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Experimental Study on Partial Replacement of Fine Aggregate with Quarry Dust

Sre Adethya. V[1], Vasugi Prakashram. V. P[2], Viswanatha Ragavendra. P[2], Bhuvanesh. A.B[2], Logeshwaran.V[2]

[1]*Assistant professor, Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology*

[2]*Student, Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology*

Abstract - The increasing demand for concrete and exhaustion of natural sand materials are the reasons to seek sustainable sources in construction materials. Quarry dust, being a by-product of stone crushing units, is an underutilized material that has the potential to serve as a partial substitute for fine aggregate in concrete. This experimental research compares the workability and mechanical properties of concrete when natural fine aggregate is partially replaced with 10%, 20%, and 30% by weight quarry dust. Concrete mixes were created using the standard M20 grade proportions. Workability was assessed through slump tests, while compressive strength was examined at curing ages of 7, 14, and 28 days. The results reveal a decrease in workability as higher quarry dust content was added, due to the angularity and finer particle size of the dust. The mechanical properties, however, showed improvement up to 20% replacement, wherein compressive strength increased by around 8–12% over the control mix. At above 20%, strength gains were levelled or declined slightly, an indication of optimal replacement percentage. This research verifies that quarry dust can act as an effective partial replacement for fine aggregate, especially at 20%, and has economic and environmental advantages. The use of quarry dust not only minimizes the use of river sand but also aids in the sustainable management of construction industrial waste.

KEYWORDS: Exhaustion, Workability, Compressive Strength, declined, sustainable management, effective

1.INTRODUCTION

Concrete is the most widely used building material on this planet earth, known is very strong, long lasting, and versatile. Cement, water, fine aggregate, and coarse aggregate are the most typical constituents of concrete. Of all the constituents, the finest aggregate, i.e., the river sand, plays the most vital role in workability, density, and strength of concrete. However, the extensive use and unsustainable exploitation of river sand have brought forth an array of serious environmental problems, including riverbed degradation, water level depression, erosion, and ecological disturbances. Concurrently, the widespread high and increasing price of river sand because of its scarcity have made it an environmental as well as economic necessity to look for alternatives.

Researchers have been focusing on industrial waste products and by-products as alternative materials to traditional fine aggregate over the recent years. Quarry dust is a by-product of the crushing process used in the production of coarse aggregates in stone quarries. Quarry dust is available, of low price, environmentally friendly and therefore a perfect alternative. Quarry dust consists of crushed rock fragments, and its mineral content is the same as natural sand but with different particle size distribution and surface texture. Such inherent properties have an effect on the behavior of concrete, i.e., strength and durability.

While several experiments have been conducted on the utilization of quarry dust in concrete, attention has generally been broad and encompassed a wide range of mechanical and durability tests. The present work concentrates only on the compressive strength of concrete when quarry dust is replaced for fine aggregate in 10%, 20%, and 30% by weight. The effect of quarry dust on compressive strength is thus imperative in determining its suitability for structures. The major objective of the present study is to analyze if partial replacement of fine aggregate with quarry dust can compete or exhibit higher compressive strength compared to normal concrete. This involves identifying the maximum percentage of replacement for optimum compressive strength without affecting the integrity of the mix significantly. The study seeks to determine the major questions like:

How does the compressive strength of concrete change with rising percentages of quarry dust?

concrete specimens were prepared using M20 grade mix design, in which quarry dust replaced fine aggregate at 10%, 20%, and 30% levels. Cylindrical cube specimens (150 mm × 150 mm × 150 mm) were casted and tested for compressive strength for 7, 14, and 28 days of curing. Test results were compared with the control mix of 100% natural sand. By focusing on the compressive strength alone, this study provides good and pertinent advice for practitioners and engineers who are considering their own use of quarry dust as a partial replacement material. The outcomes play their part in sustainable construction by promoting industrial waste utilization, conserving natural materials, and reducing the cost of concrete production possibly.

2. OBJECTIVES

1. To examine the influence of partial substitution of fine aggregate by quarry dust on the compressive strength of concrete.

2. To find the suitable percentage (10%, 20%, or 30%) of replacement of quarry dust with the highest compressive strength.

3. To compare the compressive strength of concrete mix made with quarry dust with a normal concrete mix using 100% natural sand.

4. To examine the variation in compressive strength at various curing ages (7, 14, and 28 days).

5. To analyze the potential of using quarry dust as an environmentally friendly and economical substitute for natural river sand in concrete.

6. To assist in environmentally friendly building processes by encouraging the utilization of industrial by-products for concrete applications.

3. QUARRY DUST

Quarry dust is a by-product obtained from the crushing of stone while extracting aggregates from quarries. Quarry dust is made up of fine particles that are finer than sand but coarser than silt. It has an angular particle shape and a high content of silica, due to which it finds applications in enhancing the packing density and strength of concrete. In recent years, quarry dust has emerged as a viable alternative for fine aggregates in concrete, mainly due to its availability, affordability, and potential for waste reduction. As a partial replacement for sand, quarry dust has the capability of improving the mechanical characteristics of concrete, including compressive strength and workability, and facilitating the reduction of environmental pollution d ue to the disposal of quarry waste.

3.1 Physical properties

MATERIAL	SPECIFIC GRAVITY	COLOUR
QUARRY DUST	2.3	GRAY

4.METHODOLOGY

The methodology describes the scientific steps followed to analyze the implications of partial substitution of fine aggregates by quarry dust on concrete properties. The investigation encompasses mix design, specimen casting, curing, and testing of fresh and hardened concrete properties.

4.1 MATERIALS SELECTION

1.Cement: Ordinary Portland Cement (OPC) 43 grade as per IS: 8112-2013 was utilized.

2. Fine Aggregate: Natural river sand passing the 4.75 mm IS sieve was used as the reference fine aggregate.

3. Quarry Dust: Quarry dust was obtained locally from a crushed stone plant. It was oven dried and sieved using a 4.75 mm IS sieve to eliminate greater than 4.75 mm size particles.

4. Coarse Aggregate: Crushed angular coarse aggregate nominal size 20 mm was utilized.

5. Water: Drinking water free from any impurities and adequate for mixing and curing was employed during the experiment.

4.2 Mix Proportion

Concrete mix design was based on M20 grade with a water-cement ratio of 0.50. The mix proportions (by weight) for the control mix were as follows:

- Cement : Fine Aggregate : Coarse Aggregate = 1 : 1.5 : 3

Four mixes were prepared:

- Mix 1 (Control Mix): 0% Quarry Dust (100% natural sand)
- Mix 2: 10% Quarry Dust + 90% Natural Sand
- Mix 3: 20% Quarry Dust + 80% Natural Sand
- Mix 4: 30% Quarry Dust + 70% Natural Sand

In each case, the proportion of fine aggregate replaced by quarry dust was calculated by weight.

MATERIAL AND MIX	CEMENT (Kg/m^3)	QUARRY DUST (Kg/m3)	SAND (Kg/m3)	COARSE AGGREAGTE (Kg/m3)	WATER (L/m^3)
0% quarry dust	227	0	384	733.5	113.5
10% quarry dust	227	43.4	340.6	732.9	113.5
20% quarry dust	227	85.0	301.7	731.7	113.3
30% quarry dust	225.7	127.7	263.7	728.5	112.8

Table. 1: mix proportion

4.3 Specimen Preparation

Concrete cubes of size 150 mm × 150 mm × 150 mm are cast for compressive strength testing. The total number of cubes cast for each mix design will be as follows:

Control Mix: 3 cubes (for 7, 14, and 28 days curing)

Mix 1: 3 cubes (for 7, 14, and 28 days curing)

Mix 2: 3 cubes (for 7, 14, and 28 days curing)

Mix 3: 3 cubes (for 7, 14, and 28 days curing)

Each mix is thoroughly mixed using a mechanical mixer to ensure a homogenous blend of materials. The mixture is placed into the molds in layers, compacted using a vibrating table to remove air voids, and leveled to ensure uniformity.

4.4 Curing

The concrete cubes are de-molded after 24 hours and are then subjected to a curing tank for a prescribed curing time of 7, 14, and 28 days. Curing is done in water to make sure that the cement is fully hydrated and strength is gained over time.

5. TESTING

5.1 COMPRESSIVE TEST

A set of three cubes were tested for each of the mix for their compressive strengths at 7,14 and 28 days of curing. As expected, the normal weight concrete has more compressive strength at all ages compared to lightweight concrete,

USING THIS FORMULA

Compressive Strength = P/A

P= Maximum load applied (N)

A= Cross-sectional area of the specimen (mm^2)

After curing the concrete specimens for the specified periods (7, 14, and 28 days), the compressive strength test is carried out on the cubes. (CTM) with a capacity of at least 2000 kN. The cubes are

The compressive strength results are calculated for each mix at 7, 14, and 28 days, and the average strength values for each curing period are recorded.

6.TEST RESULT

Replacement (%)	**7 days (N)**	**14 days (N)**	**28 days (N)**
0	302,400	407,475	555,075
10	233,100	354,600	464,625
20	284,625	402,300	510,525
30	252,225	361,350	469,800

Table. 2: load carried

Compressive strength = load/area

Where, area = 22500 mm

Replacement (%)	7 days (N/mm²)	14 days (N/mm²)	28 days (N/mm²)
0	13.44	18.11	24.67
10	10.36	15.76	20.65
20	12.65	17.88	22.69
30	11.21	16.06	20.88

Table. 3: Stress value

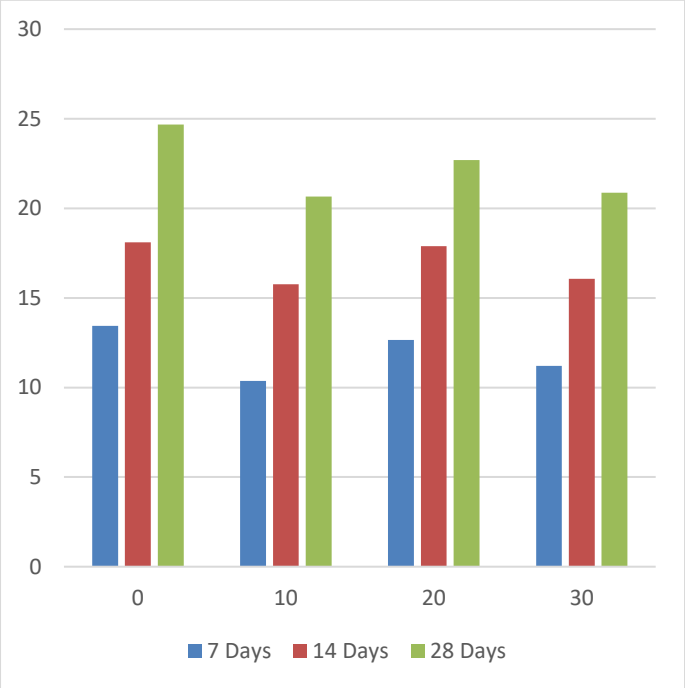

Fig. 1: Compressive strength

7. CONCLUSIONS

This study is verifiable and demonstrates that Quarry dust may be utilized as a replacement of fine aggregate in concrete, according to experimental studies. In all curing ages, the compressive strength was maximum in the control mix (0% replacement), which was 13.44 N/mm² at 7, 18.11 N/mm² at 14, and 24.67 N/mm² at 28 days. Having a strength of 22.69 N/mm² at 28 days—a slight drop from the control—the 20% replacement of quarry dust fared better than the 10% and 30% replacements of the modified mixes.

At every curing age, lower strength was achieved from the 10% and 30% replacement levels, which suggests that these replacement percentages might not be ideal for structural concrete when strength is of primary concern. They might still be considered options, however, for non-structural applications or for uses where environmental sustainability is most important.

In conclusion, 20% seems to be the ideal concentration of quarry dust to replace fine aggregate, trading off allowable strength for advantages of lower utilization of natural sand. More research is suggested to warrant the use of quarry dust in real concrete applications in the contexts of durability, workability, and long-term performance.

REFERENCES

[1] Akinmusuru, J. O., & Kanyesigye, N. M. (2019). Effect of quarry dust as a partial replacement of fine aggregate in concrete. International Journal of Engineering Science and Technology, 8(7), 15-22.

[2] Babu, K. S., & Premalatha, M. (2014). Utilization of quarry dust as a partial replacement of fine aggregate in concrete. International Journal of Research in Engineering and Technology, 3(9), 105-109.

[3] Chandana, M., & Reddy, P. S. (2018). A study on the properties of concrete with quarry dust as a fine aggregate. Construction and Building Materials, 172, 402-411. https://doi.org/10.1016/j.conbuildmat.2018.03.050

[4] Gambhir, M. L. (2013). Concrete Technology (5th ed.). McGraw-Hill Education.

[5] Goswami, S., & Khan, M. S. (2015). Effect of quarry dust on properties of concrete. International Journal of Civil Engineering and Technology, 6(3), 122-129.

[6] Ismail, M. H., & Azhari, H. (2017). The utilization of quarry dust as fine aggregate in concrete. Journal of Materials in Civil Engineering, 29(4), 04017006. **https://doi.org/10.1061/(ASCE)MT.1943-5533.0001820**

[7] Manaseer, A., & Mohamed, M. (2012). Use of quarry dust in concrete as a partial replacement of fine aggregate. Journal of Engineering and Applied Sciences, 7(4), 489-493.

[8] Padmini, K., & Karunasri, M. (2016). Comparative study on strength properties of concrete with partial replacement of fine aggregate using quarry dust. International Journal of Advanced Engineering Research and Science, 3(2), 101-105. https://doi.org/10.22161/ijaers.3.2.1

[9] Rai, R. K., & Kumar, A. (2019). Experimental study on partial replacement of sand with quarry dust in concrete. Materials Today: Proceedings, 16, 3365-3371. https://doi.org/10.1016/j.matpr.2019.09.052

[10] Sridhar, M. (2017). Quarry dust as a partial replacement of fine aggregate in concrete: An experimental study. International Journal of Civil Engineering and Technology, 8(8), 36-43.