

# EXPERIMENTAL STUDY ON FINE AGGREGATE REPLACEMENT WITH QUARRY DUST IN CONCRETE RIGID PAVEMENTS

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## Abstract

Every year the consumption of concrete is increasing due to rapid growth in infrastructure. Concrete is extremely versatile and is used for all types of structures. Traditionally, river sand has been the preferred material for making concrete. However, with its continuous use and ever increasing consumption, the sources of sand are dwindling globally. As a result, restrictions are being put in place by various governmental agencies, with a view to preserve the ecology and environment. This has brought in severe strains on the availability of sand forcing the construction industry to look for alternative materials. The present investigation aims in the study of properties of concrete in which quarry dust is used as a partial replacement for natural sand. The basic strength properties of concrete were investigated by replacing natural sand by quarry dust at replacement levels of 10%, 15%, 20%, 25%, 30%, 35%, 40% and 50% for mix design of M30. In the hardened state compression strength test, split tensile of quarry dust concrete as well as normal concrete were performed at 3,7 and 28 days that demonstrates maximum strength. As the properties are good as sand, the quarry dust is used as fine aggregate in replacement with sand in the cement concrete. Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. It is found that 30% and 35% replacement of fine aggregate by quarry dust gives maximum result in strength than normal concrete and then decreases from 40% and 50%. The compressive strength is quantified for varying percentage and grades of concrete by replacement of sand with quarry dust.

**Key Words:** Cement, Fine Aggregate, Coarse Aggregate, Quarry Dust, Compressive Strength and Split Tensile Strength

## 1. Introduction

Concrete has been the popular construction material used, since the past until now. It is an assemblage of cement, aggregate and water. The most commonly used material, fine aggregate which is derived from river banks. The use of sand in construction results in excessive sand mining which is objectionable. 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. Due to rapid growth in construction activity, the available sources of natural sand are getting exhausted. Also, good quality sand may have to be transported from long distance, which adds to the cost of construction. In some cases, natural sand may not be of good quality. Construction industries of developing countries are in stress to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete. On the other hand, the advantages of utilization of by products or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load & waste management cost, reduction of production cost as well as augmenting the quality of concrete. Quarry dust, a by-product from the crushing process during quarrying activities is one of those materials that have recently gained attentions to be used as concreting aggregates, especially as fine aggregates. By exploding mountain, rock has been crushed to small size

stones and along with this dust type particles called quarry dust will be formed during the process which is going as waste. So it becomes as a useless material and also results in air pollution too. Therefore, quarry dust should be used in construction works, which will reduce the cost of construction and the construction material would be saved and the natural resources can be used properly. Quarry dust have been used for different activities in the construction industry, such as road construction, and manufacture of building materials, such as lightweight aggregates, bricks, tiles and autoclave blocks. High percentage of dust in the aggregate increases the fineness and the total surface area of aggregate particles. The surface area is measured in terms of specific surface, i.e. the ratio of the total surface area of all the particles to their volume. The present study is intended to study the effects of quarry dust addition in conventional concrete and to assess the rate of compressive strength development for different quarry dust to coarse aggregate ratio. This research has aimed to study about compressive strength of the concrete using quarry dust as fine aggregate to replace sand. The main objective is to provide more information about the effects of various proportion of dust content as partial replacement of crushed stone fine aggregate on workability, air content, compressive strength, tensile strength, absorption percentage of concrete.

## 2. Materials & Methods

In this study, 53 grade ordinary Portland cement conforming to IS: 12269-1987 is used. Natural sand belonging to zone II as per IS 383-1970 is used. Crushing coarse aggregate 20mm size belonging to IS: 383-1970 is used in this investigation. In this study we go through with the determination of the engineering properties for all the constituent materials as well as for the additives and admixtures to suitably incorporate in the mix design and other assessment. Making a conventional concrete mix design for M30 grade concrete using ACI, BS and IS methods and proposing an optimum mix based on the 7 day strength, for all experimentation. Investigation on the workability and strength characteristics of quarry dust based concrete for sand replacement levels of 10%, 15%, 20%, 25%, 30%, 35%, 40%, and 50% with quarry dust. Assessment of the comparison of characteristics of different replacement concrete after analysis of their experimental results. Assessment on the possibility of maximum replacement level of sand with quarry dust in M30 grade concrete. Main study for 50% sand replaced quarry dust concrete (QDC) by making Mix design for M30 grade quarry dust concrete using IS method and investigating the workability, strength and durability characteristics. Assessment on the possibility of 100% replacement of sand with quarry dust in M30 grade concrete. Mix design for M40, M50 and M60 grades of high strength quarry dust concrete using relevant methods and investigating the workability, strength and durability characteristics. Assessing the requirement of additives like fly ash and silica fume for enhancing the properties. Analyzing the results for comparison between sand concrete and quarry dust concrete.

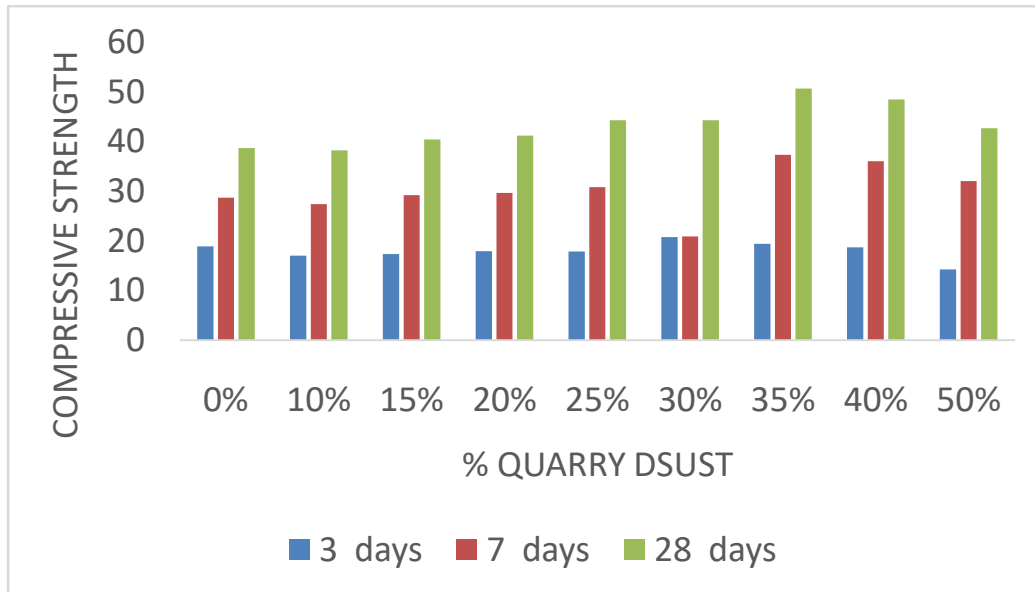
## 3. Results and Discussions

With reference to the materials and methods, the compressive strength and split tensile strengths are estimated for all the cubes casted on 3day, 7day and 28day basis. The obtained results are tabulated. The compressive strengths are given in Table.1. And plotted in Figure.1.

**Table: 1 Compression Strength Test**

S.No	Quarry dust mix	Average compressive Strength, Mpa		
		3days	7days	28days
	0%	18.9	28.44	38.66
1	10%	17.03	27.47	38.22
2	15%	17.33	29.18	40.44
3	20%	17.92	29.62	41.18
4	25%	17.85	30.81	44.29

5	30%	20.74	28.88	44.29
6	35%	19.4	37.33	50.66
7	40%	18.66	36	48.44
8	50%	14.22	32	42.66



**Figure.1.Compressive Strength of Concrete**

Variation of compressive strength with conventional concrete and quarry dust concrete is shown in the figure. It is observed that the variation is about 10-15% increment of compressive strength for quarry dust concrete (35%) when compared to conventional concrete.

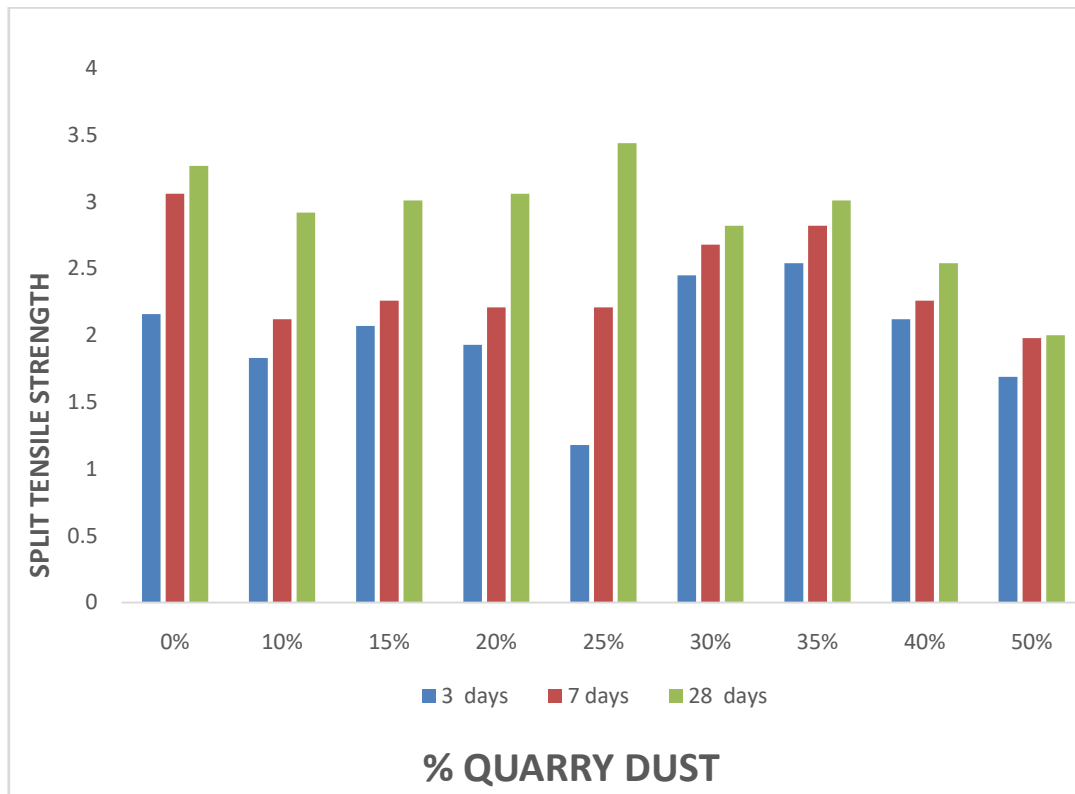
It is noticed that, as the percentage of quarry dust increases, the compressive strength values increases. The partial replacement of CGF with sand gave a 28 days peak compressive strength value of 50.66 N/mm<sup>2</sup> at 35% replacement level. The 40% and 50% the peak compressive strength values is 48.44N/mm<sup>2</sup> and 42.66N/mm<sup>2</sup>. The graph show the compressive strength values is decreases. The graph shows that the

Increase in compressive strength associated with partial replacement of sand with quarry dust can be attributed to frictional resistance's component's contribution to compressive strength arising from the rough and irregular nature of quarry dust particles that fills the voids between the gravel and sand particles while cement binds the components together. Strength obtained with the use of only river sand as fine aggregate and river gravel as coarse aggregate is dependent more on the bonding strength of cement that fills the voids between the coarse aggregate and the river sand particles as its frictional resistance contribution to strength is less due to smooth and rounded nature of river gravel and sand particles used as coarse and fine aggregate respectively. The Split tensile strength of quarry dust concrete are given in Table.2 and were plotted on Figure.2.

**Table: 2 split tensile strength of the concrete**

S.no	Quarry dust mix	Average Tensile Strength,Mpa		
		3days	7days	28days
1	0%	2.16	3.06	3.27
2	10%	1.83	2.12	2.92
3	15%	2.07	2.26	3.01
4	20%	1.93	2.21	3.06
5	25%	1.18	2.21	3.44
6	30%	2.45	2.68	2.82

7	35%	2.54	2.82	3.01
8	40%	2.12	2.26	2.54
9	50%	1.69	1.98	2.26



**Figure. 2. Split tensile strength of the concrete**

Variation of split tensile strength with conventional concrete and quarry dust concrete is shown in the figure. It is observed that the variation is about 2-3% increment in split tensile strength for quarry dust concrete (35%) when compared to conventional concrete.

It is shown that, as the percentage of quarry dust increases with an increase up to 35% replacement with conventional concrete, the split tensile strength values increased, after which a decline was observed. The graph shows that the split tensile strength relation for both conventional concrete and quarry dust concrete, at the age of 3 days, 7 days, 28 days. It is spotted that the split tensile strength values for conventional concrete and the concrete replaced with 35% quarry dust in fine aggregate obtained the same result. Peak compressive strength is found to be  $4 \text{ N/mm}^2$ . It is spotted that the split tensile strength values for conventional concrete and the Concrete replaced with 40% and 50% quarry dust in fine aggregate obtained the same Result the peak compressive strength is found to be  $2.54 \text{ N/mm}^2$  and  $2.26 \text{ N/mm}^2$ .

#### 4. Conclusions

The partial replacement of fine aggregate with that of rock dust of gives excellent strength. Compressive strength of concrete mixes in which fine aggregate was replaced by quarry dust could be higher than the control concrete mixes at all the ages. The difference in strength between the quarry dust concrete mixes and control concrete mixes could be more distance after 28 days.

Maximum compressive strength of quarry dust concrete  $50.66 \text{ N/mm}^2$  achieved at 35% replacing of concrete by quarry dust (M30 grade). When compared to normal concrete it increases 12%. And suddenly decreases in replacing of 40% and 50% of quarry dust. Maximum split-Tensile strength of quarry dust concrete  $3.44 \text{ N/mm}^2$  achieved at 25% replacing of concrete by quarry dust (M30 grade). When compared to normal concrete it increases 0.17% and suddenly decreases in replacing of 30% to 50%.

It could be finally concluded that quarry dust could be very conveniently used as partial Replacement in mortars and structural concrete successfully. The fineness of quarry dust is more than fine

aggregate in which it reduces the workability of concrete. The analysis of experimental data showed that the replacement of the quarry dust improved the strength properties of concrete.

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