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Strength Properties of High Grade Concrete Replacing Main Ingredients by Quarry Dust & Silica fume

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Abstract: *The waste material from rock after processing for different purposes having sizes less than 4.75mm is known as quarry dust which size is equivalent to river sand. Using this quarry dust in alternative to river sand reduce the demand of the latter and protect environmental depletion in fetching same. Similarly in last decades production of cement needs high heat which has negative impact on global warming and hence silica fume is added to reduce the amount of cement content but increasing concrete binding capacity. In this study the physical and chemical properties of the quarry dust, silica fume cement with super plasticizer on M50 grade Concrete samples done using IS Mix design Method. Various proportions of sieved quarry dust and river sand as well as silica fume and cement were used for making concrete specimens. Then the tests have been carried out and compared with those prepared by controlled concrete.*
Keywords: *Quarry Dust, Sand, Silica fume, Strength Properties, Super plasticizer.*

I. Introduction

Concrete is one of the valuable and the most highly used construction material in throughout the world. It is easily obtainable, relatively cheap, strong, and durable. On the other hand, the construction industry is one of the major consumers of the natural resources.**[2]$_{\mathbf{REF}}$** In the construction industry, river sand is used as an important building material, and also for world consumption of the sand in concrete generation alone is around 1000 million tonnes per year, making it scarce and limited.[1] $_{\mathbf{REF}}$ Therefore In that condition construction industry selected so many alternative materials for the river sand such as fly ash, limestone, slag, etc., materials used for making the concrete as a partial and fully replacement for the sand. Also the Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete. Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand. [3] $_{\mathbf{REF}}$ Quarry dust, the waste material that causes disposal problem is made as a valuable resource by the successful utilization of this quarry dust as a fine aggregate and this will also overcome the strain on supply of river sand as fine aggregate and also the cost will be reduced.[6]$_{REF}$

II. Materials Used And Their Properties

2.1 Cement
Ordinary Portland Cement (43 Grade) with 29 percent normal consistency conforming to IS: 8112-1989 [3] was used. The specific gravity and fineness modulus of cement are 3.15 and 1.2% respectively.
2.2 Fine Aggregate
The properties of sand & quarry dust by conducting tests according with IS 2386 (part-1) – 1963.
2.3 Coarse Aggregates
Crushed stone coarse aggregate conforming to IS 383 – 1987 was used. The values of loose and compacted bulk density values of coarse aggregates were 1600 and 1781 Kg/m^3.
2.4 Quarry Dust
It is collected from maduranthakam near the cengalpattu, tamilnadu. The physical and chemical properties of Quarry Rock Dust obtained by testing the samples as per Indian Standards are listed in Tables 1 and 2, respectively.
2.5 Silica Fume
The Silica Fume used was procured from M/s. Elkem India Private Ltd. Navi Mumbai, India. The below values are given in the brochure of the Silica Fume Product and the properties of specific gravity, fines modulas,specific surface area is 2.20,520kg/m^2,520m^2/kg.
2.6 Water
Water is an important ingredient of concrete as it actively participates in chemical reactions with cement. Clean potable water conforming to IS 456 – 2000 was used for the preparation of concrete mixture.
2.7 Super plasticizer
The Sulphonated Naphthalene Formaldehyde based super plasticizer (Conplast Super Plasticizer – SP 430) was used. The properties of solid content 42% and specific gravity is 1.22.

Table 1 Physical properties of cement, sand, quarry dust and coarse aggregate

Properties	**Cement**	**Natural sand**	**Quarry Dust**	**Coarse aggregate**
Specific gravity	3.15	2.52	2.41	2.79
Initial Setting Time (min)	45	-	-	-
Final Setting Time (min)	240	-	-	-
Normal Consistency (%) (by weight of cement)	29	-	-	-
Fines modulus	-	2.46	3.77	5.91
Uniformity coefficient	-	1.82	1.28	1.5
Coefficient of curvature	-	0.98	1.06	1.1
Sieve Analysis	-	2.43	3.36	-
Fineness (by sieving)	1.2	-	-	-

Table 2 Chemical properties of quarry dust

Constituents	Values
Loss of ignition, (% by mass)	0.74
Silica as SiO_2 (% by mass)	63.58
Aluminium as Al_2O_3 (% by mass)	14.97
Iron as Fe_2O_3 (% by mass)	7.07
Titanium TiO_2 (% by mass)	0.64
Calcium as CaO (% by mass)	5.36
Magnesium MgO (% by mass)	3.83
Sodium Na_2O (% by mass)	2.55
Potassium as K_2O (% by mass)	1.26

III. Mix Details

3.1 Mix Design General

The concrete mix has been designed for M_{50} grade as per IS 10262 – 2009. The specific concrete grade involves the economical selection of relative proportions of cement, fine aggregate, coarse aggregate, water and Super plasticizer.

Table 3 Details of Mix Proportions of Concrete

INGREDIENTS	**MIX DESIGNATION**			
	Q_0S_0	**Q_1S_1**	**Q_2S_2**	**Q_3S_3**
Silica fume (S.F)%	0	0	5	10
Superplasticer (S.P) %	0	1.4	1.4	1.4
Cement (Kg/m^3)	518	518	492.1	466.2
Silica fume (Kg/m^3)	0	0	25.9	51.8
Sand (Kg/m^3)	740.25	0	0	0
Quarry dust(Kg/m3)	0	725.08	725.08	725.08
Coarse aggregate(Kg/m^3)	934.92	934.92	934.92	934.92
water(lit/m^3)	197	197	197	197
Super plasticizer(lit/m^3)	0	6.73	6.73	6.73

Q_0S_0 = Control concrete without silica fume, Q_1S_1 = Quarry dust concrete without silica fume, Q_2S_2 = Quarry dust concrete with silica fume 5% replace for cement, Q_3S_3 = quarry dust concrete with silica fume 10% replace for cement.

IV. Results And Discussion

4.1 Workability of Concrete

The concrete mix used for the test are of low to medium workability hence Slump- cone and compaction factor tests are carried out since it is relevant for the study. The workability was improved by adding Super plasticizer to the concrete. Slump value decreases with the increase in amount of fineness particles. At first it decreases rapidly and then it decreases gradually. This is because water absorption capacity of fineness particles is more. The reasons for the reduction in workability of concrete are attributable to the properties of fine aggregates. The properties of aggregates that are likely to affect the workability are discussed. The ratio of the surface area of the particles to their volume increases then the workability of concrete decreases. When the percentage of the finer particles is increased then workability decreases.

Table 4 Results of Workability Tests on Concrete

Type of concrete	**Slump value mm**	**Compaction Factor**	**Flow %**	**Remarks**
Q_0S_0	80	0.90	40	workable
Q_1S_1	95	0.96	50	More workable
Q_2S_2	85	0.85	48	Medium workable
Q_3S_3	82	0.8	42	Medium workable

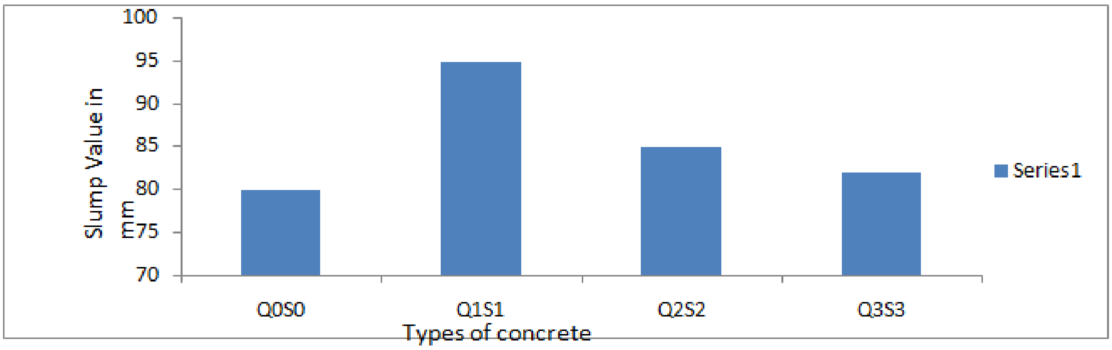

Fig.1 Comparison of Slump Cone Test values

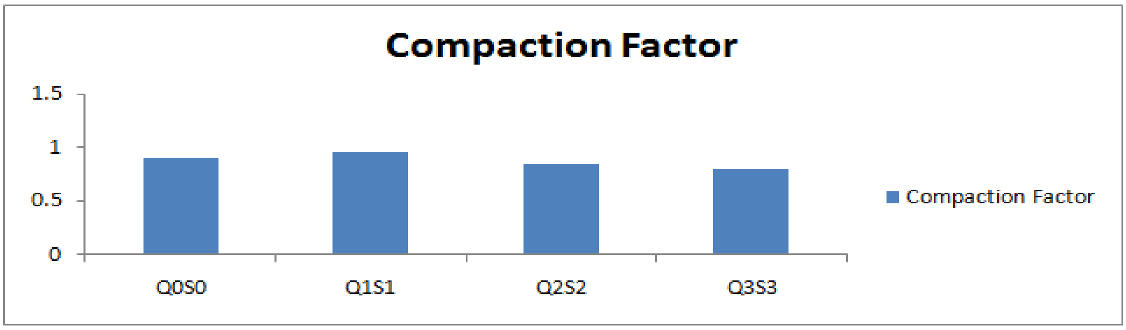

Fig.2 Comparison of Compaction Factor Test values

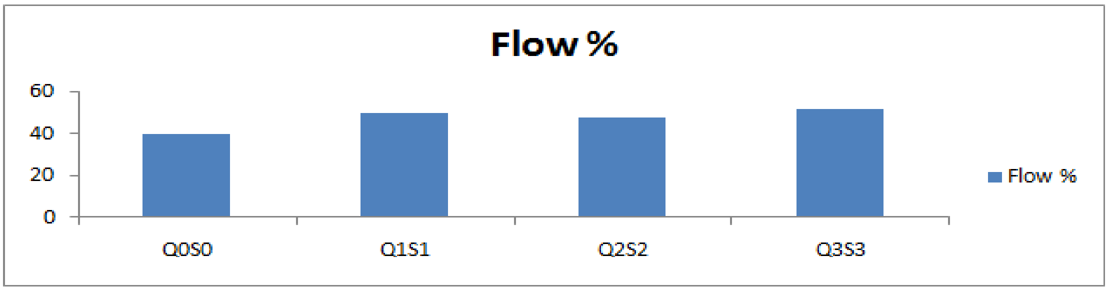

Fig.3 Comparison of Flow Table Test values

4.2 Compressive Strength of Concrete

The compressive strength of hardened concrete is considered one of the most important properties and is often used as an index of the overall quality of concrete. It can be observed from table that the compressive strength of 10% replacement of cement by silica fume in quarry dust concrete is nearly equal to the control concrete.

Fig.4 Specimen for Compressive Strength of Cubes **Fig.5** Failure of compressive cube

Table 5 Test Results of Cube for Compression

SI.no	Curing days	Average compressive strength in N/mm^2			
		Q_0S_0	Q_1S_1	Q_2S_2	Q_3S_3
1	3	28.6	26	28	28.30
2	7	38	34.64	34	34.60
3	14	49	46	49	49
4	28	58.56	56	57.65	58
5	60	58.73	56.58	58	58.40
6	90	59	56.76	58.90	59

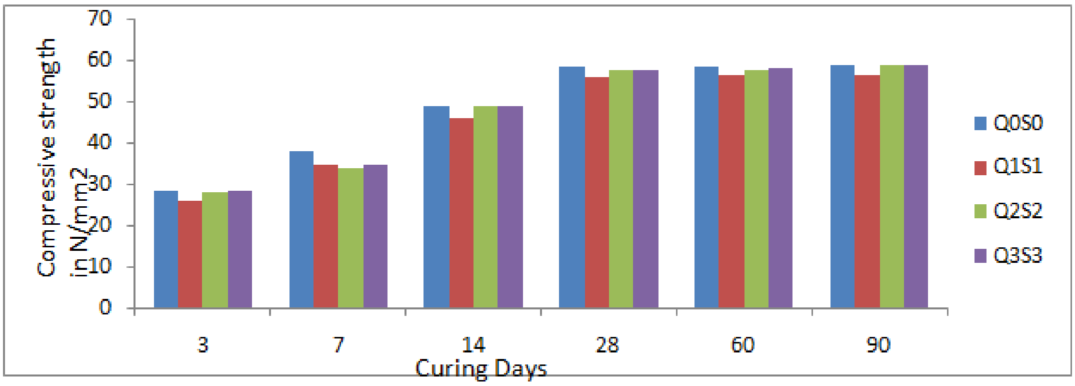

Fig.6 Development of Compressive Strength of cube

Fig.7 Specimen for compressive strength of cylinder

Fig.8 Failure of Compressive Cylinder

Table 6 Test Result of Cylinder for Compression

s.no	Curing days	Average compressive strength in N/mm^2			
		Q_0S_0	Q_1S_1	Q_2S_2	Q_3S_3
1	3	22.88	20.8	22.4	22.64
2	7	30.4	27.71	27.2	27.68
3	14	39.2	36.8	39.2	39.2
4	28	46.84	44.8	46.12	46.47
5	60	46.98	45.2	46.40	46.72
6	90	47.20	45.40	47.12	47.20

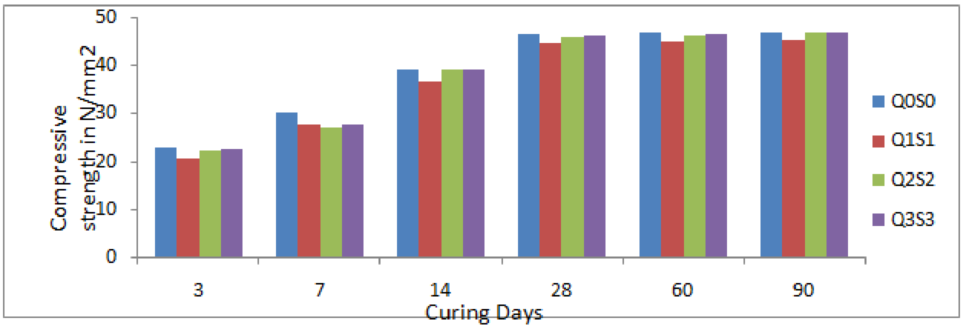

Fig.9 Development of Compressive Strength of Cylinder

4.3 Split Tensile Strength of Concrete

The variation of split tensile strength for different fine aggregate with and without silica fume is similar to that of compressive strength. It can be observed from table that the split tensile strength of 10% replacement of cement by silica fume in quarry dust concrete is more than the control concrete.

Fig.10 Specimen for split tensile strength of cylinder

Fig.11 Failure of split tensile Cylinder

Table 7 Test Result of Cylinder for Split Tensile

s.no	Curing days	Average split tensile strength of cylinder in N/mm2			
		Q0S0	Q1S1	Q2S2	Q3S3
1	3	3.46	3	3.20	3.52
2	7	3.94	3.60	3.52	4.30
3	14	4.40	4.25	4.25	4.75
4	28	4.98	4.60	4.84	5.20
5	60	5.0	4.68	4.96	5.26
6	90	5.15	4.80	5.0	5.39

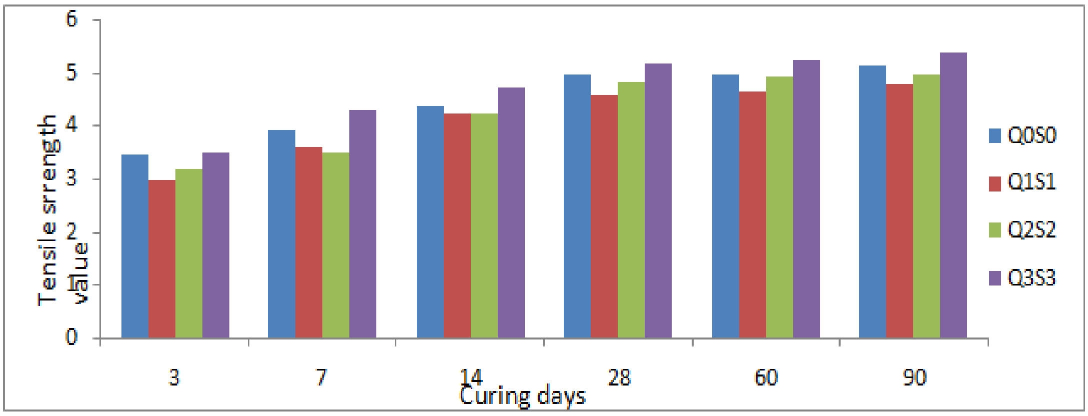

Fig.12 Development of Split Tensile Strength of Cylinders

4.4 Flexural Strength of Concrete

It can be observed from table that the Flexural strength of 10% replacement of cement by silica fume in quarry dust concrete is nearly equal to the control concrete.

Table 8 Test Result of Beam for Flexural

s.no	Curing days	Average flexural strength of beam in N/mm^2			
		Q_0S_0	Q_1S_1	Q_2S_2	Q_3S_3
1	3	6.5	6	6.5	6.65
2	7	6.7	6.5	6.9	7.1
3	14	7.8	7.1	7.6	7.7
4	28	8.2	7.8	8	8.2
5	60	8.3	7.9	8.25	8.4
6	90	8.5	8	8.3	8.55

Fig.13 Specimen for Flexural Strength of Beam

Fig.14 Failure of Beam

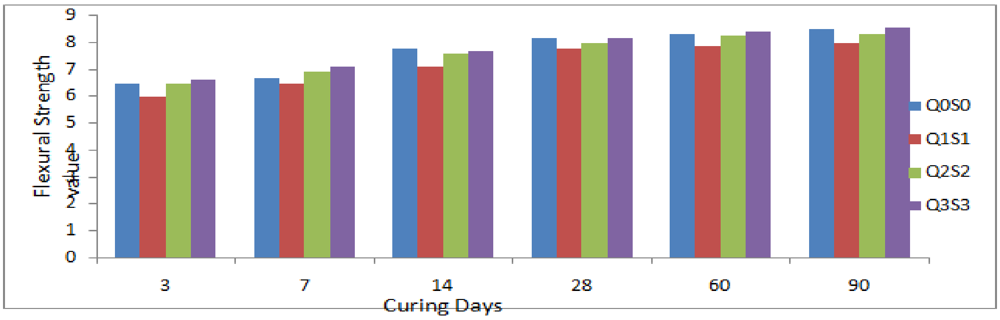

Fig.15 Development of Flexural Strength of Beams

V. Conclusion

The development of concrete with quarry dust as fine aggregate and 10% replacement of silica fume by cement has been successfully completed and the results were presented and analyzed in the previous pages. Based on the test results of M50 grade concrete the following conclusions are

- The reduction of Workability of concrete due to the increase in percentage of fineness particles can be coped up with the addition of super plasticizer.
- Quarry waste fine aggregate and addition of 10% silica fume increased the compressive strength of concrete due to increasing fineness.
- Split tensile strength of quarry dust concrete and addition of 10% silica fume is more than the conventional concrete
- Flexural strength of quarry dust concrete and addition of 10% silica fume is more or less equal to conventional concrete.
- Finally quarry dust can be used as fine aggregate due to scarcity of sand availability for M50 grade concrete as well as replacement of cement with 10% silica fume can be used to reduce heat consumption in cement production and hence both in combination for increasing of the strength of concrete.

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