

Effect of Quarry Dust on High Performance Concrete

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Abstract -Concrete is the most widely used construction material all over the world. It has been in use for centuries in various type of structure due to its versatile nature. Increase in demand and decrease in supply of aggregate for the production of concrete motivated to identify new source of aggregates. So we use other materials to replace the appropriate amount of aggregates and study was made on quarry dust. The objective of this study is to find the suitability of using quarry dust in concrete and to compare its properties with that of the conventional concrete. Hence a simple mix design procedure has been developed especially for M60 grade concrete. In this work, the feasibility of the usage of quarry dust as 60:40 proportion of substitution of natural sand i.e (quarry dust replaces 60% of natural sand) in concrete. Silica fume is added as mineral admixture by 15% of weight of cement and steel fiber used in different percentage (0.5%, 1.0%, and 1.5%) to increase the tensile strength. Tests were conducted for 3, 7 and 28 days to study the compressive, tensile, flexural strength and durability test of concrete also conducted. From the result it was found that addition of silica fume will increase the compressive strength, steel fibre will increase the tensile strength. Addition of 1% steel fibre is found as optimum from the experimental results.

Keywords - High performance Concrete, Quarry dust, Strength, Workability, Mechanical properties.

1.0 INTRODUCTION

Concrete is a widely used material in the world. Based on global usage, it is placed at second position after water. Fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand. The global consumption of natural sand is very high due to the extensive use of concrete owing to rapid infrastructural growth. In this situation, the construction industries of developing countries are in stress to identify alternative materials to lessen or eliminate the demand for natural sand. So, quarry waste fine aggregate could be an alternative of natural sand. It is a byproduct generated from quarrying activities involved in the production of crushed coarse aggregates. Quarry waste fine aggregate, which is generally considered as a waste material after the extraction and processing of rocks to form fine particles less

than 4.75mm, causes an environmental load due to disposal problem. Hence, the use of quarry waste fine aggregate in concrete mixtures will reduce not only the demand for natural sand but also the environmental burden. Moreover, the incorporation of quarry waste fine aggregate will offset the production cost of concrete. In brief, the successful utilization of quarry waste fine aggregate will turn this waste material into a valuable resource. Unfortunately, limited research has been conducted to explore the potential utilization of quarry waste fine aggregate in concrete mixtures. Usually, Quarry Rock Dust is used in large scale in the highways as a surface finishing material and also used for manufacturing of hollow blocks and lightweight concrete prefabricated Elements. Use of Quarry rock dust as a fine aggregate in concrete draws serious attention of researchers and investigators.

2.0 LITERATURE REVIEW

Ganesan (2009) reported that volume fraction of steel fibre to be used are 0.5, 1.5, 2.0%. For M60 compaction factor ranges from 0.88 to 0.92. Indira P V (2009) reported that the standard mix design methods cannot be directly applied to HPC since various additional parameters are to be considered simultaneously. ACI 211 was a recommended code to make a mix proportioning of HPC. Subramanian, Kalaiarasu (2008) reported that the workability of concrete decreases as percentage of silica fume in concrete increases. Raman, Md. Safiuddin and Zain (2007) indicated that quarry waste did not significantly affect the non-destructive properties of the concretes except initial surface absorption. Dynamic modulus of elasticity, ultrasonic pulse velocity, and initial surface absorption varied linearly with compressive strength. Moreover, dynamic modulus of elasticity and ultrasonic pulse velocity were well-correlated. Ilangoan and Nagamani (2006) reported that Natural Sand with Quarry Dust as full replacement in concrete as possible with proper treatment of Quarry Dust before utilization. Quarry waste fine aggregate was used in presence of silica fume. The overall test results revealed that quarry waste fine aggregate can be utilized in concrete mixtures as a good substitute of natural sand. It is found that the compressive, flexural strength and durability studies of concrete made of quarry rock dust are nearly 10% more than the

conventional concrete. Sahu, Sunil Kumar and Sachan (2003) reported significant increase in compressive strength, modulus of rupture and split tensile strength when 40 percent of sand is replaced by Quarry Rock Dust in concrete. Nagaraj (2000) studied that the consumption of cement content, workability, compressive strength and cost of concrete made with Quarry Rock Dust. The mix design proposed shows the possibilities of ensuring the workability by wise combination of rock dust and sand, use of super plasticizer and optimum water content. Hudson(1997) reported that the strength of Quarry Rock Dust concrete is comparatively 10-12 percent more than that of similar mix of Conventional Concrete. Also the result of this investigation shows that drying shrinkage strains of Quarry Rock Dust concrete are quite large to the shrinkage strain of Conventional Concrete. However, at the later age, they have shown equal strain than Conventional Concrete. Durability of Quarry Rock Dust concrete under sulphate and acid action is higher inferior to the Conventional Concrete Permeability Test results clearly demonstrates that permeability of Quarry Dust concrete is less compared to conventional concrete. Nagaraj and Zahinda Banu (1996) produced concrete using the rock dust as an alternative to natural sand. They studied the effect of rock dust on the strength and workability of concrete.

3.0 MATERIALS

3.1 Cement

The Ordinary Portland cement was used in this study conforming to IS: 8112-1989. The specific gravity of cement is 3.15. The initial and final setting times were found as 26 minutes and 120 minutes respectively. Standard consistency of cement was 31%.

3.2 Fine aggregates

The river sand is used as fine aggregate conforming to the requirements of IS: 383-1970, having specific gravity of 2.68 and fineness modulus of 2.52 has been used as fine aggregate for this study.

3.3 Coarse Aggregate

Coarse aggregate obtained from local quarry units has been used for this study, conforming to IS: 383-1970 is used. Maximum size of aggregate used is 20mm with specific gravity of 2.63 and fineness modulus of 6.11 has been used.

3.4 Quarry Dust

The quarry dust used for this investigation work is obtained from the quarry near tindivanam in Tamil Nadu. The quarry dust passing through 4.75 mm retained on 150 micron IS sieves are taken. Specific gravity of 2.617 and fineness modulus of 2.706 has been used.

3.5 Silica Fume

The specific gravity of silica fume is 2.2. It consists of 0.1 to 1 micron sized fine, smooth spherical glassy particles with fineness of 20m²/gm conforming to ASTM C1240-1999 standards.

4.0 EXPERIMENTAL PROCEDURE

Mix proportions were arrived at for M60 grade of HPC trial mix based on the above formulated mix design procedure by adding 15% of the mass of cement with silica fume at a W/C ratio of 0.29 and a super plasticizer namely, CONPLAST SP430 was used at 2% by weight of a cements for obtaining workable concrete. The mixes were designated in accordance with IS: 10262-2009. However, as the steel fibres were added to the HPC, the workability was found to decrease. Percentage replacement of Quarry dust (Q: S =60:40) with partial replacement of 15% of silica fume and addition of steel fibre of various proportions (0.5%, 1.0%, 1.5%). A total of 36 concrete cubes, 36 concrete cylinders and 12prisms were casted. The specimens were demoulded after 24 hours and curing was done for different age of testing. They were tested for their strength properties on 3, 7, 28th day confirming to IS: 516-1959.

Table -1: Details of Mix Proportions of Concrete

| Water | Cement | Fine aggregate | Coarse aggregate | Silica fume | Super plasticizer |
|-------|--------|----------------|------------------|-------------|-------------------|
| 139.2 | 497.17 | 602.91 | 1193.24 | 74.57 | 9.94 |
| 0.29 | 1 | 1.21 | 2.40 | 15% | 2% |

Table -2: Compressive strength of cubes on 3, 7 and 28 Days

| % of Replacement | Cube Compressive Strength (N/mm ²) | | |
|------------------|--|--------|---------|
| | 3 days | 7 days | 28 days |
| CC | 35.75 | 46.34 | 64.65 |
| steel fibre 0.5% | 38.2 | 48.79 | 67.97 |
| steel fibre 1.0% | 42.72 | 51.31 | 72.34 |
| steel fibre 1.5% | 41.61 | 49.2 | 70.72 |

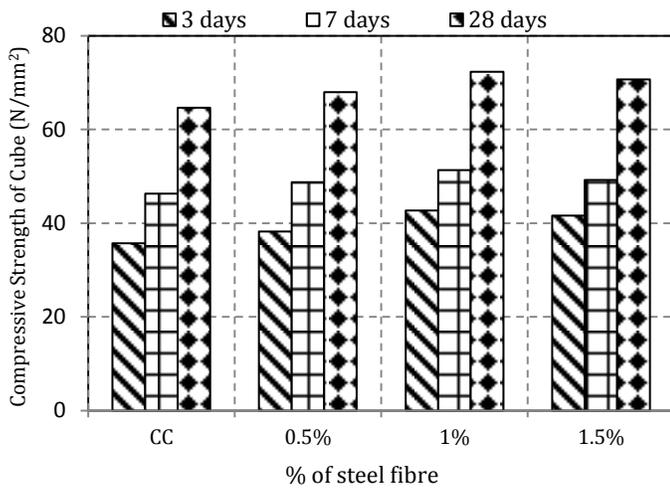


Chart -1: Compressive strength of cubes on 3, 7 and 28 Days

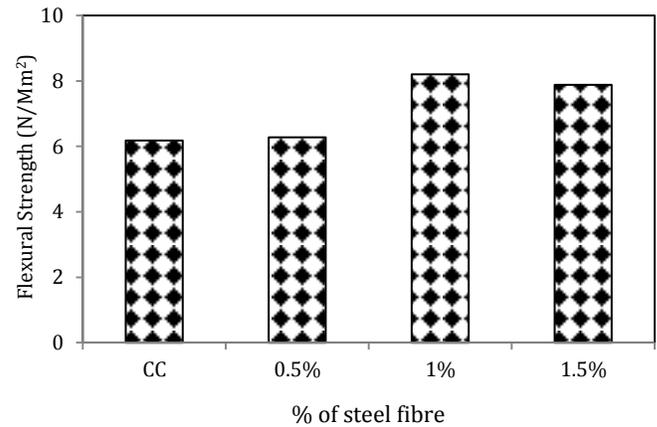


Chart -3: Flexural strength of prism on 28 Days

Table -3: Split tensile strength of cubes on 3, 7 and 28 Days

| % of Replacement | Split tensile strength(N/mm ²) | | |
|------------------|--|--------|---------|
| | 3 days | 7 days | 28 days |
| CC | 1.85 | 3.1 | 4.38 |
| steel fibre 0.5% | 1.92 | 3.33 | 4.57 |
| steel fibre 1.0% | 2.69 | 4.68 | 6.7 |
| steel fibre 1.5% | 2.32 | 4.11 | 5.9 |

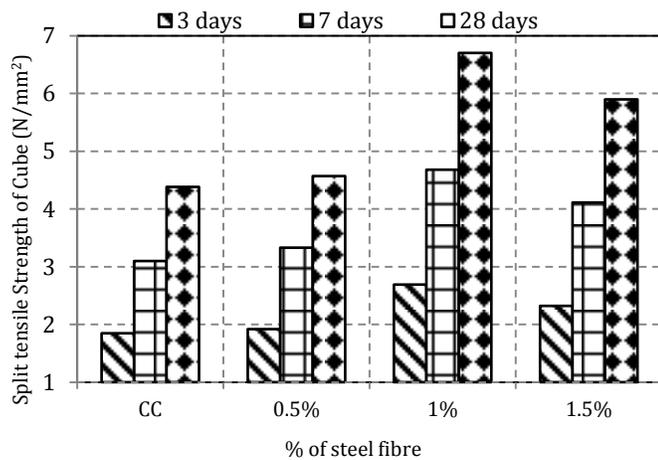


Chart -2: Split tensile strength of cubes on 3, 7 and 28 Days

5.0 DURABILITY TEST

Table -5: Saturated water absorption test

| % of Replacement | Flexural strength (N/mm ²) 28 days |
|------------------|--|
| CC | 3.15 |
| steel fibre 0.5% | 2.86 |
| steel fibre 1.0% | 2.75 |
| steel fibre 1.5% | 2.81 |

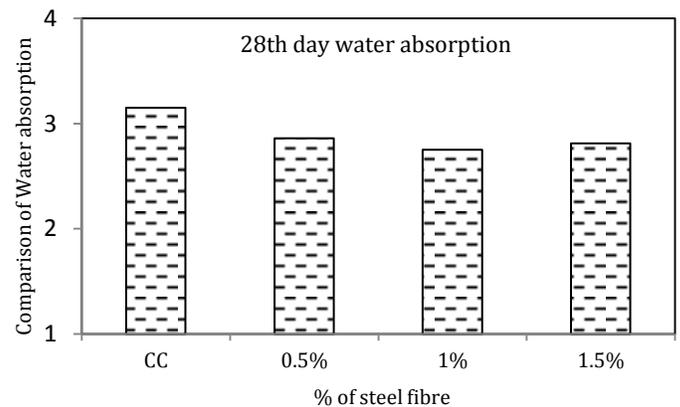


Chart -4: Comparison of Water absorption values at 28th day

Table -4: Flexural strength of cubes on 3, 7 and 28 Days

| % of Replacement | Flexural strength (N/mm ²) 28 days |
|------------------|--|
| CC | 4.38 |
| steel fibre 0.5% | 4.57 |
| steel fibre 1.0% | 6.7 |
| steel fibre 1.5% | 5.9 |

6.0 RESULTS AND DISCUSSION

The compressive, split tensile and flexural strength of M60 grade concrete mix for quarry dust 60%, silica fume 15% and different percentage of steel fibre as shown in Table 2, Table 3 and Table 4. The results for various percentages are discussed below.

1. For M60 concrete the compressive strength at the end of 3, 7 and 28days for 0.5% of additional of steel fibre the compressive strength showed an increasing value of 38.2, 48.79 and 67.97N/mm² as shown in Table 2.
 2. A similar trend of increasing value was observed when the steel fibre is increased to 1% the maximum value obtained for 42.72, 51.31 and 72.34N/mm² at the end of 3, 7 and 28days as shown in Chart 1.
 3. A gradually increase of 0.5% of steel fibre (1.5%) showed a decreasing trend in the compressive strength at the end of 3, 7 and 28 days. The compressive strength observed at the end of 3, 7 and 28days for 1.5% of steel fibre is 41.61, 49.2 and 70.72N/mm².
 4. The Split tensile strength at the end of 3, 7 and 28days for 0.5% of additional of steel fibre the Split tensile strength showed an increasing value of 1.92, 3.33 and 4.57N/mm² as shown in Table 3.
 5. A similar trend of increasing value was observed when the steel fibre is increased to 1% the maximum value obtained for 2.69, 4.68 and 6.70N/mm² at the end of 3, 7 and 28days as shown in Chart 2.
 6. A gradually increase of 0.5% of steel fibre (1.5%) showed a decreasing trend in the Split tensile strength at the end of 3, 7 and 28 days. The Split tensile strength observed at the end of 3, 7 and 28days for 1.5% of steel fibre is 2.32, 4.11 and 5.9N/mm².
 7. The flexural strength at the end of 28days for 0.5%, 1.0% and 1.5% of additional of steel fibre the flexural strength showed an value of 4.57, 6.7 and 5.9N/mm² as shown in Table 4.
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CONCLUSIONS

From Compressive Strength, Split Tensile Strength, Flexural Strength and the Durability test results it was observed that Quarry dust concrete is better than the Nominal concrete and the replacement of 60% of Quarry dust and 40% of Natural sand with the replacement of 15% of silica fume with cement and 1.0% of steel fibres proves to be optimum level to produce High Performance Concrete.

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