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Investigation on durability properties of concrete with partial replacement of sand by quarry dust & cement by fly ash

Dr. K. Chandrasekhar Reddy[1],
Guide, Professor of Civil Engineering and Principal, Siddharth Institute of Engineering & Technology, Puttur, A.P. India

S.M.Omkar[2]
PG student, Department of Civil Engineering, Siddharth Institute of Engineering & Technology, Puttur, A.P. India

Abstract

The reduction in the sources of natural sand and the requirement for reduction in the cost of concrete production has resulted in the increased need to identify substitute material to sand as fine aggregates in the production of concretes. In such a situation the Quarry dust can be an economic alternative to the river sand. The project deals with the study of durability condition of concrete. Natural sand is replaced by quarry dust with 0%, 10%, 20% and 30%, and in combination Natural sand is replaced by quarry dust with its highest strength& Cement replaced by fly ash with 0%, 10%, 20and 30 % . The immersion test of sulphuric acid (H_2SO_4) is conducted at 5% by volume of water. The result showed that there is an effect of sulphuric acid on concrete.

Keywords: Durability, Fly ash, Quarry dust, Sulphuric acid, and conventional concrete, Combinations.

1. INTRODUCTION

All over the planet concrete can be considered as the most widely used ingredient material in the construction industry. In the present day construction exercise, durability of concrete has equal importance like the strength of concrete. The Indian Standard Code of practice book for plain and reinforced concrete design recommends the minimum cement content to satisfy the strength and durability requirements. Hence, in the concrete production increase the utilization of cement. But, in the system of manufacture of cement expends large amount of energy and outputs, carbon dioxide brings in environmental pollution. Hence, one of the solution method or way to overcome these problems is to trim down the using up of cement and utilize Pozzolana materials for the preparation of concrete. Previous studies indicates that the applying the Fly-Ash(FA), Micro Silica(MS), Metakaoline(MK) and Ground Granulated Blast Furnace Slag(GGBS)as partial replacement of cement trim down the cement spending and also increases the strength and durability of concrete. Supplementary material like alkali activator is added to improve the strength of concrete.

By Using up the fly ash in various products and partly substituting in cement at current annual levels in India reduces the result of output of CO_2 by 25 million tons, amount of good quality lime by 35 million tons and coal by 15 million tons a year. The probable that is yet to be tapped is multi-fold of the existing levels. The river beds are the primary sources for natural sand. By the reason, due to exploitation and contamination caused by chemicals and unwanted waste from nearby industries, because of all of these reasons natural assets are being depleted very fast. Several choices of optional materials for sand are available in market. By adopting Boulders of rock squashed to small pieces in crushers to dig up different sizes of material like 40 mm, 20 mm, 10 mm, 4.75 mm and the crushed powder material of size less than 4.75 mm . Quarry dust, available from the crushing process of stones as a by-product (Blue metal) which is available abundantly from rock crushing quarries at low cost in many areas can be an economical alternative to the river sand.

2. LITERATURE REVIEW

Ilangovan (2008) Conducted on strength and durability properties of concrete containing quarry dust as fine aggregate revealed that the overall workability value of quarry dust concrete is less, when compared to conventional concrete. In standard concrete sulphate and acid resistance and its penetrability is more, on the other way by use of quarry dust those properties are less. In this case water absorptions was more than the nominal concrete. The high amount of cement content for an essential strength of concrete is necessary when using higher w/c ratio.

Sahu et al (2003) Reported that concrete containing quarry dust as fine aggregate is promising greater strength, lower permeability and greater density which enable it to provide better resistance to freeze/thaw cycles and durability in adverse environment.

Lohani et al (2012) Studied the property of the quarry dust and the suitability to use it as partial replacement material for sand in concrete. Design mix of M20 grade of concrete was prepared with incomplete replacement of 0%, 20%, 30%, 40% and 50% of sand by quarry dust. The durability of concrete was studied by immersing the concrete cube in 5% solution of $MgSO_4$, 5% solution of NaCl and 2N solution of HCl for 28 and 91 days and results were compared with the standards to achieve the desired parameters.

Bhavana(2015) This thesis reported the durability of concrete made with the partial replacement of cement by quarry dust with 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% by weight of cement. The cubes are immersed in the sulphuric acid and hydrochloric acid is conducted at 5% by volume of water.

3. MATERIALS AND METHODOLOGY

3.1 Cement: Ultratech Ordinary Portland Cement (OPC) of 53 grade of Cement conforming to IS: 12269 standards has been procured and various tests have been carried out according IS: 8112-1989 from them it is found that

a) Specific Gravity of Cement is 3.11
b) We get initial setting time of 50 min and final setting time of 480 min
c) 6% is the fineness of cement

3.2 Fine Aggregates: The natural river sand is taken from the usual place and it is confirmed to grading zone-I from the Table 4 of IS 383-1970.Some of the tests have been voted for out as per the technique given in IS 383(1970)

a) Fine aggregate specific gravity is 2.62
b) Fineness Modulus of Fine Aggregate is 3.05

3.3 Coarse Aggregates: From IS 383-1970consisting 20 mm maximum size of aggregates has been taken from the local quarry industry. After that we tested the aggregate physically and mechanically mainly such as specific gravity and sieve analysis results are written as below

a) CA Specific Gravity is 2.67
b) CA Fineness Modulus of 7.52

3.4 Water: For mixing and curing purpose local drinking water free flow impurities has been used in this program

3.5 Fly Ash: Low sulphur& very low unburnt carbon presented in Good quality of Fly ash, being produced in modern power stations of India. i.e. less loss on ignition. In order to make fly ash available for various uses, most of the new thermal power stations in world have set up dry fly ash evacuation &

storage system. In this system fly ash from Electrostatic Precipitators (ESP) is evacuated through pneumatic system and stored in silos. in this case the soil is backed in bags through correct machine or otherwise in open trucks. Depending on the ESP 6 to 8 rows are designed. The end of the field at chimney is called last filed. The coarse particles of fly ash are collected in first fields of ESP. In this one, the fineness of particle is increased in the different order field. The fly clinker properties are as shown in below table 3.1

Table 3.1Properties of Fly Ash (fly cinder)

S.No.	component	Value
1	Silica dioxide (SiO_2)	56.85 %
2	Aluminum trioxide (Al_2O_3)	27.68 %
3	Ferric oxide (Fe_2O_3 + Fe_3O_4)	6.28 %
4	Titanium dioxide (TiO_2)	0.31 %
5	Calcium oxide (Cao)	3.6 %
6	Magnesium oxide (MgO)	0.32%
7	Sulphate (SO_4)	0.28 %
8	Loss of ignition (LOI)	4.46 %
9	Specific gravity of Fly Ash	2.12

3.6 Quarry Dust: The tamped rock particles having size below 4.75 mm is clear as fine aggregate. It is further classified into coarse, medium and fine. The grains size of from 4.75mm - 2mm is known as coarse, 2mm to 0.425mm as medium and 0.425 mm to 0.075 mm defined as fine.

Table 3.2 Properties of Quarry Dust

S.No.	Property	Value
1	Specific Gravity	2.57
2	Fineness Modulus	2.41
3	Density	1.85 gm/cc
4	Void Ratio	0.42

3.6 MIX DESIGN: The ratio of mix proportion and quantities of ingredients by weight is tabulated in table 3.3

Table 3.3 Mix proportion

WATER l/m^3	CEMENT kg/m^3	FINE AGGREGATE kg/m^3	COARSE AGGREGATE kg/m^3
209	437	637	1111
0.47	1	1.45	2.54

3.8 CONCRETE MIX PROPORTION: M40 grade of concrete were designed as per the Indian Standard code of practice. The various ingredients for one cubic meter of M40 grade concrete are shown in Table 3.4.

Table 3.4 Quantities of Ingredients per cum of M40 Grade Concrete

S. No	Mix Identification	Cement (kg/m³)	Fly ash (kg/ m³)	Fine Aggregate		Coarse Aggregate (kg/ m³)	Water (lit)
				Sand (kg/ m³)	Quarry Dust (kg/ m³)		
1	C.C	437	0	637	0	1111	209
2	10% Q.D.	437	0	573	62	1111	209
3	20% Q.D.	437	0	510	123	1111	210
4	30% Q.D.	437	0	446	185	1111	210
5	10% F.A.	393	30	637	0	1111	209
6	20% F.A.	350	60	637	0	1111	209
7	30% F.A.	306	90	637	0	1111	209
8	20% Q.D+ 10% F.A	393	30	510	123	1111	210
9	20% Q.D + 20% F.A	350	60	510	123	1111	210
10	20% Q.D + 30% F.A	306	90	510	123	1111	210

3.9 Durability test:

Sulphuric, nitric, hydrochloric and phosphoric acids these are the mineral acids to attack the concrete. When concrete is in get in contact with such acidic waters the calcium hydroxide reacts with the sulphuric acid to form gypsum, which can be promptly washed left. One of the consider Sulphuric acid is also acidifying agents of the acid rain.

In natural ground water, only sulphuric acid is likely to be found as a result of the oxidation of sulphide minerals such as pyrites and marcasite, a process which is catalyzed by the presence of the aerobic bacterium, thiobacillusferro-oxidans.
In the present experimental investigation, Acid attack test was performed on Concrete cubes of size 150mm × 150mm × 150mm were cast and stored in a place at room temperature for 24 hours and then the specimens were demoulded and kept for curing in water for 28 days. After 28 days of curing, the specimens were taken out and allowed to dry for one day. Weights of the cubes were taken.

For acid attack, 5% of dilute sulphuric acid (H_2So_4) by volume of the water is in use. After that, cubes were immersed in the above acid water for a period 28 days and then taken out and allowed to dry for one day. Weights of the cubes were taken and tested for compressive strength.

The mass loss due to deterioration of concrete was calculated after 28 days of immersion by using the following formula

$$\text{Mass loss} = \left[\frac{(M_{i-M_f})}{M_i}\right] \times 100$$

where,

M_i = Initial mass of concrete specimen before immersion
M_f = Final mass of concrete specimen after immersion

4. RESULTS AND DISCUSSIONS:

4.1 Acid Attack Results:

The behavior of acids on solidified concrete is the exchange the ferrous compounds into the ferrous salts of the striking acid. It is experienced to additional loss of weight along loss in compressive strength when compared with regulated concrete.

The experiment results of acid attack test with 5% Sulphuric acid (H_2SO_4) of M40 grade concrete with different proportions of Quarry Dust and Fly Ash is displayed in Table 4.1. The difference of loss of weight and decrease in compressive strength of M40 grade concrete with altered percentages of Quarry Dust and Fly Ash is shown in Figure 4.1 and 4.2.

Table 4.1 Effect of acid attack on compressive strength at 28 days

S. No	Mix Designation	Weight of cubes (Kg)		% Loss in wt.	Comp strength N/mm^2		% Loss of Comp Strength
		Before	After 28 Days		Before acid attack	After acid attack 28 days	
1	Control Concrete	8.35	8.23	1.51	49.21	46.68	5.15
2	10% QD	8.95	8.71	2.68	48.35	41.99	13.16
3	20% QD	8.27	8.05	2.75	50.23	42.92	14.56
4	30% QD	8.66	8.40	3.02	49.32	41.13	16.61
5	10% FA	8.84	8.47	4.13	50.68	42.92	15.32
6	20% FA	8.47	8.07	4.78	52.34	43.33	17.21
7	30% FA	8.05	7.63	5.15	51.69	41.57	19.58
8	20% QD + 10% FA	8.54	7.96	6.75	52.56	43.87	16.53
9	20% QD + 20% FA	8.98	8.26	7.97	54.36	44.40	18.32
10	20% QD + 30% FA	8.76	8.19	6.58	53.72	42.84	20.25

Each and every concrete specimen gets affected by acid attack. The outer portion of cubes gets bust and there is a maximum reduction of 2mm at all sides for all the concrete specimens. Control specimens exposed better-quality resistance to acid attack than Quarry Dust and Fly Ash replaced specimens.

From the test results, it was noted that the % of loss of weight for controlled concrete is 1.51%. The extreme % of loss of weight of concrete cubes found at 20% substitute of Quarry Dust likewise sand and 20% Fly Ash as cement.

The loss of percentage in compressive strength for controlled concrete is 5.15%. The percentage loss of highest in compressive strength is found at 20% replacement of Quarry Dust as sand with 30% Fly clinker as cement.

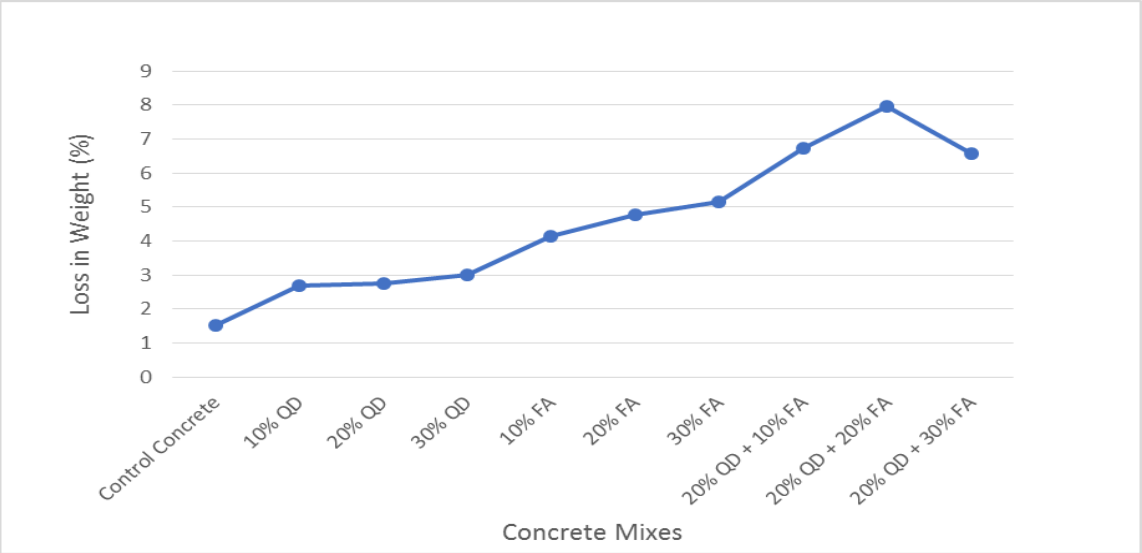

Fig 4.1 Percentage of Loss of Weight with various percentages of Q D and FA

In Fig 4.1 the percentage loss of weight with different percentages of Quarry Dust and Fly Ash was displayed. The graph is displayed for Quarry Dust replacements at 10%, 20% and 30% with 10%, 20% & 30% Fly Ash. From this one well-known that maximum percentage loss of weight discovered at 20% replacement of QD and 20% FA.

In Fig 4.2 the percentage loss in compressive strength with various percentages of Quarry Dust and Fly Ash was shown. Quarry Dust replacements at 10%, 20% and 30% with 10%, 20% & 30% Fly Ash were shown in graph. The highest % of loss in compressive strength is found at 20% replacement of Quarry Dust with 30% Fly Ash.

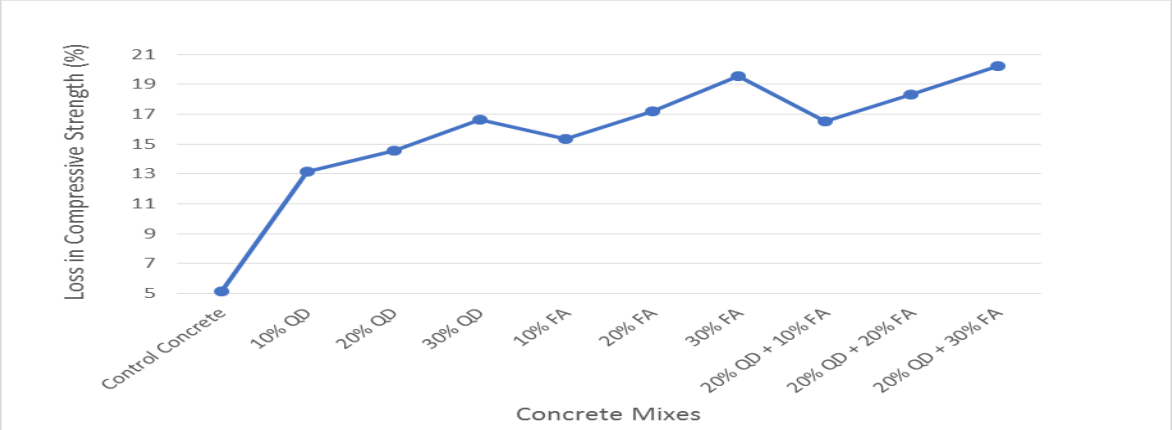

Fig 4.2 Percentage of Loss in compressive strength with various percentages of QD &FA

Generally, the deterioration of concrete is found maximum in the Sulfuric acid environment when compared to other acidic environments is probably due to combined effect of Sulfate ions attack and dissolution effect of hydrogen ions in sulfuric acid solution.

5. CONCLUSIONS:

The present study of effect is alarmed with the estimation of the performance of Quarry Dust and Fly Ash in concrete. Experimental investigation was carried out to study the durability properties of concrete.

The following conclusions were knows at from the experimental investigation:

1. From acid resistance test, it might have been watched that the concrete containing fly ash have been discovered to be low resistant to the H2So4 solution over the control concrete.
2. At most percentage loss in weight is discovered at20% replacement of Quarry Dust and 20% Fly Ash.
3. The maximum percentage loss of Compressive Strength is found for 20% replacement of Quarry Dust and 30% Fly Ash.
4. These results on strength and durability studies give a clear conclusion that Quarry Dust can be used as a good substitute for natural river sand and Fly Ash can be used as replacement for Cement with higher strength at 20% replacement, saving in cost of concrete and reducing the demand for sand.

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