

Experimental Studies on the Effect of Silica Fume and Quarry Dust in Concrete

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ABSTRACT: Concrete is most widely used construction material today in any structure. Increase in construction activities has led to an increase in demand for various raw materials in concrete. This led to researches on alternate materials as ingredients of concrete that are in no way inferior to the conventional materials. By partially replacing the ingredients with different proportions, the strength of concrete can be determined. Natural river sand is one of the key ingredients of concrete, is becoming expensive due to excessive cost of transportation from sources. Also large scale depletion of sources creates environmental problems. Unfortunately, production of cement also involves large amount of carbon dioxide gas into the atmosphere, a major contributor for green house effect and the global warming. To overcome these problems there is a need of cost effective, alternative and innovative materials. Based on the proportion of ingredients used in concrete, its properties can also be changed. In most of the building works normal concrete is used. This project work concentrates on the effective use of Silica Fume and Quarry Dust in concrete mix. The main parameter investigated in this study is M20 grade concrete with partial replacement of cement by silica fume by 0, 10 and 15% and Quarry dust by 20, 30, and 40%.

KEYWORDS: Silica Fume, Quarry Dust, Compressive Strength, Split Tensile Strength, Ultrasonic Pulse Velocity tests.

I. INTRODUCTION

Concrete is the mostly used material in various types of construction, from the flooring of a hut to a multi storied high rise structure from pathway to an airport runway, from an underground tunnel and deep sea platform to high-rise chimneys and TV Towers. In the last millennium concrete has demanding requirements both in terms of technical performance and economy while greatly varying from architectural masterpieces to the simplest of utilities. It is the most widely used construction materials. It is difficult to point out another material of construction which is as versatile as concrete. In modern concrete technology, adding mineral admixtures to cement is a well-established practice. Mineral admixtures are added to concrete for various purposes such as, improving compressive strengths at early ages, increasing durability of hardened concrete, enhancing some mechanical properties of concrete, reducing heat generation and temperature rise of concrete for hot weather concreting, producing greener concrete for environmental sustainability. Over the years, silica fume has often been used for improvement of early strengths of concretes. This paper presents a detailed experimental study on Compressive strength at age of 7, 14, 28, 56 and 90 days, split tensile strength at 28 days and ultrasonic pulse velocity test at 28 days.

II. RELATED WORK

The literature review presents the current state of knowledge and examples of successful uses of alternative materials in concrete technology. In the modern age of concrete design, concrete researchers and developers are taking advantage of secondary cementations materials to give concrete greater strengths. In the last decades many people have been done to investigate the Silica fume used as cementitious

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material and quarry dust used as fine aggregate in concrete and to find the strength properties of concrete. Here are some of the earlier studies on the effectiveness in designing of structures with concrete are as follows:

1. S. Bhanjaa, B. Sengupta et al. (2014) on the basis of 28-day strength results have proposed modified strength water-cementitious material ratio relationships for concrete containing cement plus silica fume as a supplementary cementitious material to evaluate the strength of silica fume concrete for obtaining high strength concrete mixes.
2. 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.
3. N. K. Amudhavalli, Jeena Mathew et al(2012): Investigated the effect of silica fume on strength and durability parameters of concrete, The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by silica fume by 0, 5, 10,15and by 20%. This paper presents a detailed experimental study on Compressive strength, split tensile strength, flexural strength at age of 7 and 28 day. Durability study on acid attack was also studied and percentage of weight loss is compared with normal concrete. Test results indicate that use of Silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect.
4. 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%.
5. 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.

III. MATERIALS

Cement:

Cement is a material, generally in powder form, that can be made into a paste usually by the addition of water and, when moulded or poured, will set into a solid mass. The specific gravity of cement is 3.15.

Fine Aggregate:

The fine aggregate was passing through 4.75 mm sieve and had a specific gravity of 2.58. The grading zone of fine aggregate was zone II as per Indian Standard specifications.

Coarse Aggregate:

Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is granite, limestone, and trap rock. The maximum size of coarse aggregate was 20 mm and specific gravity of 2.78.

Silica Fume:

Silica fume, also known as micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. Silica fume is added to Portland cement concrete to

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improve its properties, in particular its compressive strength bond strength, and abrasion resistance. These improves structure from both the mechanical properties resulting from addition of a very fine powder to the cement paste mix as well as from the pozzolanic reactions between the silica fume and free calcium hydroxide in the paste. Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion, especially in chloride-rich environments such as coastal regions and those of humid continental roadways and runways and saltwater bridges. Specific gravity of Silica Fume is 2.2

Quarry Dust:

Quarry Rock Dust can be defined as residue, tailing or other non-volatile waste material after the extraction and processing of rocks to form fine particles less than 4.75mm. Quarry dust is fine rock particles. When boulders are broken into small pieces quarry dust is formed. It is gray in color and it is like fine aggregate. Quarry dusts are produced during the extraction and processing of aggregates. It was collected from a Stone Quarry near Chittoor. Specific Gravity of Quarry dust is 2.64

IV. EXPERIMENTAL RESULTS

Mix Proportions

Cement = 320 kg/m³
Water = 175 lit/m³
Coarse aggregate = 1217.24 kg/m³
Fine aggregate = 727.48 kg/m³
Mix proportion 1: 1.27: 3.8: 0.55

TESTS ON CONCRETE

A) Fresh Concrete

1. Slump Cone test:

Table No: 1 Workability of fresh concrete by using silica fume and quarry dust in concrete

S.No	Details of Material	Slump Value (mm)
1	100% cement + 0% Silica fume	72
2	90% cement +10% Silica fume	54
3	85% cement + 15% Silica fume	36

B) Hardened Concrete

The following tests were conducted on the hardened concrete:

- Compression Test.
- Split tensile Test.
- Ultra sonic pulse velocity Test

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1. COMPRESSION TEST

To determine the hardened properties of concrete the most common test used is compression test. This test is easy to perform good characteristic properties of concrete. By conducting this test to determine the strength properties of concrete and to analyse how much strength it will bear. The size of the specimens for cube 150mm x 150mm x 150mm and cylinder is 15cm diameter 30cm height were casted with various concrete mixtures.

Compressive strength of cubes:

Table:1 shows the basic M20 concrete has given the design strength of 26.96 MPa at 28 days and with 20% Quarry dust the strength has gone up-to 28.59 MPa, 30% Quarry dust the strength has gone up-to 30.52 MPa with work and 40% Quarry dust the strength has gone up-to 24.59 MPa. With 10% silica fume and 20% Quarry dust the strength is going up to 30.81 MPa, with 10% silica fume and 30% Quarry dust the strength is going up to 29.18 MPa, with 10% silica fume and 40% Quarry dust the strength is going up to 26.67 MPa, with 15% silica fume and 20% Quarry dust the strength is going up to 27.26 MPa, with 15% silica fume and 30% Quarry dust the strength is going up to 33.04 MPa, with 15% silica fume and 40% Quarry dust the strength is going up to 27.41 MPa.

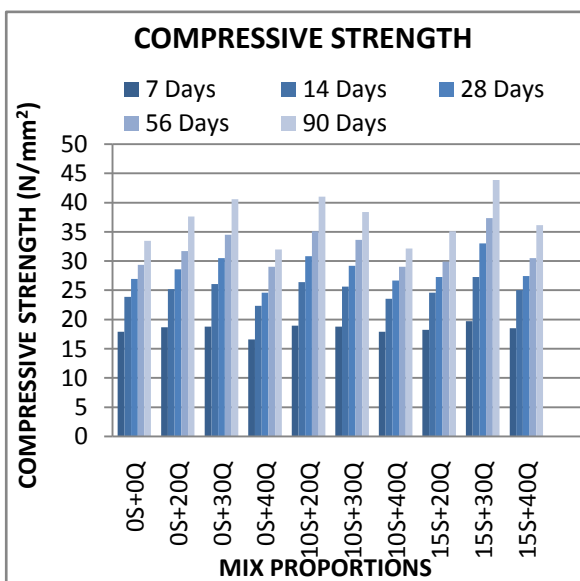


Fig 1: Compressive strength for the age of 7, 14, 28, 56 and 90 days

Table No 2: Compressive strength for the age of 7, 14, 28, 56 and 90 days

Sample	Compressive Strength (N/mm ²)				
	7 Days	14 Days	28 Days	56 Days	90 Days
0S+0Q	17.92	23.85	26.96	29.33	33.48
0S+20Q	18.67	25.18	28.59	31.70	37.63
0S+30Q	18.81	26.07	30.52	34.52	40.59
0S+40Q	16.59	22.37	24.59	29.03	32.00
10S+20Q	18.96	26.37	30.81	35.11	41.04
10S+30Q	18.81	25.62	29.18	33.63	38.37
10S+40Q	17.92	23.56	26.67	29.03	32.15
15S+20Q	18.22	24.59	27.26	29.92	35.11
15S+30Q	19.70	27.26	33.04	37.33	43.85
15S+40Q	18.51	25.04	27.41	30.51	36.15

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2. SPLIT TENSILE TEST

As per IS specifications IS 5816:1999 Split tensile test were conducted. The cylinder of size is 150 mm diameter and 300 mm length. The specimen were kept in water for curing for 28 days and on removal were tested in wet condition by wiping water and grit present on the surface. By conducting the test the cylinders were placed horizontally between the loading plate surfaces of a compression testing machine. Then the load was applied to the cylinder until failure of the vertical diameter along the cylinder length. The applying of maximum load on the cylinder was to be observed and then recorded for the failure of concrete.

Split tensile strength of cylinders:

Table:2 shows the basic M20 concrete has given the design strength of 2.45 MPa at 28 days and with 20% Quarry dust the strength has gone up-to 2.16 MPa, 30% Quarry dust the strength has gone up-to 2.59 MPa with work and 40% Quarry dust the strength has gone up-to 1.79 MPa. With 10% silica fume and 20% Quarry dust the strength is going up to 2.83 MPa, with 10% silica fume and 30% Quarry dust the strength is going up to 2.59 MPa, with 10% silica fume and 40% Quarry dust the strength is going up to 2.59 MPa, with 15% silica fume and 20% Quarry dust the strength is going up to 2.69 MPa, with 15% silica fume and 30% Quarry dust the strength is going up to 3.02 MPa, with 15% silica fume and 40% Quarry dust the strength is going up to 2.83MPa.

Compressive strength of cylinders:

Table:2 shows the basic M20 concrete has given the design strength of 23.76 MPa at 28 days and with 20% Quarry dust the strength has gone up-to 22.45 MPa, 30% Quarry dust the strength has gone up-to 25.84 MPa with work and 40% Quarry dust the strength has gone up-to 24.90 MPa. With 10% silica fume and 20% Quarry dust the strength is going up to 23.76 MPa, with 10% silica fume and 30% Quarry dust the strength is going up to 25.28 MPa, with 10% silica fume and 40% Quarry dust the strength is going up to 26.22 MPa, with 15% silica fume and 20% Quarry dust the strength is going up to 26.78 MPa, with 15% silica fume and 30% Quarry dust the strength is going up to 30.18 MPa, with 15% silica fume and 40% Quarry dust the strength is going up to 25.28 MPa.

Table 2: Results of various tests conducted on cylinders

Sample	Split Tensile Strength (MPa)	Compressive Strength (MPa)
0S+0Q	2.69	23.76
0S+20Q	2.16	22.45
0S+30Q	2.45	25.84
0S+40Q	1.79	24.90
10S+20Q	2.83	26.78
10S+30Q	2.83	25.28
10S+40Q	2.59	26.22
15S+20Q	2.69	23.76
15S+30Q	3.02	30.18
15S+40Q	2.69	25.28

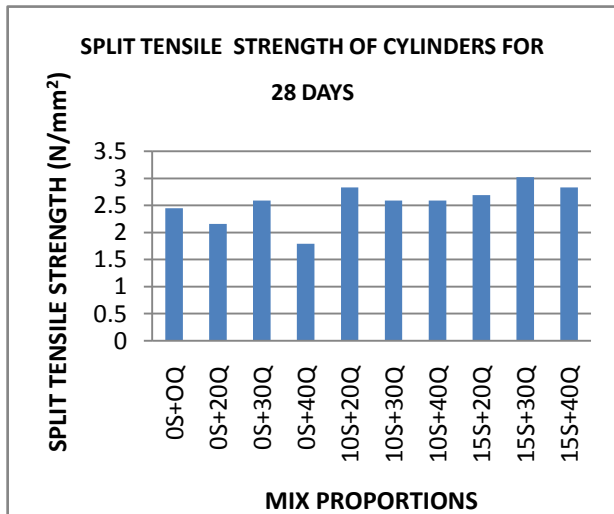


Fig 2: Split tensile strength of cylinders

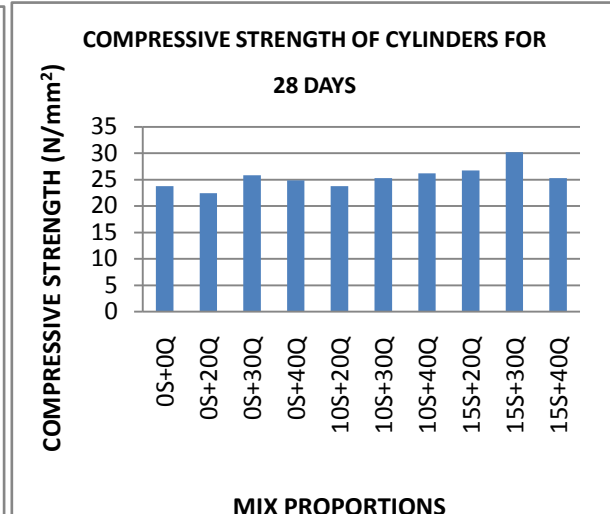


Fig 3: Compressive strength of cylinders

Fig 2&3 shows the variation of split tensile strength and compressive strength of cylinders at 28 days. From the figure, it has been observed that maximum strength attains at 15S+30Q.

3. ULTRA PULSE VELOCITY TEST

The direction in which the maximum energy is propagated is at right angles to the face of the transmitting transducer; however, it is possible to detect pulses travelling through concrete in some other direction. In other words it is possible, to make measurements of pulse velocity (BS 12504-4, 2004) by placing the two transducers on either opposite faces - direct transmission or adjacent faces - semi-direct transmission.

Ultra sonic pulse velocity of cubes:

All the samples tested for ultrasonic pulse velocity ranges between 3.87 km/sec to 4.54km/sec which can be termed as very good concrete and the mix proportion 15S+30Q indicates the quality of concrete as Excellent.

V. CONCLUSION

Silica Fume and Quarry Dust are used in production of concrete cubes by replacement levels of 10% and 15% by weight of cement and 20%, 30% and 40% by weight of sand respectively. These cubes were cured and tested for compressive strength for 7 days, 14 days, 28 days, 56 days and 90 days and results were noted. Based on the experimental investigation conducted following conclusions are made.

- Industrial waste materials are used as partial replacement of cement at different levels produced concrete with high strength and acceptable structural grade concrete. Curing conditions adopted in this research produced significant changes in the properties of concretes especially those containing different replacement levels.
- Silica Fume retards the initial setting time and accelerates the final setting time of concrete.
- High volume Silica Fume replacement is not appropriate because of its high water absorption capacity.
- Strength of concrete of different mixes increases at early ages than later ages.
- By replacement of 15% silica fume with cement and 30% Quarry Dust with sand, observed that the compressive strength for cubes increases by 9.93%, 14.30%, 22.55%, 27.28% and 30.97% for 7days, 14days, 28 days, 56 days and 90 days respectively.

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- By replacement of 15% silica fume with cement and 30% Quarry Dust with sand, observed that the split tensile strength for cylinders attains maximum strength of 3.02 N/mm^2 which increases by 23.26%.
- By replacement of 15% silica fume with cement and 30% Quarry Dust with sand, observed that the compressive strength for cylinders attains maximum strength of 30.18 N/mm^2 which increases by 27.02%.
- By replacement of 15% silica fume with cement and 30% Quarry Dust with sand, observed that the Ultrasonic pulse velocity strength of cubes indicates the quality of concrete is excellent.

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