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*Research Paper*

# EXPERIMENTAL STUDY ON REPLACEMENT OF FINE AGGREGATE BY QUARRY DUST IN CONCRETE

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The reduction in the sources of natural sand and the requirement for reduction in the cost of concrete production has resulted in the increased need to identify substitute material to sand as fine aggregates in the production of concretes. Quarry dust, a by-product from the crushing process during quarrying activities is one of such materials. Granite fines or rock dust is a by-product obtained during crushing of granite rocks and is also called quarry dust. This present work is an attempt to use Quarry Dust as replacement for Sand. Attempts have been made to study the basic properties of Quarry dust and compressive strength of Quarry dust concrete. The quarry dust behaves similar to conventional fine aggregate (sand) with respect to aggregate properties and zonal study. The optimum compressive strength is achieved at the proportion of fine to coarse with 60:40 ratio.

***Keywords:*** Quarry dust concrete, Alternative fine aggregate, Cost reduction

## INTRODUCTION

Concrete is an assemblage of cement, aggregate and water. The most commonly used fine aggregate is sand derived from river banks. The global consumption of natural sand is too high due to its extensive use in concrete. The demand for natural sand is quite high in developing countries owing to rapid infrastructural growth which results supply scarcity. Therefore, construction industries of developing countries are in stress to identify alternative materials to replace the demand for natural sand. On the other hand, the advantages of utilization of byproducts or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load and waste management cost, reduction of production cost as well as augmenting the quality of concrete. In this context, fine aggregate has been replaced by quarry dust a byproduct of stone crushing unit and few admixtures to find a comparative analysis for different parameters which are tested in the laboratories to find the suitability of the replacement adhered to the Indian Standard specifications for its strength. Quarry

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dust has been used for different activities in the construction industry such as road construction and manufacture of building materials such as light weight aggregates, bricks, and tiles. Crushed rock aggregates are more suitable for production of high strength concrete.

## LITERATURE REVIEW

**Nagabhushana *et al*. (2011):** The strength of mortar containing 40% Crushed Rock Powder is much higher than normal mortar containing only sand as fine aggregate. It is concluded that the compressive strength, split tensile strength and flexural strengths of concrete are not affected with the replacement of sand by CRP as fine aggregate up to 40%.

**Sivakumar *et al. (*2010):** The 28 days compressive strength of 100% replacement of sand with quarry dust of mortar cube (CM 1:1) is higher than the controlled cement mortar cube. The 56 days maximum Compressive strength, split tensile strength and modulus of elasticity of concrete for 100% replacement of sand with quarry dust of 400 kg/m$^3$ at F/C=0.6, was higher than the reference concrete.

**Bhikshma *et al*. (2010):** The stone dust as replacement for natural sand enhances the strength of concrete mix. The rough profile of stone dust provides good interlocking and bond between ultra fine particles of cement paste. The concrete is less permeable and durable than conventional concrete with river sand. The compressive strength increased significantly up to about 20% for concrete with crusher dust compared to conventional concrete.

**Lohani *et al*. (2012):** The slump value increases with increase in percentage replacement of sand with quarry dust. The increase in dust content up to 30% increases compressive strength of concrete, if the dust content is more than 30% the compressive strength decreases gradually. But the compressive strength of quarry dust concrete continues to increase with age for all the percentage of quarry dust contents.

**Ilangovan *et al*. (2008):** Studied and reported that the strength of Quarry Rock Dust concrete is comparatively 10% to 12% more than that of similar mix of Conventional Concrete. The permeability of Quarry Rock Dust concrete is less compared to that of conventional concrete. The water absorption of Quarry Rock Dust concrete is slightly higher than Conventional Concrete.

**Joseph O Ukpata *et al*. (2012):** The workability of concrete using lateritic sand and quarry dust as fine aggregates was found to have the same trend with normal concrete.

The density of hardened concrete using lateritic sand and quarry dust was found to range from 2293-2447 kg/m$^3$.

## NEED OF WORK

Common river sand is expensive due to excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems. As environmental transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete Industry needs to be found. In such a situation the quarry rock dust can be an economic alternative to the river sand.

# MATERIAL USED

## Quarry Dust

Common river sand is expensive due to excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems. As environmental transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete Industry needs to be found. In such a situation the quarry rock dust can be an economic alternative to the river sand. Quarry rock dust can be defined as residue, tailing or other non-voluble waste material after the extraction and progressing of rocks to form fine particles less than 4.75 mm. Use of quarry rock dust as a fine aggregate in concrete draws serious attention of researchers and investigators.

## Coarse Aggregate

Natural granite aggregate having density of 2700 kg/m$^2$ and Fineness Modulus (FM) of 6.80 was used. The specific gravity was found to be 2.58.

## Cement

Ordinary port land cement (43 grade).

## Water

Potable tap water.

# METHODOLOGY

This research work divided in to three phases

Phase 1: Replacement for fine aggregates

Phase 2: Replacement of Binders

Phase 3: Replacement of Coarse Aggregates

Presently the research work is preceding on

Phase 1: Replacement of conventional fine aggregate (sand) by Quarry dust.

Following are the step has to be carried out in the experimental studies of phase 1.

1. Sieve analysis of QD
2. Bulking character of QD
3. Bulk density of QD
4. Bulk density of Coarse Aggregate (CA)
5. Sieve analysis of CA
6. Mix proportion by varying the proportion of CA and QD
7. Compression Testing on Concrete cube.

# EXPERIMENTAL PROGRAM

## Sieve Analysis of Quarry Dust

The experiment is conducted to study the grading zone of fine aggregate (Figure 1 and Table 1).

The quarry dust samples are confirms to IS 383 -1970 Grading Zone-II.

**Figure 1: Sieve Analysis**

**Table 1: Sieve analysis**

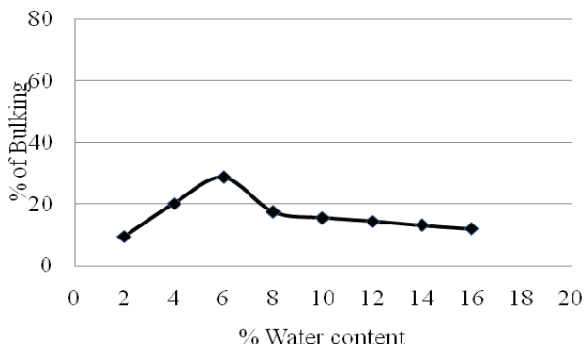
| Sieve Designation | Percent of Passing |
|---|---|
| 10 mm | 100 |
| 4.75 mm | 94 |
| 2.36 mm | 89 |
| 1.18 mm | 84 |
| 600 Micron | 72 |
| 300 Micron | 18 |
| 150 Micron | 04 |

## Bulking of Quarry Dust

The bulking properties of quarry dust are examined as specified as specified in IS 1180. Figures 2 and 3 shows the experimental work and result of bulking of QD.

**Figure 2: Testing of Bulking of QD**

**Figure 3: Bulking of QD V/S Water Content**




## Physical Properties of Quarry Dust

The physical properties of quarry dust is examined under two test by bulking density and specific gravity (Figures 4 and 5).

**Figure 4: Testing of Bulk Density**

**Figure 5: Testing of Specific Gravity**

- Bulk density of Quarry Dust (IS 2386) 1774.36 kg/m$^3$
- Specific gravity of Quarry Dust (IS 2386) 2.58

## Physical Properties of Coarse Aggregate

The physical properties of Coarse aggregate is examined under three test by bulking density specific gravity and sieve analysis (Figures 6, 7 and 8).

**Figure 6: Test of Bulk Density**

**Figure 7: Testing of Specific Gravity**

**Figure 8: Sieve Analysis of CA**

- Bulk Density-1742 kg/m$^3$
- Specific Gravity-2.48
- Sieve analysis Confirm to IS 383-1970 For 20 mm down size Aggregate

## MIXING HANDLING AND COMPACTION OF CONCRETE

The trial mix is prepared by varying the coarse and fine aggregate ratios and the Table 2 shows the proportions of CA and FA.

The fine aggregate and coarse aggregate is mixed thoroughly and the water is added as per the water binder ratio. The concrete is mixed on the non absorbent flat form. The concrete is filled in the concrete mould in three layers. Each layers compacted by 25 Manual strokes applied by 16 mm diameter rod. Figures 9 and 10 shows the mixing and compaction of concrete. After 24 h of casting the concrete specimen is removed from the mould then place the specimens in side of the curing tank filled with clean water. After 28 days, the test specimen is removed from the curing tank and kept it for 24 h for drying the specimen. The cured specimen is kept in compression testing machine to test compressive strength.

## TESTING OF SPECIMENS

The compression testing is the basic test which would conduct to analyze the strength of concrete. Generally the compression test on concrete specimens will be tested after 7 days and 28 days.

**Table 2: Trial Mix proportions**

| Trial Mix | Cement contentKg/m$^3$ | QD to CA Ratio | QD Kg/m$^3$ | CAKg/m$^3$ | W/C |
|---|---|---|---|---|---|
| M1 | 350 | 60:40 | 820 | 1230 | 0.6 |
| M2 | 350 | 50:50 | 1025 | 1025 | 0.6 |
| M3 | 350 | 40:60 | 1230 | 820 | 0.6 |
| M4 | 350 | 30:70 | 1435 | 615 | 0.6 |

**Figure 9: Concrete Mixing**

**Figure 10: Compactionof Concrete**

## Compression Test

The Compression test is conducted on 150 mm x 150 mm x 150 mm cube specimens by compression testing machine of 200 kN capacity with load increment of 5 N/min. Figures 11 and 12 shows the the compression test of concrete.

**Figure 11: Compression Test on Cubes**

**Figure 12: Load Indicators**

**Table 3: Compression Test Results**

| Trial mix | CementKg/m$^3$ | QD to CA Ratio | 7 daysStrength(Mpa) | 28 days strength(Mpa) |
|---|---|---|---|---|
| M1 | 350 | 60:40 | 23.22 | 34.83 |
| M2 | 350 | 50:50 | 22.11 | 33.55 |
| M3 | 350 | 40:60 | 21.35 | 32.25 |
| M4 | 350 | 30:70 | 20.05 | 30.15 |

**Figure 13: Application of Quarry Dust Concrete in Buildings, Jyothy Institute of Technology**

## APPLICATIONS

The quarry dust is widely used in construction industry especially preparation of mortar and concrete. The quarry dust is used to prepare the paver blocks of good permeability capacity and high grade concrete productions. The quarry dust gives better work ability and strength when it is mixed with the ingredients like fly ash, silica fume in concrete.

## CONCLUSION

Present Phase work discussed only about the basic property and compression strength. The sieve analysis of the quarry dust referred with zone-II, the gradation is almost matched with the conventional fine aggregate. The bulking of quarry dust is considerably increasing and it found 30% volume increased by 5 to 6% of water content. The compression strength of concrete is decreased gradually as increase in the voids in the concrete. The voids increase with increasing in coarse aggregate. The compressive strength decrease by 4% by increase in the 10 percentage of coarse aggregate in combined percent of aggregate. The optimum strength found to 34.83 kN/m$^2$ at the combined proportion of 60:40 ratio.

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