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Durability studies and NDT of High Grade Concrete Replacing Main Ingredients By Quarry Dust & Silicafume

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Abstract: *The durability of concrete is one of its most important properties because it is essential that especially the high grade concrete should be capable of withstanding the conditions its intended life. The durability and strength characteristics of high grade concrete can be enhanced by the replacement of some ingredients by high quality waste products.The durability of high grade concrete is crusial to its other strength properties.The Rapid Chloride Permeability Test, acid attack resistance and alkaline attack resistance on 10% silicafume replaced quarry dust of high strength concrete is increased but the porosity and saturated water absorption test on the quarry dust replaced by 10% silicafume is less when compared to controlled concrete.*
When the strength properties of replaced high strength concrete on Non Destructive tests of Ultrasonic Pulse Velocity and rebound hammer is concerned the Ultrasonic Pulse Velocity of the replaced quarry dust by 10% silicafume is excellent while the Rebound Hammer Test of both the control concrete is similar to the quarry dust replaced concrete.In conclusion the strength and durability properties of the quarry dust replaced by silicafume high grade concrete is good especially the property increases as the percentage of the silicafume replacement is increasing.

Keywords: *Durability, Non destructive, Quarry dust, Silicafume, River sand.*

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I. Introduction

A good quality concrete is essentially a homogeneous mixture of cement, coarse and fine aggregates and water which consolidates into a hard mass due to chemical action between the cement and water. **[Ref 1]**Partial or full replacement of these raw materials of concrete by waste products may decrease cost, reduce energy consumption and decrease environment pollution as well as protect the environment from industrial and agro wastes such like municipal waste, coal mine, lime sludge, ground nut shell ash, Quarry dust, iron tailing, marble dust, rice husk, lime stone, Hazardous waste, zinc tailing, jute fiber, rice wheat straw, etc., **[Ref 2]**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.

An attempt has also been made to durability studies on Quarry Rock Dust when compared with the Natural Sand concrete. 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. **[Ref 3]**

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. **[Ref 4]**

II. Materials Used And Their Properties **[Ref 4]**

2.1 Cement

Ordinary Portland Cement (43 Grade) with 29 percent normal consistency conforming to IS: 8112-1989 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/m3.

2.4 Quarry Dust

It is collected from maduranthakam near the cengalpattu, tamilnadu.

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/m2,520m2/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.

III. Mix details [REF 4]

Q0S0 = Control concrete without silica fume, Q1S1 = Quarry dust concrete without silica fume, Q2S2 = Quarry dust concrete with silica fume 5% replace for cement,

Q3S3 = quarry dust concrete with silica fume 10% replace for cement.

IV. Results And Discussions

4.1 Determination of Porosity

Porosity test were conducted using 100mm cubes. Cubes were immersed in water for 24 hours. The weight of the wet cubes was taken. Afterword's the cubes were dried in oven for 24 hours at 100^{o} c. then difference between wet and dry cubes were calculated. The saturated water absorption (SWA) was calculated from the formula given below

$$\text{SWA} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} * 100\ \%$$

Determination of porosity will be finding out by following formula

$$\text{Determination of porosity} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Density of water}}$$

The Porosity values of different type of concrete are shown in Table 1. From result it will be observed that porosity should be less in control concrete when compare to other types of concrete, but silica fume replacement level increases porosity level get decrease. Because of the high pozzolanic nature of silica fume and its void filling ability.

Fig.1 Placing of Cubes in Oven at 100^{o} C

Fig.2 Cube Weighed after Taking out from Oven

Table 1 Result of Porosity and Saturated Water Absorption (SWA)

S.no	Types of concrete	SWA	Porosity M^3
1	Q0S0	3.84%	9×10^{-05}
2	Q1S1	4.57%	1.06×10^{-04}
3	Q2S2	4.40%	1.02×10^{-04}
4	Q3S3	4.28%	9.9×10^{-05}

4.2 Acid test

The chemical control test is carried out to assess the weight loss concrete cubes.Accordingly, for acid test hydrochloric acid was prepared by mixing 5% of Hcl with one liter of water as per ASTM G20-8. After

normal curing (28 days) cubes were taken out and weight of cube was noted. Then weighted cubes were immersed in the prepared hydrochloric acid for 60 days. After that the cubes were taken out from acid and weight of cubes was noted.

From this weight loss of cubes, it is find out.

Weight loss=weight of cube after normal curing − weight of cube after taken from acid

Tests were carried out according to ASTM G20-8 to obtain weight loss of different type of concrete. From result of table 2, it can be observed that weight loss is more in control concrete when compare to silica fume replacement with quarry dust as fine aggregate concrete. Because silica fume have void filling ability and it have ability to resist acid attack.

Fig.3 Cubes Exposed in Acid

Fig.4 Cubes after Acid Attack

Table 2 Test Result of Acid Attack

S.no	Types of concrete	Average weight Before put in to Acid (kg)	Average weight After taken from Acid attack (kg)	Loss in (kg)	Percentage Loss
1	Q0S0	2.447	2.395	0.052	5.2%
2	Q1S1	2.423	2.392	0.031	3.1%
3	Q2S2	2.449	2.422	0.027	2.7%
4	Q3S3	2.454	2.430	0.024	2.4%

4.3 Alkaline test

To assess the weight loss concrete cubes is exposed to chemical media. For alkaline test sodium hydroxide was prepared by mixing 5% of sodium hydroxide with one liter of water as per ASTM G20-8. After normal curing (28 days) cubes were taken out and weight was noted. Then weighted cubes were immersed in the prepared sodium hydroxide solution for 60 days. After completion of 60 days concrete cubes were taken out and weighted. Then loss of weight is calculated.

Weight loss=weight of cube after normal curing − weight of cube after taken from alkaline.

Tests were carried out according to ASTM G20-8 to obtain weight loss of different type of concrete. Alkaline test results are shown in Table 3. From result it will be observed that weight loss is more or less same for all type of concrete. Because when percentage replacement of silica fume increase with quarry dust as fine aggregate it will resist the alkaline attack.

Fig.5 Cubes after alkaline attack

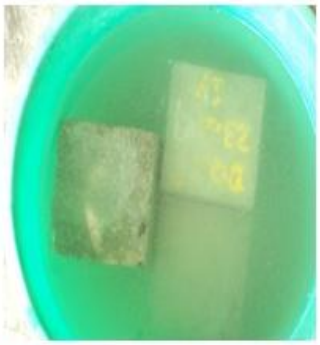

Fig.6 Cubes Exposed in Alkaline

Table 3 Test Results of Alkaline Attack

S.No	Types of concrete	Average weight Before put in to Alkaline (kg)	Average weight After taken from Alkaline attack (kg)	Loss in (kg)	Percentage Loss
1	Q0S0	2.434	2.415	0.019	1.9
2	Q1S1	2.420	2.403	0.017	1.7
3	Q2S2	2.446	2.433	0.013	1.3
4	Q3S3	2.446	2.435	0.011	1.1

4.4 RAPID CHLORIDE PENETRATION TEST

Rapid Chloride Penetration Test (RCPT) was carried out on cylinder specimens. The size of the specimen is 10cm diameter and 20cm height. The specimen were submerged in clean fresh water in a curing tank and kept there until taken out just prior to test. The specimens are allowed to become dry at an oven for 3 hours any after that the specimens were tested. First 100 mm diameter and 50 mm diameter discs were cut from concrete cylinders of various types of concrete. The test was conducted as per ASTM–C 1202–97.

This test method consists of monitoring the amount of electrical current passed through h (50 mm) thick slices of (100 mm) nominal diameter cylinders during a 6 hours period. A potential difference of 60 volts DC is maintained across the ends of the specimen, one of which is immersed in a sodium chloride (Nacl) solution, the other in a sodium hydroxide (NaOH) solution. The total charge passed, in coulombs, has been found to be related to the resistance of the specimen to chloride ion penetration.

A solution consisting of 3% sodium chloride (NaCl) was prepared. Another solution consisting of 3% sodium hydroxide (NaOH) was also prepared. The cut discs were arranged in the RCPT apparatus in two compartments. In one of the compartments sodium chloride solution was poured and in the other sodium hydroxide solution was poured. Set specimen onto screen. Apply sealant like Anabond 666T plus around specimen –cell boundary. Cover exposed face of specimen with an impermeable material such as silicon rubber sheeting. They were connected to positive and negative terminals of the equipment. Current readings for every 30 minutes were recorded for a total duration of 6 hours.

If the current is recorded at 30 minutes intervals, the following formula, based on the trapezoidal rule, charge obtained in Columbs,

$$\mathbf{Q = 900x10^{-3}\,[(I_0+I_{360}) +2(I_{30}+I_{60}+I_{90}+\ldots\ldots\ldots +I_{330})]}$$

Where, Q = Charge passed in Columbs,

I_0 = Current (amperes) immediately after voltage is applied, and

I_t = Current (amperes) at't' min after voltage is applied.

The test was conducted as per ASTM–C 1202–97. Test result of RCPT for various type of concrete is shown in Table 4. From result it will be observed that conventional concrete value is slightly less than other type of concrete. Quarry dust with silica fume concrete for both 5% and 10% are more are less equal with each other. Accordingly chloride penetration of concrete decreases with an increase in a degree of compaction.

Fig.7 Rapid Chloride Set Up

Table 4 Test Results of RCPT

S.no	Types of concrete	Charge Passed in Coloumbs
1	Q0S0	3560
2	Q1S1	3736
3	Q2S2	3658
4	Q3S3	3637

4.5 Ultrasonic Pulse Velocity Test

Ultrasonic pulse velocity testing method, which involves measurement of the time of travel of electronically generated sound wave through the concrete. From table 5 it will be obsevered that for all the concrete time of travel of an ultrasonic pulse is very good. Because all velocity values are more than 4.5 km/sec. if velocity value is more than 4.5 km/sec quality of concrete is excellent it will be suggested by Central Water and Power Research Station khadakwasla (India).

Fig.8 Ultrasonic Pulse Velocity

Table 5 Result of Ultrasonic Pulse Velocity

Types of concrete	Time travelling	Velocity value (km/sec)
Q0S0	21	4.76
Q1S1	21.3	4.69
Q2S2	21.6	4.62
Q3S3	21.6	4.62

4.6 Rebound hammer test

Rebound hammer test is used to find out hardness of concrete. From table 6 it will be observed that control concrete value is higher than quarry dust concrete. But silica fume replacement with cement concrete is nearer to control concrete value. Because when silica fume mixed with cement and quarry dust it form like a gel and make a concrete hard.

Fig.9 Rebound hammer

Table 6 Test result of rebound hammer

Types of concrete	Rebound number
Q0S0	27
Q1S1	26
Q2S2	27
Q3S3	27

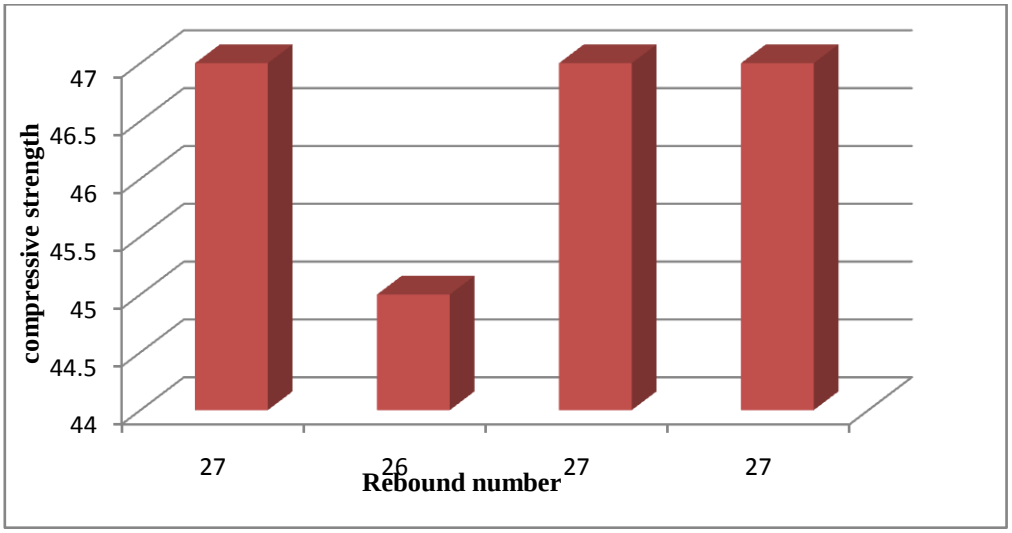

Fig.10 Comparison of Rebound Number

V. Conclusion

In previous publication the strength properties of concrete with quarry dust and silica fume replacement in concrete ingredients were discussed. Similarly the non-destructive test on the concrete with replacement of quarry dust and silica fume shows good results as indicated.

The ultrasonic pulse velocity test on replaced concrete ingredients with quarry dust and silica fume with varying proportion shows excellent result. It even showed that the cement replaced with 10% silica fume and quarry dust replaced normal sand the ultrasonic pulse velocity test result was very good.

When the rebound hammer test of NDT test on the sample is concerned, the concrete with quarry dust and 10% silica fume has good number of average rebound.

The durability of high grade concrete is crucial to its other strength properties accordingly the rapid chloride permeability test of high grade concrete with quarry dust replacement only shows around 3736 columbs charge passage and the quarry dust with 10% silica fume passage is 3637 columbs so the quarry dust replacement only has better columbs passage. Generally as the columbs passage ranges from 2000 to 4000 is moderate. The rapid chloride permeability test on this replaced concrete is moderate.

The capacity of quarry dust and silica fume replaced concrete to acid attack is very less when compared to the control concrete. The 10% silica fume with quarry dust concrete has higher acid attack resistance as we can observe the percentage loss in them.

Similarly the alkaline attack on quarry dust and silica fume concrete is very less when compared to the control concrete.Espesially as the silica fume 10% is increased in replaced concrete the alkaline attack resistance highly decreases.

The porosity and saturated water absorption test on quarry dust concrete is high when compared to the control concrete and the concrete with quarry dust and 10% silica fume. This is due to the fact that the pozalanic nature of silica fumes it filling the void.

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