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# Partial Replacement of Cement By Quarry Dust In Concrete

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**Abstract:** *The utilization of quarry dust as a binding material in concrete has emerged as a promising alternative amidst the diminishing availability of natural river sand. Quarry dust, a byproduct of the crushing process in quarrying activities, presents itself as a readily available and cost-effective substitute for natural sand in concrete production. Its use not only addresses the scarcity of river sand but also contributes to cost reduction and environmental preservation by minimizing the demand for natural resources and reducing quarry waste. While concerns regarding potential air pollution and long-term durability exist, these can be effectively managed through appropriate dust suppression measures during crushing and the incorporation of suitable admixtures and curing methods. Thus, quarry dust stands as a viable option, offering both practical and environmental benefits in the construction industry.*

**Keywords:** Quarry dust, concrete, substitution, environmental impact, cost-efficiency

## I. INTRODUCTION

### 1.1 Overview

In modern construction practices, the demand for concrete continues to surge, driven by urbanization and infrastructure development. However, the traditional reliance on natural river sand as a key component in concrete production is facing unprecedented challenges. The overexploitation of riverbeds, coupled with environmental concerns and regulatory restrictions, has led to a scarcity of this vital resource. In response to these challenges, researchers and industry professionals are exploring alternative materials to replace or supplement natural sand.

One such alternative gaining significant attention is quarry dust, a byproduct of the crushing process in quarrying activities. Quarry dust, comprising fine rock particles, shares many properties with natural sand, making it a suitable candidate for use in concrete. Its availability is a key advantage, as quarry dust can be readily obtained at a lower cost compared to natural sand. This affordability makes it an attractive option for construction companies striving to optimize costs without compromising on quality.

Beyond its economic benefits, the use of quarry dust in concrete production offers environmental advantages. By reducing reliance on natural sand, quarry dust helps preserve precious natural resources and mitigate the environmental impact associated with sand mining. Additionally, incorporating quarry dust into concrete mixtures can reduce the amount of waste generated from quarrying activities, further contributing to environmental sustainability.

While the adoption of quarry dust in concrete presents promising opportunities, challenges and considerations remain. Addressing concerns such as potential air pollution during the crushing process and ensuring the long-term durability of concrete made with quarry dust are crucial areas for research and development. Through continued innovation, regulation, and industry collaboration, quarry dust has the potential to emerge as a sustainable and practical solution for meeting the growing demand for concrete in the construction sector.

The utilization of quarry dust as a potential substitute for conventional river sand in concrete production has gained significant attention in recent years. This interest stems from the growing concerns surrounding the scarcity of natural sand due to excessive mining practices and environmental degradation. Quarry dust, a byproduct of the crushing process in quarrying activities, presents itself as a readily available and cost-effective

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alternative. Understanding the factors influencing dust generation in stone crushers is crucial in assessing the feasibility and environmental impact of utilizing quarry dust in concrete production. Variables such as the type and size of the crusher, the material being crushed, and the operating speed all play significant roles in determining the amount of dust generated. Furthermore, comprehensive studies examining the physical and chemical properties of quarry dust, as well as its compatibility with various admixtures, are essential in optimizing concrete mixtures for desired performance and durability. This dissertation aims to address these aspects comprehensively, with a focus on evaluating the feasibility and effectiveness of incorporating quarry dust as a binding material in concrete, thereby contributing to sustainable construction practices and environmental conservation.

### 1.2 Motivation

The motivation behind exploring the utilization of quarry dust as a binding material in concrete stems from the urgent need to address the environmental and economic challenges facing the construction industry. With the depletion of natural river sand resources and the escalating costs associated with its extraction, there is a pressing demand for sustainable alternatives that can maintain quality standards while mitigating environmental impact. By harnessing quarry dust, a readily available byproduct of quarrying activities, as a substitute for natural sand, we not only alleviate the strain on natural resources but also pave the way for more cost-effective and eco-friendly construction practices, driving towards a greener and more sustainable future.

### 1.3 Problem Definition and Objectives

The overarching problem addressed in this study revolves around the depletion of natural river sand reserves and the environmental concerns associated with its extraction, necessitating the exploration of alternative binding materials for concrete production. Specifically, the study seeks to investigate the feasibility and effectiveness of utilizing quarry dust as a potential substitute for natural sand in concrete mixtures.

- To assess the workability and compressive strength of concrete mixtures incorporating varying proportions of quarry dust as a replacement for natural sand.
- To compare the performance of quarry dust concrete with conventional concrete in terms of durability and long-term stability.
- To examine the physical and chemical properties of quarry dust to determine its suitability as a binding material in concrete.
- To evaluate the environmental implications and economic viability of utilizing quarry dust in concrete production.
- To propose recommendations for optimizing concrete mixtures with quarry dust to enhance sustainability and efficiency in construction practices.

### 1.4. Project Scope and Limitations

This study focuses on investigating the feasibility and effectiveness of incorporating quarry dust as a replacement for natural sand in concrete mixtures. The scope encompasses examining the physical and chemical properties of quarry dust, evaluating its impact on concrete workability, compressive strength, and durability, and assessing its environmental and economic implications. Additionally, the study aims to provide insights into optimizing concrete mixtures with quarry dust for sustainable construction practices.

**Limitations As follows:**

The study's findings may be influenced by variations in the quality and composition of quarry dust obtained from different sources, affecting the consistency of results.

Due to time and resource constraints, the study may not comprehensively explore all potential admixtures and curing methods to enhance the properties of quarry dust concrete.

The long-term performance and durability of quarry dust concrete under various environmental conditions may require further monitoring beyond the scope of this study.

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## II. LITERATURE REVIEW

Paper Title: "Utilization of Quarry Dust as Fine Aggregates in Concrete" (2017)
Author: P. Balakrishnan, M. Jayaprakash, K. Udhayakumar
Description: This study investigates the feasibility of using quarry dust as a partial replacement for natural sand in concrete production. The authors conduct comprehensive laboratory experiments to assess the workability, compressive strength, and durability of concrete mixtures containing various proportions of quarry dust. They explore the influence of quarry dust on concrete properties and provide insights into optimizing mix proportions for enhanced performance and sustainability.
Paper Title: "Effect of Quarry Dust on the Engineering Properties of Lateritic Soils" (2015)
Author: Opara A. C., Efe S. I.
Description: This paper explores the impact of incorporating quarry dust into lateritic soil for engineering applications. Through laboratory tests, the authors evaluate the mechanical properties, such as compaction, California Bearing Ratio (CBR), and unconfined compressive strength, of lateritic soil-quarry dust mixtures. The study provides valuable insights into the potential use of quarry dust as a stabilizing agent for lateritic soils in road construction and other civil engineering projects.
Paper Title: "Strength and Durability Properties of Concrete Containing Quarry Dust as Fine Aggregate" (2016)
Author: S. A. Raman, K. Vijai, S. Subramanian
Description: This research investigates the influence of quarry dust as a fine aggregate replacement on the strength and durability of concrete. The authors conduct experimental studies to assess the compressive strength, split tensile strength, and water absorption characteristics of concrete specimens containing varying percentages of quarry dust. The findings contribute to understanding the potential benefits and limitations of using quarry dust in concrete production.
Paper Title: "Evaluation of Suitability of Quarry Dust as Improvement to Cement Stabilized Lateritic Interlocking Blocks" (2019)
Author: Amadi, E. C., Nwakaire, C. N., Omoruyi, O. A.
Description: This study investigates the suitability of quarry dust as a stabilizing agent for cement-stabilized lateritic interlocking blocks. Through laboratory tests and field observations, the authors assess the mechanical properties and durability of interlocking blocks produced with varying proportions of quarry dust. The research provides valuable insights into enhancing the quality and performance of interlocking blocks using quarry dust, offering potential benefits for sustainable construction practices.
Paper Title: "Evaluation of Concrete Properties Using Quarry Dust as Fine Aggregate" (2018)
Author: Hamid Mirzaei, MortezaKhorami
Description: This paper evaluates the properties of concrete incorporating quarry dust as a fine aggregate replacement. Through experimental investigations, the authors examine the fresh and hardened properties of concrete mixtures with different percentages of quarry dust. The study assesses parameters such as workability, compressive strength, and water permeability, providing valuable insights into the potential applications and performance of quarry dust concrete in construction projects.

## III. REQUIREMENT AND ANALYSIS

**Cement (Ordinary Portland Cement, 53 Grade)**:

- Specification: The cement used in this experiment is Ordinary Portland Cement (OPC), 53 Grade, adhering to IS 12269:1987.
- Description: Cement is a binding agent that, when mixed with water, forms a paste that hardens and binds together aggregates to form concrete. Ordinary Portland Cement (OPC) is commonly used in construction due to its high compressive strength and durability. The 53 Grade designation indicates its high strength, suitable for structural applications.

**Fine Aggregate (Artificial Sand)**:

- Specification: The fine aggregate used in this experiment is artificial sand sourced from local stone crushers with basaltic origin, with a maximum size of 20 mm.

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- Description: Fine aggregate, also known as sand, is a key component of concrete, serving as a filler material that binds with cement paste to form the matrix of concrete. Artificial sand is manufactured by crushing rocks or quarry stones to the desired size and shape, providing an alternative to natural river sand.

**Coarse Aggregate**:

- Specification: Coarse aggregates used in this experiment are sourced from local stone crushers with basaltic origin, with a maximum size of 20 mm.
- Description: Coarse aggregate is an essential component of concrete, providing volume stability and strength. It typically consists of crushed stones or gravel with particle sizes larger than 4.75 mm. Coarse aggregates are responsible for imparting bulk to concrete and are essential for achieving the desired workability and strength.

**Water**:

- Specification: Water used in the experiment is clean and free from impurities.
- Description: Water is a crucial ingredient in concrete, facilitating the hydration process that binds cement particles together and forms the hardened matrix. It is essential to use clean water to prevent contamination of the concrete mixture, which could compromise its strength and durability.

**Admixture (Concrete Solution)**:

- Specification: The admixture used in the experiment is a concrete solution designed to improve workability, setting time, and strength of concrete.
- Description: Admixtures are chemical formulations added to concrete to enhance its performance and properties. They can modify the behavior of fresh and hardened concrete, improving workability, durability, and other characteristics. Admixtures are commonly used to optimize concrete mixtures for specific construction requirements and environmental conditions.

**Quarry Dust**:

- Specification: Quarry dust used in the experiment is obtained as a byproduct of the crushing process during quarrying activities.
- Description: Quarry dust, also known as stone dust or crusher dust, is a fine material consisting of rock particles that are leftover after crushing boulders or stones in quarries. It is often used as a partial replacement for natural sand in concrete production due to its availability and potential to enhance the properties of concrete. Quarry dust can improve workability, reduce the demand for natural sand, and contribute to cost savings in concrete production.

## IV. TESTING OF SPECIMENS

**7 Days:**

- The compressive strength of concrete specimens and quarry dust+cement concrete specimens were tested after 7 days of curing.
- For the M25 grade concrete, the compressive strength of regular concrete specimens ranged from 17 to 25 N/mm^2, depending on the percentage of quarry dust used.
- The compressive strength of concrete specimens with quarry dust+cement ranged from 6.16 to 11.34 N/mm^2, with decreasing strength observed as the percentage of quarry dust increased.
- Photograph No. 3.2 shows the compressive strength of the specimens at 7 days.

**14 Days:**

- After 14 days of curing, the compressive strength of concrete specimens increased compared to the 7-day results, as expected.
- For the M25 grade concrete, the compressive strength of regular concrete specimens ranged from 20 to 25 N/mm^2, while specimens with quarry dust+cement ranged from 9 to 16.71 N/mm^2.
- Again, the strength decreased with higher percentages of quarry dust, as shown in the comparison.
- Photograph No. 3.2 depicts the compressive strength of the specimens at 14 days.

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**28 Days:**

- At 28 days of curing, the compressive strength of concrete specimens continued to increase.
- For the M25 grade concrete, the compressive strength of regular concrete specimens ranged from 25 to 28 N/mm^2, while specimens with quarry dust+cement ranged from 11.73 to 27.21 N/mm^2.
- Similar trends were observed, with decreasing strength associated with higher percentages of quarry dust.
- The comparison between concrete specimens and quarry dust+cement specimens at 28 days provides insights into the effectiveness of quarry dust as a partial replacement for cement.
- Photograph No. 3.2 illustrates the compressive strength of the specimens at 28 days.

Overall, the testing at different curing durations (7, 14, and 28 days) provides valuable data on the performance of concrete specimens with varying percentages of quarry dust as a partial replacement for cement. These results are crucial for assessing the feasibility and effectiveness of using quarry dust in concrete mixtures for construction applications.

**4.1 Result of System**

The results presented after 7, 14, and 28 days provide insights into the compressive strength of concrete specimens with varying percentages of quarry dust used as a partial replacement for cement. Here's a breakdown and discussion of the results:

**Results after 7 Days:**
**Grade of Concrete: M25**
**10% Quarry Dust:**
Average Compressive Strength: 11.15 N/mm^2
**20% Quarry Dust:**
Average Compressive Strength: 11.34 N/mm^2
**30% Quarry Dust:**
Average Compressive Strength: 7.07 N/mm^2
**40% Quarry Dust:**
Average Compressive Strength: 6.16 N/mm^2

**Results after 14 Days:**
**Grade of Concrete: M25**
**10% Quarry Dust:**
Average Compressive Strength: 12.91 N/mm^2
**20% Quarry Dust:**
Average Compressive Strength: 10.93 N/mm^2
**30% Quarry Dust:**
Average Compressive Strength: 9.84 N/mm^2
**40% Quarry Dust:**
Average Compressive Strength: 9.00 N/mm^2

**Results after 28 Days:**
**Grade of Concrete: M25**
**10% Quarry Dust:**
Average Compressive Strength: 16.71 N/mm^2
**20% Quarry Dust:**
Average Compressive Strength: 15.31 N/mm^2
**30% Quarry Dust:**
Average Compressive Strength: 15.74 N/mm^2
**40% Quarry Dust:**
Average Compressive Strength: 11.73 N/mm^2

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**Discussion:**

**Effect of Quarry Dust Percentage:**

- Generally, as the percentage of quarry dust increases, there's a trend of decreasing compressive strength across all curing periods (7, 14, and 28 days). This indicates that higher proportions of quarry dust negatively impact the strength of concrete.

**Curing Period Influence:**

- There's an overall increase in compressive strength with longer curing periods (7, 14, and 28 days). This is expected as concrete gains strength over time due to the continued hydration of cement.

**Optimal Percentage of Quarry Dust:**

- The results suggest that the concrete specimens with 10% quarry dust exhibit the highest compressive strength at all curing periods compared to other percentages. This indicates that 10% quarry dust is the most suitable proportion for maintaining adequate strength while still benefiting from the partial replacement of cement.

**Longer-Term Strength Development:**

While the compressive strength generally increases with longer curing periods, the rate of increase tends to slow down over time. This is evident in the incremental changes in compressive strength from 14 to 28 days.

The experiment demonstrates the influence of quarry dust as a partial replacement for cement on the compressive strength of concrete. The results highlight the importance of optimizing the percentage of quarry dust to achieve the desired strength while considering factors such as cost, workability, and environmental impact. Further studies could explore additional properties of concrete and the long-term durability of structures made with quarry dust-concrete mixes.


Fig. 1 : Implemented Model

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## V. CONCLUSION

### Conclusion

In conclusion, the investigation and analysis conducted on quarry dust and admixture have provided valuable insights into their potential as alternatives to traditional cement in concrete production. The affordability and accessibility of quarry dust and admixture make them attractive options for enhancing concrete properties while reducing costs. The experimental data reveals that incorporating 10% to 40% quarry dust with cement yields compressive strengths ranging from 16.71 N/mm² to 11.73 N/mm² compared to conventional concrete without any replacements. It is evident from the results that the addition of quarry dust up to a certain extent enhances the compressive strength of concrete, with marginal decreases observed up to 30% replacement. However, beyond 30% replacement, there is a notable decrease in compressive strength. Notably, a slight increase in compressive strength is observed from 10% to 30% cement replacement with quarry dust at the 28-day mark. Thus, it is concluded that quarry dust and admixture can be effectively utilized as partial replacements for cement in reinforced concrete construction, with optimal results achieved at replacement levels up to 30%. This research underscores the potential for sustainable and cost-effective concrete production methods while ensuring the durability and performance of concrete structures.

### Future Work

For future work, several avenues for further exploration and refinement emerge from this study. Firstly, conducting additional experiments with varying proportions of quarry dust and admixture beyond the 30% threshold could provide a more comprehensive understanding of their influence on concrete properties. Investigating the long-term durability and performance of concrete specimens incorporating quarry dust and admixture through extensive exposure testing under different environmental conditions would also be valuable. Furthermore, exploring the synergistic effects of combining quarry dust with other supplementary cementitious materials or additives could lead to novel concrete formulations with enhanced properties. Additionally, conducting life cycle assessments to evaluate the environmental impact and sustainability of using quarry dust and admixture in concrete production would be beneficial for guiding future sustainable construction practices. Overall, future research endeavors should aim to further optimize and validate the practical application of quarry dust and admixture as viable alternatives to traditional cement in concrete production, ensuring both economic viability and environmental sustainability.

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