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Investigation of Strength Characteristics of Concrete with Partial Replacement of Cement by Silica Fume and Sand by Quarry Dust

K Unnati[1] | P Y R V S S Ammiraju[1] | M Rohith S V Rama Raju[1] | K Abishek[1] | A Rajendra[1]

[1]Department of Civil Engineering, Godavari Institute of Engineering & Technology (A), Rajahmundry, AP, India.

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ABSTRACT

Concrete is the most commonly used man-made material on earth. It is an important construction material used extensively in buildings, bridges, roads and dams. Its uses range from structural applications to pipes and drains. Concrete is a composite material, consisting mainly of cement, water and aggregate (fine and coarse). When these materials are mixed together, they form a workable paste which then gradually hardens over time. In engineering industry, the improvement of existing materials allows for technological advancement and the construction of more reliable structures without over design. The partial replacement is done in order to reduce the cement content, cost of materials and to overcome the scarcity of materials. In this project, we presented an experimental investigation of effect of silica fume and quarry dust in concrete.. This effect will be studied on compressive strength, flexural strength and tensile strength at 7 days, 14 days and 28 days taken at room temperature. M30 concrete is taken with partial replacement of cement by silica fume by 12%, 15% and partial replacement of sand by quarry dust by 20%, 30% and 40%.

KEYWORDS: *Compressive strength, Flexural strength, Silica fume, Split tensile strength, Quarry dust.*

I. INTRODUCTION

1.1 General:

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. Many other non-cementitious types of concrete exist with different methods of binding aggregate together, including asphalt concrete with a bitumen binder, which is frequently used for road surfaces, and polymer concretes that use polymers as a binder.

When aggregate is mixed with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and moulded into shape. The cement reacts with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Often, additives (such as pozzolans or super plasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile

strength, yielding reinforced concrete. Concrete is one of the most frequently used building materials.

Aggregate consists of large chunks of material in a concrete mix, generally a coarse gravel or crushed rocks such as limestone, or granite, along with finer materials such as sand.

1.2 Objectives of the project

1. To improve the utilization of generated quarry dust
2. To improve the compressive strength,
3. To improve the split tensile strength
4. To improve the flexural strength of concrete than the normal concrete

II. LITERATURE REVIEW

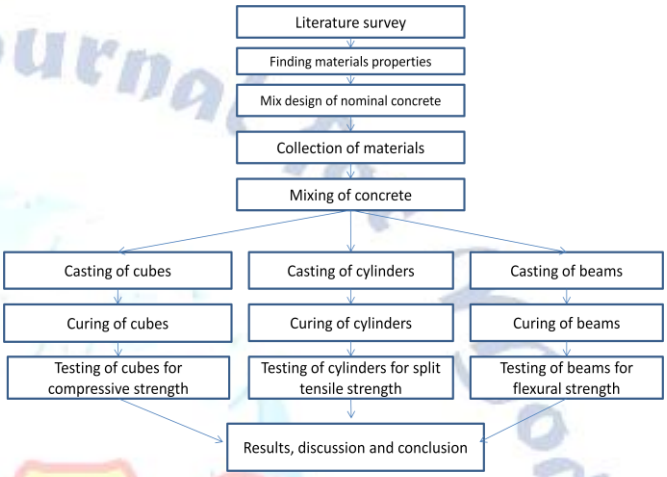
The literature review presents the current state of knowledge and examples of successful uses of alternative materials in concrete technology. Some of the earlier studies on the effectiveness in designing of structures with concrete are as follows:

Experimental Studies on the Effect of Silica Fume and Quarry Dust in Concrete by U.Vamsi Mohan (2015). This work investigated 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%. Maximum strength was obtained for 15% silica fume and 30% quarry dust replacement.

Gurdeep Singh work (2017) has drawn conclusions on effects studied on compressive strength, workability and durability of M25 concrete. Replacement levels of 8, 10 and 12% for silica fume and 20, 30 and 40% for quarry dust have adopted. The results of various tests conducted on control mix and other mixes with different proportions of silica fume an quarry dust have been compared. The mix with 10% silica fume and 30% quarry dust have shown better results than control concrete.

Studies by Prakash.R (2017) show that the compressive strength of HPC with silica fume of 15% replacement by the weight of cement and quarry dust as partial and full replacement of fine aggregate is investigated. Results were found that the silica fume is beneficial to concrete in increasing the compressive strength of concrete and quarry dust replacement further increases the compressive strength of high performance concrete. A compressive strength of 23% is increased due to inclusion of silica fume and 12.4 % is increases due to the replacement of quarry dust. Maximum strength was obtained at 15% silica fume and 50% quarry dust.

III. METHODOLOGY



IV. MATERIALS AND TEST PROCEDURES

4.1 Properties of cement

Various properties of cement such as Specific gravity, Consistency, Initial & Final setting time of cement are studied. The cement properties are determined from experimental investigations and presented in Table 4.1. The cement is confirming to the IS: 8112-1989.

Table 4.1 Properties of Cement

S.NO	CHARACTERISTICS	VALUES OBTAINED
1	Specific gravity of cement	3.16
2	Fineness of cement	92.8%
3	Standard consistency	33%
4	Initial setting time	35mins
5	Final setting time	602mins
6	Compressive strength of cement(MPa)	
	3days	28.4
	7days	36.9
	28days	54.2

4.2 Properties of fine aggregates

The properties of Fine aggregates such as Specific gravity, Fineness modulus, Water absorption, etc are determined from experimental investigations and presented in a Table. 4.2. Fine aggregate confirming to IS 383-1970.

Table 4.2 Properties of Fine Aggregates

S. No	Property	Test Results
1	Specific gravity (Fine aggregate)Zone II Sand	2.62
2	Fineness modulus of Fine aggregates	2.58
3	Bulk Density inFine aggregates	1.49
4	Water absorption	1.62%

4.3 Properties of coarse aggregates

The properties of coarse aggregates are determined by using IS: 383-1970. Coarse aggregates properties are determined from experimental investigations and presented in Table 4.3.

Table 4.3 Properties of Coarse Aggregates

S.No	Property	Test Results
1	Specific gravity	For 20mm-2.64
2	Water Absorption	For 20 mm-0.62%
3	Bulk density (kg/m ^{3})	1738
4	Flakiness Index %	11.3%
5	Elongation Index	18.9%
6	Aggregate Impact Value	28.6%
7	Aggregate Crushing Value	26.459%
8	Fineness modulus	6.27

4.4 Silica fume

Silica fume is a by-product after producing silicon metal or ferrosilicon alloys. Because of its chemical and physical properties, it is a very reactive pozzolanic. Concrete containing silica fume can have very high strength and can be very durable.

Properties of silica fume as per IS code (IS 15388-2003) are Specific gravity and Fineness

Silica fume is also known as micro silica which is a non-crystalline material of silicon dioxide and silica. It contains spherical particles with an average particle diameter of 150nm. Silica fume is an ultrafine powder and improves bonding with in the concrete. Silica fume reduces the permeability, increases the durability and increases the compressive and flexural strength. Silica fume used in experimental work was obtained from local industries

Fig. 4.1 Silica fume

The properties of silica fume such as maximum specific gravity and specific surface are determined.

Table 4.4 Properties of Silica fume

S.No	Property	Results
1	Specific gravity	2.22
2	Fineness	91.2%

4.5 Quarry Dust

Quarry dust is a by-product after crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In **quarrying** activities, the rock has been crushed into various sizes; during the process the **dust** generated is called **quarry dust** and it is formed as waste. Quarry dust is an elongated and flaky particle. It is fractured dust of Jaw Crusher. It is a waste product in the production process of stone crusher. Quarry dust come at cheaper cost. Partial replacement of sand with this dust will make good concrete that is well desired in residential construction.

The benefits of using quarry dust:-

- Strength When Needed
- Saves cost
- Easily available
- Quality
- Reduces the pollution in environment.

Fig: 4.2 Quarry dust

The properties of quarry dust like specific gravity, bulk relative density, absorption, sieve analysis are found as

Table 4.5 Properties of Quarry dust

S.No	Property	Results
1	Specific gravity	2.55
2	Bulk density (kg/m^3)	1722
3	Absorption (%)	1.25%
4	Fine particles less than 0.075mm(%)	13
5	Sieve analysis	Zone II

V. MIX DESIGN

Finalized quantities of materials:

- Cement = 400kg/m³
- Fine aggregate = 689.95kg/m³
- Coarse aggregate = 1134.3kg/m³
- Water = 180 lit/m³

Mix proportions

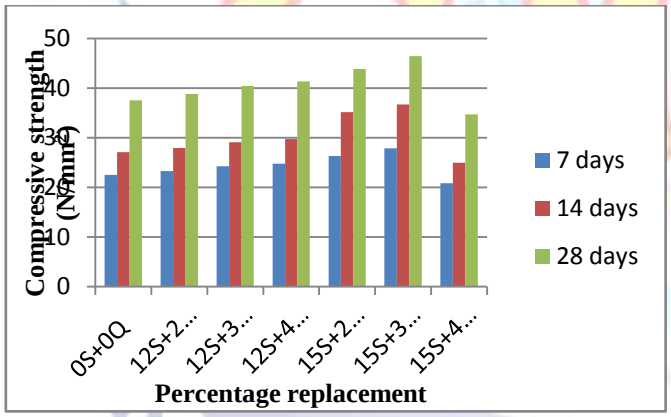
Cement	:	fine aggregate	:	coarse aggregate	:	water
400	:	690	:	1134	:	180
1	:	1.62	:	2.79	:	0.45

VI. RESULTS & DISCUSSIONS

Compressive strength

Table 6.1 Compressive Strength for Cubes

S.No	Percentage replacement	7days (N/mm²)	14days (N/mm²)	28days (N/mm²)
1	0S+0Q	22.5	27.1	37.52
2	12S+20Q	23.28	27.94	38.81
3	12S+30Q	24.25	29.11	40.43
4	12S+40Q	24.79	29.76	41.33
5	15S+20Q	26.32	35.19	43.88
6	15S+30Q	27.88	36.73	46.48
7	15S+40Q	20.82	24.98	34.7

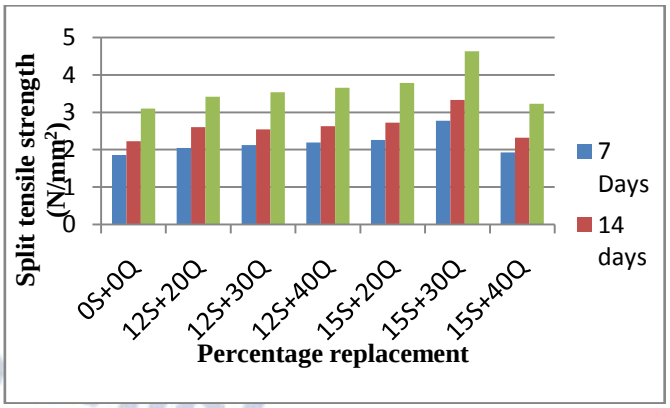


Graph 6.1 Compressive Strength Results

Split Tensile strength

Table 6.2 Split Tensile Test for Cylinders

S.No	Percentage replacement	7days (N/mm²)	14days (N/mm²)	28days (N/mm²)
1	0S+0Q	1.86	2.23	3.1
2	12S+20Q	2.05	2.46	3.42
3	12S+30Q	2.12	2.54	3.54
4	12S+40Q	2.19	2.63	3.66
5	15S+20Q	2.26	2.72	3.78
6	15S+30Q	2.77	3.33	4.63
7	15S+40Q	1.93	2.32	3.23

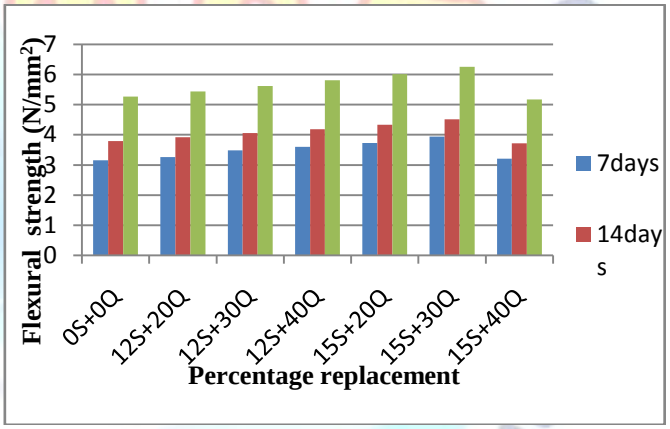


Graph 6.2 Split Tensile Strength Results

Flexural Strength

Table 6.3 Flexural Strength for beams

S.No	Percentage replacement	7days (N/mm²)	14days (N/mm²)	28days (N/mm²)
1	0S+0Q	3.16	3.79	5.27
2	12S+20Q	3.26	3.92	5.45
3	12S+30Q	3.48	4.06	5.62
4	12S+40Q	3.60	4.18	5.81
5	15S+20Q	3.73	4.33	6.01
6	15S+30Q	3.94	4.51	6.26
7	15S+40Q	3.21	3.72	5.17



Graph 6.3 Flexural Strength Results

VII. CONCLUSION & FUTURE SCOPE

- The compressive strength of concrete with 15% of silica fume and 30% of quarry dust is found to be increased by 19.27% than that of conventional concrete.
- The split tensile strength of concrete with 15% of silica fume and 30% of quarry dust is found to be increased by 33.04% than that of conventional concrete.
- The flexural strength of concrete with 15% of silica fume and 30% of quarry dust is found to be increased by 15.81% than that of conventional concrete.
- From the above said points, the percentage replacement of 15% silica fume with 30% quarry dust was found to have a greater compressive strength, split tensile strength and

flexural strength. So this percentage replacement is found to better than the other replacements.

- Thus, the percentage replacement 15S+30Q is found to be optimum percentage of replacement.

Further Scope of Work:

- Instead of replacing cement with silica fume, other materials like dolomite powder, fly ash etc can also be used.
- The replacement of the fine aggregate in concrete can be done with other materials like copper slag, foundry sand, etc.
- This experiment can be done by using other grades of cement like 43 grade.
- This project can also be done by changing the mix proportion of the nominal concrete like M25, M35 etc.
- Investigation can be planned for the high performance concrete.

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