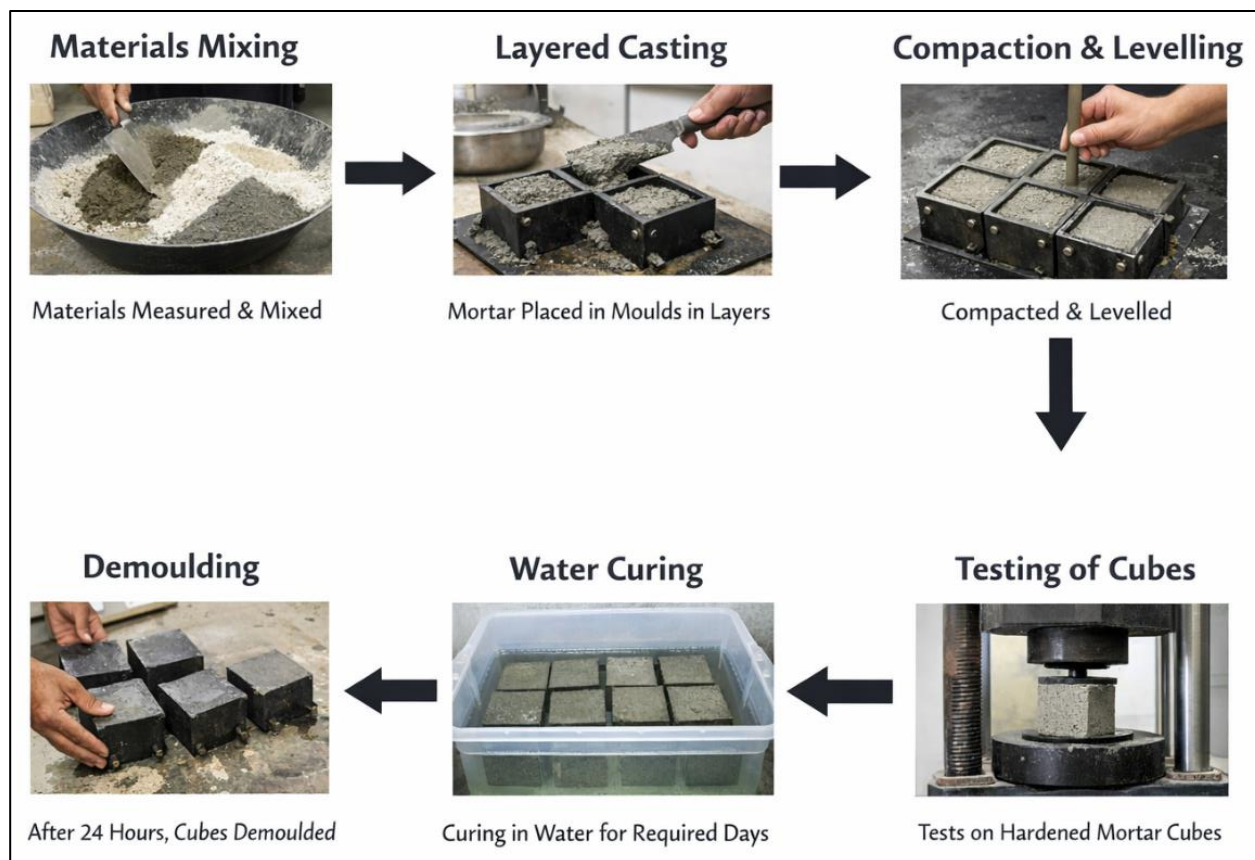


Figure 1: Experimental methods

3. RESULTS AND DISCUSSION

3.1. COMPRESSIVE STRENGTH

Table 1: Compressive strength test

% of mix	Compressive strength for 28 days (N/mm ²)
0%	26.00
10%	27.50
20%	21.00
30%	16.00

The improvement of compressive strength from a period of 7 days to 28 days for mixes with varying percentages of Quarry dust is presented in Table 1. It reports the % increase in compressive strength between specimens with different amounts of quarry dust and control specimens. According to the table, adding 10% quarry dust raises the 28-day strength from 26 MPa to 27.50 MPa. The increase in pozzolanic action that occurred when quarry dust was added to mortar was responsible for the 8.51% improvement in compressive strength. However, following a 28-day curing period, the mortar's compressive strength decreased for other variations in quarry dust. It was also discovered that the percentage difference in compressive strength with respect to 0% quarry dust replacement of quarry dust mortar increased gradually up to almost 10% replacement before declining.

3.2. WATER ABSORPTION TEST

For a predetermined amount of time, a dried specimen with a known weight was submerged in water. Following that time, the specimen was weighed once more, and the weight increase relative to the initial weight was expressed as the percentage of water absorption. Water absorption percentages for various quarry dust percentages. % of water absorbed for different quarry dust percentages. Water absorption was observed to increase with the proportion of quarry dust. This could be because water fills the pores in the more porous quarry dust, increasing the rate of water absorption. The purpose of the water absorption test is to determine how much water cement mortar can absorb in order to evaluate its porosity and durability. This test assists in determining the mortar's moisture resistance, which is important for buildings that are subjected to damp circumstances. A well cured mortar specimen is first dried in

an oven between 105°C and 110°C until it reaches a constant weight in order to conduct the test. The dry weight is noted once it has cooled. Following a 24-hour immersion in water, the specimen's surface is cleaned and its wet weight is determined. The difference between the wet and dry weights is compared to the dry weight to determine the percentage of water absorbed.

The amount of water that a material absorbs under particular circumstances is measured by a water absorption test. It aids in assessing a material's resistance to moisture as well as the likelihood of deterioration or poor performance under damp conditions. In a number of industries, including manufacturing, packing, and construction, this test is essential.

Aggregate's internal structure can be inferred from water absorption. More absorbent aggregates are more porous and are typically regarded as inappropriate unless strength, impact, and hardness testing show that they are acceptable.

3.3. TEST ON FINE AGGREGATE

The particle size distribution for fine aggregate can be ascertained with the aid of sieve analysis (Figure 2). The aggregate is sieved in accordance with IS 2386 (part-1) 1963 to accomplish this the collection of sieves with dimensions of 4.75 mm, 3.35 mm, 2.36 mm, 1.28 mm, 0.6 mm, and 0.3 mm were used. The sieve analysis results are listed in the Table 2.



Figure 2: Sieve analysis

Table 2: Sieve analysis result for fine aggregate

Passing through sieve (mm)	Retained on sieve(mm)	% retained	Cumulative % retained	% passing
4.75	2.36	3.00%	3.00%	97.00%
2.36	1.18	22.00%	25.00%	75.00%
1.18	0.6	27.00%	52.00%	48.00%
0.6	0.3	15.00%	67.00%	33.00%
0.3	0.15	25.00%	92.00%	8.00%

3.4. COMPACTION FACTOR TEST FOR MORTAR

Table 3: Compaction factor test

S. No	Types of mortar	Compaction factor
1.	0% QUARRY DUST	0.812
2.	10% QUARRY DUST	0.913
3.	20% QUARRY DUST	0.763

The compaction factor test was done to see how well mortar mixes with different amounts of quarry dust replacement worked (Table 3). The results show that the mortar with 10% quarry dust had the highest compaction factor of 0.913, which means it was easier to work with than the control mix (0.812). However, when the amount of quarry dust was raised to 20%, the compaction factor dropped to 0.763, which means that the workability was lower. This trend may be due to the fact that quarry dust is finer and needs more water at higher replacement levels, which makes it harder to flow. Overall, a 10% partial replacement seems to make mortar easier to work with, while larger amounts make it harder to work with [8-10].

4. CONCLUSIONS

This study examined the viability of substituting cement with quarry dust in mortar to encourage sustainable construction methodologies. The experimental results indicate that quarry dust is a feasible supplementary material when utilized in restricted quantities. The compressive strength tests showed that a 10% replacement level gives the best performance, with a maximum strength of 27.50 MPa due to better particle packing and pozzolanic activity. However, adding more quarry dust (20% and 30%) made the strength go down, which shows that too much replacement can hurt the binding properties of mortar. The compaction factor test showed that the workability of mortar got better when 10% of the material was replaced, but it got much worse when more was added because quarry dust is finer and needs more water. Also, the amount of water that the material could absorb went up as the amount of quarry dust went up. This could mean that the material was more porous, which could affect how long it lasts. In general, the study shows that replacing up to 10% of cement with quarry dust is the best way to find a balance between strength, workability, and sustainability. Using quarry dust not only cuts down on the amount of cement used and the damage it does to the environment, but it also helps with managing industrial waste, making it useful for building projects.

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CONFLICT OF INTEREST

There is no conflict of interest among the authors.

DATA AVAILABILITY

Corresponding authors is will provide the data on request

REFERENCES

1. Anup K. Chitkeshwar, P.L. Naktode, Concrete with rock quarry dust with partial replacement of fine aggregate, *Materials Today: Proceedings*, 62(12), 2022, 6455-6459.
2. A. Kumar, S. Pratheba, R. Rajendran, K. Perumal, N. Lingeshwaran, Susmitha Sambaraju, An experimental study on the mechanical properties of concrete replacing sand with quarry dust and waste foundry sand, *Materials Today: Proceedings*, 33(1), 2020, 828-832.
3. Ngayakamo, B. H., & Ikotun, B. D. (2026). Utilization of quartz quarry dust as a sustainable partial sand replacement in cement mortar. *Scientific Reports*.
4. Sundaralingam, K., Peiris, A., Anburuvel, A., & Sathiparan, N. (2022). Quarry dust as river sand replacement in cement masonry blocks: Effect on mechanical and durability characteristics. *Materialia*, 21, 101324.
5. Ansari, Y., Husain, D., Das, U. K., Haloi, J., Khan, N. A., Prakash, R., & Husain, M. (2023). Ecological footprint assessment of concrete: Partial replacement of cement by water treatment sludge and stone dust. *Sustainability*, 15(9), 7512.
6. AL-Kharabsheh, B. N., Moafak Arbili, M., Majdi, A., Ahmad, J., Deifalla, A. F., Hakamy, A., & Majed Alqawasmeh, H. (2022). Feasibility study on concrete made with substitution of quarry dust: a review. *Sustainability*, 14(22), 15304.
7. Akmal, U., Fatima, S., Khurram, N., Shaukat Khan, Q., Ahmed, T., Alabduljabbar, H., & Ahmed Awad, Y. (2023). Performance of concrete developed by enhanced gradation of natural fine river sands by partial replacement of waste quarry dust. *Advances in Civil Engineering*, 2023(1), 5508001.
8. Helal, K. A., Tahwia, A. M., & Youssf, O. (2024). Performance of eco-friendly ECC made of pre-treated crumb rubber and waste quarry dust. *Journal of Building Engineering*, 97, 110820.
9. Taiwo, L. A., Obianyo, I. I., Omoniyi, A. O., Onwualu, A. P., Soboyejo, A. B., & Amu, O. O. (2022). Mechanical behaviour of composite produced with quarry dust and rice husk ash for sustainable building applications. *Case Studies in Construction Materials*, 17, e01157.
10. Teja Prathipati, S. R. R., Paluri, Y., Vijay, K., & Bhavita Chowdary, V. (2022, September). Evaluating the feasibility of blending fly ash and quarry dust in high-strength concrete to develop a sustainable concrete: A Study on the Mechanical and Durability Properties. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1086, No. 1, p. 012060). IOP Publishing.
11. Shaheen, A. U. H., Ahmed, K. S., Sarfraz, Y., Riaz, M. T., & Shahzad, A. (2023). Physico-Mechanical characterization of cement concrete using Quarry Waste as fine aggregate replacement of natural sand. *Arabian Journal for Science and Engineering*, 48(10), 13807-13821.
12. Alaneme, G. U., Mbadike, E. M., Attah, I. C., & Udousoro, I. M. (2022). Mechanical behaviour optimization of saw dust ash and quarry dust concrete using adaptive neuro-fuzzy inference system. *Innovative Infrastructure Solutions*, 7(1), 122.
13. Chandramouli, K., Chaitanya, J. S. N., & Babu, M. T. (2022). An experimental investigation on steel fiber reinforced concrete with quarry dust as a partial replacement of fine aggregate. *Int J Res Appl Sci Eng Technol Int J Res Appl Sci Eng Technol (IJRASET)*, 10, 522-1524.
14. Njoku, C. E., Ekeleme, A. C., Ekwueme, B. N., Onuoha, C., Onuzulike, E. P., Chibundu, W., & Ozoh, C. C. (2025). Utilization of quarry dust and periwinkle shell ash in concrete production. *Environmental Science and Pollution Research*, 32(54), 29957-29966.
15. Samuel, J., & Okafor, F. O. (2025). Optimization of indirect tensile strength of modified asphalt concrete using ceramic tile wastes and quarry dust. *International Journal of Pavement Research and Technology*, 18(4), 979-991.