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DURABILITY PROPERTIES OF CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY USING QUARRY DUST

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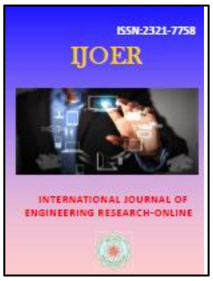

ABSTRACT

Leaving waste materials into environment directly can cause environmental problems. Quarry dust a waste from the quarry processing units accounts 30% of the final product from quarry industry. Therefore this waste can be used to produce new products or can be used as admixtures so that the natural resources are used efficiently and hence environmental wastes can be reduced.

The present project deals with the study of durability conditions of concrete made with partial replacement of cement with quarry dust in proportions of 0%, 5%, 10%, 15%, 20%, 25%, 30%, and 35% by weight of cement. Immersion test of sulphuric acid and hydrochloric acid are conducted at 5% by volume of water. The results showed that there is an effect of sulphuric acid on quarry dust concrete. And there is no effect of hydrochloric acid on quarry dust concrete.

Keywords—Cement, Quarry Dust, Sulphuric Acid and Hydrochloric Acid.

INTRODUCTION

For quite a while cement was thought to be exceptionally strong material requiring. We assemble solid structures in profoundly dirtied urban and modern ranges, forceful marine situations, destructive sub-soil water in territory and numerous other antagonistic conditions where different materials of development are found be non –durable. Since the utilization of solid as of late have spread to exceptionally cruel and unfriendly conditions, the prior impression that solid is an extremely strong material is being debilitated, especially because of untimely disappointments of number of structures. In the past just quality of cement was considered in the solid blend outline strategy accepting quality of solid in all plaguing variable for all other attractive properties of solid including strength. In the late correction of IS 456 of 2000, one of the points discussed, deliberated and revised is the durability aspects of concrete, in line with codes of practice of other countries, which have better experiences in dealing with durability of concrete structures. One of the main reasons for deterioration of concrete in the past is that too much emphasis is placed on concrete compressive strength.

SCOPE

The objective of the present project work is to study the behavior of concrete in partial replacement for cement with quarry dust in proportions. It includes a brief description of the materials used in the concrete mix, mix proportions, the preparation of the test specimens and the parameters studied. In order to achieve the stated objectives, this study is carried out in different stages. In the initial stage, all the materials and equipment needed must be gathered or checked for availability. Once the characteristics of the materials selected have been studied through appropriate tests, the applicable standards of specification are referred. The properties of hardened concrete are important as it is retained for the remainder of the concrete life. In general, the important properties of hardened concrete are strength and durability. An experimental program is held to measure strength of hardened concrete.

A. ORDINARY PORTLAND CEMENT

Portland bond is the most normally utilized kind of concrete as a part of the world today. Portland bond can be found in both cement and mortar, where it goes about as coupling operators. On a concoction level, Portland bond is a fine powder included at least 66% calcium silicate, with the rest of being a blend of aluminum, and iron. Portland concrete is a pressure driven material, which requires the expansion of water so as to frame exothermic bonds, and is not solvent in water.

Initially outlined as a concrete which would set gradually, sufficiently permitting time for it to be legitimately laid, and a water safe bond which could be utilized as a part of development applications where water would interact with the bond, Portland concrete was initially protected in 1824 by an English man, Joseph Asp clamor, yet the blend which turned out to be genuinely fruitful, and which is still utilized today, was composed by his child, William Asp commotion in around 1843.

B. PORTLAND CEMENT APPLICATIONS

Portland cement is most often used in concrete and mortar. Concrete is made by combining water, sand, gravel, and cement, whereas mortars are made by combining cement with water and sand only. Concrete is much stronger than mortar, and is used in most modern buildings as a durable and strong construction material capable of bearing great loads. Mortar is used to bind other substances together, such as the bricks in a house.

C. PORTLAND CEMENT STRENGTH

Portland cement usually takes several hours to set, and will harden in a matter of weeks. Cement is a somewhat curious material in that it continues to harden over time as long as there is water available for the components of the cement to form bonds with. One week old Portland cement has strength of around 23MPa, whereas three month old cement has strength of 41MPa. These numbers apply to standard Portland cement which has not had any additives added to it. Various treatments and additives can make cement set and harden at different rates, and various types of Portland cement also possess different properties which affect the rate of setting and hardening.

D.PROPERTIES OF OPC

(i) Chemical properties

Portland concrete comprises of the accompanying H concoction mix

(a) Tricalcium silicate $3CaO.SiO_2$ (C_3S) 40%

(b) Dicalcium silicate $2CaO.SiO_2$ (C_2S) 30%

(c) Tricalcium aluminate 3CaO. Al_2O_3(C_3A) 11%

(d) Tetracalcium aluminate $4CaO.Al_2O_3.Fe_20_3$(C_3AF) 11%.

(ii) Physical properties

The following physical properties should be checked before selecting a Portland cement for the civil engineering works. IS 269–1967 specifies the method of testing and prescribes the limits:

(a) Fineness
(b) Setting Time
(c) Soundness
(d) Crushing Strength

E. SIGNIFICANCE AND OBJECTIVES

The objectives of the present investigation are to get the thoroughness with the existing mix design procedures for concrete by varying the percentage replacement of ordinary Portland cement by quarry dust (0%, 5%, 10%, 15%, 20%, 25%, 30%, and 35%).

Investigations were carried out on OPC mixes for M20 and M40 grades using 20mm maximum size of aggregates to ascertain the workability and durability properties of concrete made with partial replacement of cement with quarry dust, from H_2SO_4, HCL immersion test the effect of acids on design concrete is same as the effect for ordinary Portland cement concrete.

Hence in the present investigation more emphasis is given to study the OPC using quarry dust so as to achieve better concrete composites and also to encourage the increased use of quarry dust to maintain ecology.

F. MATERIAL PROPERTIES

(a) GENERAL

The experimental program for this project is carried out using the materials cement, fine aggregate (FA), coarse aggregate CA), quarry dust, and water. The description of each of the material is described in the following sections. The objective of this study is to evaluate the effect of the quality of Quarry Dust on the durability of concrete.

(b) Cement

The function of cement is first of all to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. It constitutes only about 20 percent of the total volume of concrete mix; it is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Any variation in its quantity affects the compressive strength of the concrete mix. Portland cement referred as (Ordinary Portland Cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipments, maintaining better particle size distribution, finer grinding and better packing. Generally use of high grade cement offers many advantages for making stronger concrete. Although they are little costlier than low grade cement, they offer 10-20% saving in cement consumption and also they offer many hidden benefits. One of the most important benefits is the faster rate of development of strength.

Ordinary Portland Cement (OPC) is the cement best suited to general concreting purposes. OPC 53 grade confirming with IS: 8112-2007 is used. The cement is kept in an airtight container and stored in the humidity controlled room to prevent cement from being exposed to moisture. The physical properties of cement are shown in Table

Table 1: Physical property of cement used for this study

Physical property	Obtained Value	IS: 8112-2007 Specifications
Fineness (retained on IS sieve 90-µm sieve)	5 %	As per IS:269-1976, max:10%
Normal Consistency	30.5 %	
Vicat initial setting time (minutes)	90 min	As per IS:4031-1968, Min:30min
Vicat final setting time (minutes)	350 min	As per IS:4031-1968, Max:600min
Specific gravity	3.15	As per IS: 2383-(part-3)1963

Vicat apparatus conforming to IS: 5513-1996, balance, whose permissible variation at a load of 1000g should be +1.0g, gauging trowel conforming to IS: 10086-1982 are used to find setting time of cement and normal consistency. The surface area of powder can be determined by measuring the pressure drop of fluid flow through a packed powder bed. The most frequently used apparatus is the Blaine, which is a standard test method. The test is carried out as per IS: 4031(II) 1999 for characterizing the fineness of cement by air permeability. The specific surface of cement is $413 m^2/kg$. The chemical properties of OPC are shown in Table 5.2.2. The soundness of cement is estimated using 'Le chatlier' method. Expansion of cement is found to be 0.2 mm. Compressive strength of cement is estimated using IS: 4031 (VI): 1999 is followed and the results obtained are as shown in Table 2. All the values obtained are within the limits given by IS 8112: 2007.

Table 2:chemical properties of cement

% by mass as per IS 4032-1968	Cement
Loss on Ignition	3.65
Silica as SiO_2	21.5
Iron as Fe_2O_3	0.55
Aluminum as Al_2O_3	5.50
Titanium as TiO_2	Nil
Calcium as CaO	63.5
Magnesium as MgO	2.15
Sodium as Na_2O	0.85
Potassium as K_2O	0.85

Table 3 :Compressive strength of Cement

Sl. No.	Curing Period (Days)	Compressive strength in MPa			Average strength (MPa)	Min. value as per IS 8112:2007 in MPa
		Sample 1	Sample 2	Sample 3		
1	3	34	34	37	35	27
2	7	45	47	49	47	37
3	28	55	57	59	57	53

G. Aggregates

Totals are the real elements of cement. They constitute 70-75% of the aggregate volume;

give an inflexible skeleton structure to cement, and go about as efficient space fillers. The totals frame the principle grid of the solid. The total particles are stuck together by the bond and water glue. With bond and water the whole network ties together into a strong mass called concrete. Totals impact the properties of cement, for example, water necessity, cohesiveness and workability of the solid in plastic stage, while they impact quality, thickness, sturdiness, surface complete and shading in solidified stage. It is in this manner fundamentally critical to explore the different properties of totals.

Totals are for the most part idle and extensively separated into two classifications, i.e. fine and coarse, contingent upon their size. Totals with grain size underneath 4.75mm are termed fine totals or more 4.75mm are termed as coarse totals. I.S.383-1963 characterizes the necessity of totals.

H. Gradation of Aggregates

Degree alludes to the molecule size circulation of totals. Reviewing is a critical property of total utilized for making solid, in perspective of its pressing of particles, bringing about the diminishment of voids. This thusly impacts the water request and bond substance of cement.

Reviewing is portrayed regarding the total rates of weights passing a specific IS sifter. IS 383-1970 indicates four territories or zones for fine total reviewing. Table 4 gives the range of percentage passing for each zone.

Table 4:Grading limits for fine aggregate as per IS: 383-1970

IS sieve Size	Percentage passing (%)			
	Grading zone I	Grading zone II	Grading zone III	Grading zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 µ	15-34	35-59	60-79	80-100
300 µ	5-20	8-30	12-40	15-50
150 µ	0-10	0-10	0-10	0-15

I. Specific Gravity

Particular gravity alludes to the relative (when contrasted with water) thickness of a unit volume of total. Particular gravity of the total by and large is sign of its quality. A low particular gravity may show high porosity and along these lines poor sturdiness and low quality. The scope of particular gravity for totals is for the most part between 2.4 and 2.9

Specific gravity of sand

$$(G)=\frac{W2-W1}{(W2-W1)-(W3-W4)}$$

where,

W1 - weight of empty pycnometer in gms

W2 - weight of pycnometer + dry sand in gms

W3 - weight of pycnometer + sand + water in gms

W4 - weight of pycnometer + water in gms

The values of specific gravity determined are given below.

J. Sand

The sand utilized as a part of this exploration for planning of ordinary cement is regular stream sand complying with reviewing zone-II according to May be: 383-1970 with particular gravity 2.6 and having fineness modulus as 3.42. The measure of fines under 0.125 mm is to be considered as powder and is essential for the philosophy of the SCC. This material is dried at room temperature for 24 hours to control the water content in the solid. The greatest size of FA is taken to be 4.75 mm. The testing of sand is done according to May be: 2386 – 1963. The sifter examination results are appeared Table 5

Table 5: Sieve analysis of River sand

Sieve size (mm)	Weight retained (grams)	Cumulative wt retained	Cumulative % retained	Cumulative % wt passing
4.75	4	4	.4	99.6
2.36	112	116	11.6	88.4
1.18	300	416	41.6	58.4
600µ	170	586	58.6	41.4
300µ	106	692	69.2	30.8
150µ	210	902	90.2	9.8
≤75µ	98	1000	100	0
Total = 287.3 Fineness modulus of river sand = 287.3/100 = 2.873				

Table 6:Physical properties of river sand

Property	River sand	Test method
Specific gravity	2.49	IS 2386 (Part III) 1963
Fineness modulus	2.87	IS 383-1970
Sieve analysis	Zone-2	IS 383 - 1970

K.Coarse Aggregates

The aggregate which is retained over IS Sieve 4.75 mm is termed as coarse aggregate. The coarse aggregates may be of following types

i) Crushed graves or stone obtained by crushing of gravel or hard stone.
ii) Uncrushed gravel or stone resulting from the natural disintegration of rocks.
iii) Partially crushed gravel obtained as product of blending of above two types.

Locally available coarse aggregate having the maximum size of 20 mm was used in this work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 383-1970. Specific gravity and other properties of coarse aggregates are given in Table.

Table 7: Properties of Coarse Aggregates

Characteristics	Value
Colour	Grey
Shape	Angular
Maximum Size	20 mm
Specific Gravity	2.75
Fineness Modulus	7-10

L.Quarry Dust

Quarry dust is a waste product obtained during the process of quarrying. In general quarry dust is used as a filler material. A attempt was made in partial replacement of cement. Quarry dust was collected from local processing units of Chowdavaram. It was initially dry in condition when collected and was sieved by IS: 90 micron sieve before mixing in concrete

Table 8: Physical Properties of Quarry Dust

property Property	Quarry dust	Test method Test method
Specific gravity	2.54-2.60	[5] IS 2386 (Part III) 1963
Fine particles	12-15	[5] IS 2386 (Part I) 1963
Sieve analysis	Zone II	[4]IS 383 – 1970

Table 9: chemical composition of quarry dust

items	Quarry rock dust (%)	Test method Test method
SiO_2	62.48	
Al_2O_3	18.72	[10]IS: 4032-1968
Fe_2O_3	06.54	[10]IS: 4032-1968
CaO	04.83	
MgO	02.56	
Na_2O	Nil	
K_2O	03.18	
TiO_2	01.21	
Loss of ignition	00.48	

M. WATER

Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contain marine life also usually is suitable. When water is obtained from sources mentioned above, no sampling is necessary. When it is suspected that water may contain sewage, mine water, or wastes from industrial plants or canneries, it should not be used in concrete unless tests indicate that it is satisfactory. Water from such sources should be avoided since the quality of the water could change due to low water or by intermittent tap water is used for casting. The potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly potable water was used for making concrete available in Material Testing laboratory. This was free from any detrimental contaminants and was good potable quality

Table 10 :MIX DESIGN M20

W	C	FA	CA
186	422.73	622.91	1181.49
0.44	1	1.47	2.79

Table 11 :MIX DESIGN M40

W	C	FA	CA
180	450	606.86	1191.52
0.42	1	1.35	2.65

P. Compressive Strength Test

Compressive strength of concrete is often considered as the most important property of concrete, and is the most common measure used to evaluate the quality of hardened concrete (Mather et al 2002). Principal factors governing the compressive strength of concrete are the W/C ratio, curing conditions, age of the concrete, cementations material, aggregates, mixing time, degree of consolidation, and air content (Mather et al 2002). The compression load is applied continuously until failure using compression testing machine at the rate of 0.3MPa/sec.

(a) Test procedure

Test specimens were prepared for testing the compressive strength of concrete. The concrete mixes with varying percentages (0%, 5%, 10%, 15%, 20%, 25%, 30%, and 35%) of quarry dust as partial replacement of cement were cast into cubes for ensuing testing.

For M20 grade concrete we prepared 6 cubes for 0% quarry dust replacement for cement. Similarly, we prepared for 5%, 10%, 15%, 20%, 25%, 30% and 35%.

For M40 grade concrete we prepared 6 cubes for 0% quarry dust replacement for cement. Similarly, we prepared for 5%, 10%, 15%, 20%, 25%, 30% and 35%.

PROCEDURE

I. Remove the example from water after determined curing time and wipe out abundance water from the surface.

II. Take the example's measurement to the closest 0.2m

III. Clean the bearing surface of the testing machine

IV. Place the example in the machine in such a way, to the point that the heap should be connected to the inverse sides of the block cast.

V. Align the example halfway on the base plate of the machine.

VI. Rotate the versatile divide tenderly by hand so it touches the top surface of the example

VII. Apply the heap steadily without stun and persistently at the rate of 140kg/cm2/moment till the example falls flat

(VIII) Record the most extreme load and note any bizarre elements in the kind of disappointment.

RESULTS

Table 12: M20 7 days average compressive strength

Mix. No	W/C	% of Cement	% of Quarry Dust	7 Days Avg Compressive Strength(Mpa)
A_2Q_0	0.44	100	0	18.45
A_2Q_1	0.44	95	5	18.39
A_2Q_2	0.44	90	10	18.33
A_2Q_3	0.44	85	15	19.47
A_2Q_4	0.44	80	20	20.65
A_2Q_5	0.44	75	25	21.33
A_2Q_6	0.44	70	30	17.42
A_2Q_7	0.44	65	35	15.37

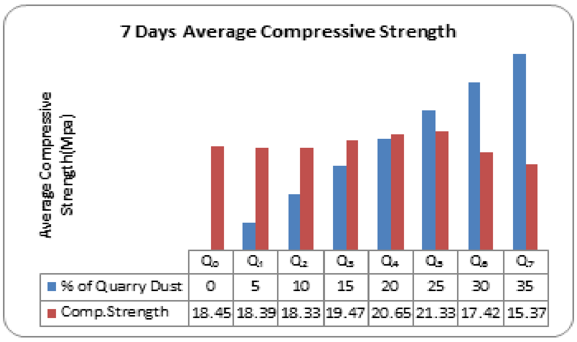

Figure 2: % of Partial Replacement of Quary Dust

Table 13: M20 28 day's average compressive strength

Mix. No	W/C	% of Cement	% of Quarry Dust	28 Days Avg Compressive Strength(Mpa)
A_2Q_0	0.44	100	0	23.69
A_2Q_1	0.44	95	5	23.55
A_2Q_2	0.44	90	10	23.42
A_2Q_3	0.44	85	15	23.70
A_2Q_4	0.44	80	20	23.84
A_2Q_5	0.44	75	25	24.32
A_2Q_6	0.44	70	30	20.64
A_2Q_7	0.44	65	35	20.23

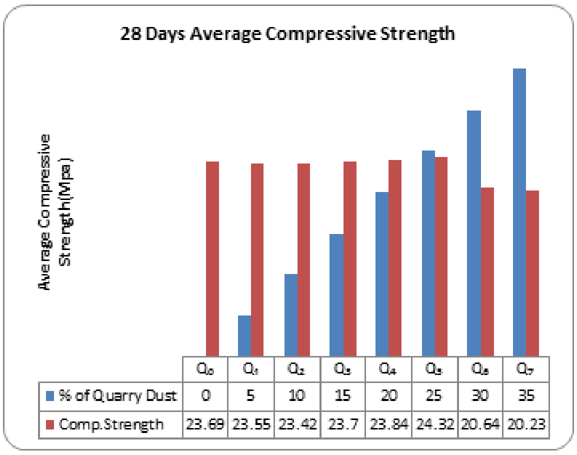

Figure 3: % of Partial Replacement of Quary Dust

Table 14: M40 7 day's average compressive strength

Mix. No	W/C	% of Cement	% of Quarry Dust	7 Days Avg Compressive Strength(Mpa)
A_4Q_0	0.4	100	0	35.51
A_4Q_1	0.4	95	5	35.62
A_4Q_2	0.4	90	10	35.72
A_4Q_3	0.4	85	15	34.35
A_4Q_4	0.4	80	20	33.57
A_4Q_5	0.4	75	25	34.13
A_4Q_6	0.4	70	30	29.28
A_4Q_7	0.4	65	35	27.33

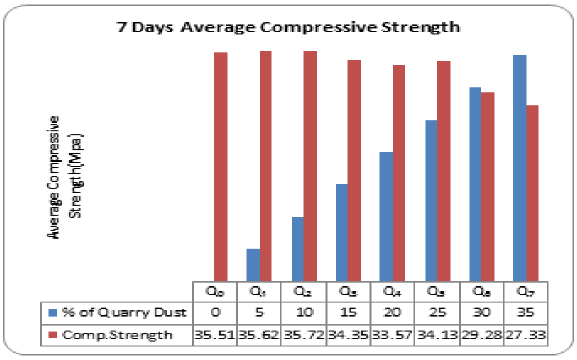

Figure 4: % of Partial Replacement of Quarry Dust

Table 15:M40 28 days average compressive strength

Mix. No	W/C	% of Cement	% of Quarry Dust	28 Days Avg Compressive Strength(Mpa)
A_4Q_0	0.40	100	0	53.79
A_4Q_1	0.40	95	5	53.65
A_4Q_2	0.40	90	10	53.50
A_4Q_3	0.40	85	15	52.70
A_4Q_4	0.40	80	20	52.46
A_4Q_5	0.40	75	25	52.57
A_4Q_6	0.40	70	30	49.67
A_4Q_7	0.40	65	35	46.24

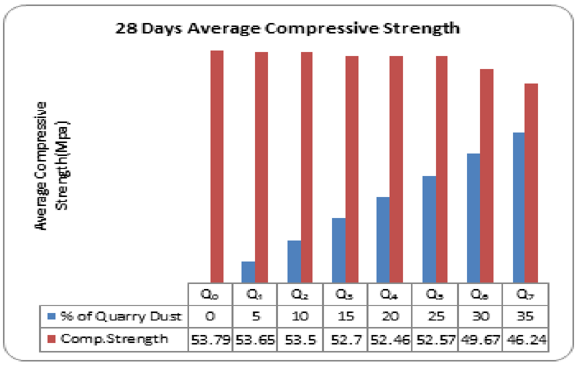

Figure 5:% of Partial Replacement of Quarry Dust

DURABILTY OF CONCRETE

Tests on durability

(a) Mass loss

(b) Strength deterioration factor (SDF)

(c) Study of weight loss and strength loss of concrete

Figure 6: Cubes immersed in H_2SO_4

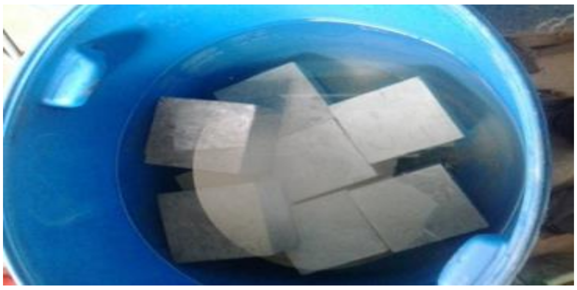

Figure 7: Cubes Immersed in HCl

EXPERIMENTAL PROCEDURE

The aim of the present study is to identify and estimate the effect of H2 S04, HCl on concrete made up of partial replacement of cement with quarry dust. The studies conducted on the durability of the concrete against the attack of H_2 SO_4, HCl.

For M20 grade concrete we prepared 5 cubes for 0% quarry dust replacement for cement. Similarly, we prepared for 5%, 10%, 15%, 20%, 25%, 30% and 35% replacement of cement with quarry dust.

For M40 grade concrete we prepared 5 cubes for 0% quarry dust replacement for cement. Similarly, we prepared for 5%, 10%, 15%, 20%, 25%, 30% and 35% replacement of cement with quarry dust.

A total of 2 sets of cubes of each grade of M20 and M40 of size 100mm x 100mm x 100 mm are casted. Each set consist of 120 cubes are cured in water. After 28 days of curing in water 120 cubes is immersed in 5% concentrated H_2SO_4 and another 120 cubes are immersed in 5% concentrated HCl. The percentage weight loss, compressive strength loss is taken for a set of cubes at 7days and 28 days for both HCL and H_2SO_4.

RESULTS

Table16: M20 average % of 7 days Strength deterioration when immersed in H_2SO_4

Mix.No	% of Cement	% of Quarry Dust	7days Avg. Compressive Strength before immersion	7daysAvg. Compressive Strength after immersion(H_2SO_4)	Average % of Strength deterioration
A_2Q_0	100	0	18.45	14.95	18.97
A_2Q_1	95	5	18.39	13.03	29.14
A_2Q_2	90	10	18.33	12.9	29.62
A_2Q_3	85	15	19.47	14	28.09
A_2Q_4	80	20	20.65	14.5	29.78
A_2Q_5	75	25	21.33	14.85	30.37
A_2Q_6	70	30	17.42	12.6	27.66
A_2Q_7	65	35	15.37	11	28.43

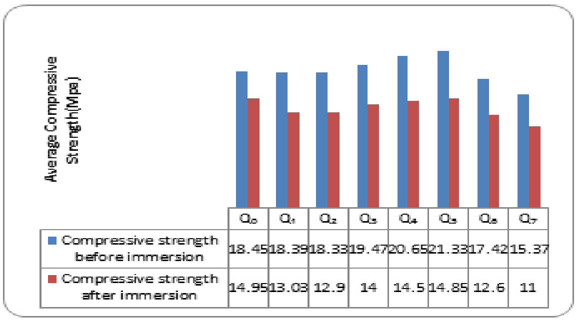

Figure 8: % of partial replacement of Quarry Dust

Table17: M20 average % of 28 days strength deterioration when immersed in H_2SO_4

Mix.No	% of Cement	% of Quarry Dust	28days Avg. Compressive Strength before immersion	28days Avg. Compressive Strength after immersion(H_2SO_4)	Average % of Strength deterioration
A_2Q_0	100	0	23.69	13	45.12
A_2Q_1	95	5	23.55	12.5	46.92
A_2Q_2	90	10	23.42	12	48.76
A_2Q_3	85	15	23.70	12.65	46.62
A_2Q_4	80	20	23.84	12.7	46.72
A_2Q_5	75	25	24.32	12.75	47.69
A_2Q_6	70	30	20.64	11.5	44.28
A_2Q_7	65	35	20.23	10	50.56

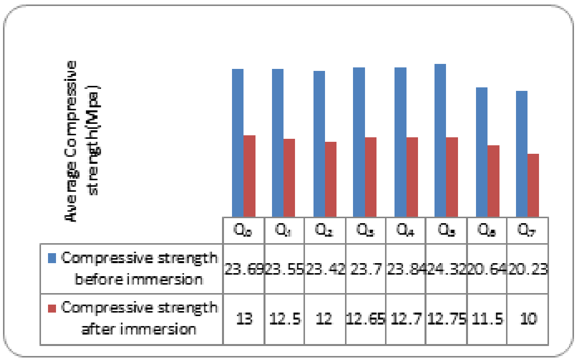

Figure 9: % of partial replacement of Quarry Dust

Table18: M40 average % of 7 days strength deterioration when immersed in H_2SO_4

Mix.No	% of Cement	% of Quarry Dust	7days Avg. Compressive Strength before immersion	7days Avg. Compressive Strength after immersion(H_2SO_4)	Average % of Strength deterioration
A_4Q_0	100	0	35.51	26.89	24.27
A_4Q_1	95	5	35.62	17.30	51.43
A_4Q_2	90	10	35.72	17.00	52.40
A_4Q_3	85	15	34.35	17.50	49.05
A_4Q_4	80	20	33.57	18.05	46.23
A_4Q_5	75	25	34.13	19.45	43.01
A_4Q_6	70	30	29.28	16.33	44.22
A_4Q_7	65	35	27.33	14.34	47.53

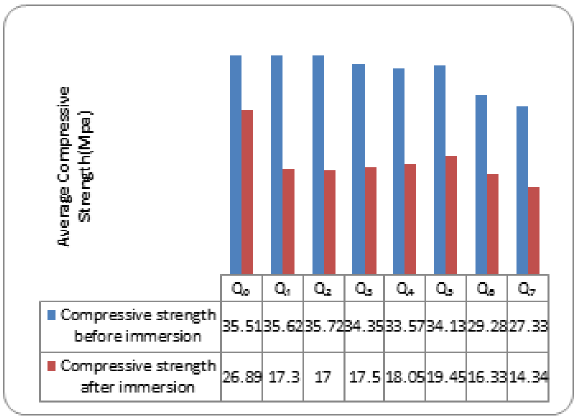

Figure 10: **% of partial replacement of Quarry Dust**

Table19: M40 average % of 28 days strength deterioration when immersed in H_2SO_4

Mix.No	% of Cement	% of Quarry Dust	28days Avg. Compressive Strength before immersion	28days Avg. Compressive Strength after immersion(H_2SO_4)	Average % of Strength deterioration
A_4Q_0	100	0	53.79	15.50	71.18
A_4Q_1	95	5	53.65	13.50	74.83
A_4Q_2	90	10	53.50	12.44	76.74
A_4Q_3	85	15	52.70	14.05	73.33
A_4Q_4	80	20	52.46	14.25	72.83
A_4Q_5	75	25	52.57	14.50	72.41
A_4Q_6	70	30	49.67	12.35	75.13
A_4Q_7	65	35	46.24	11.67	74.76

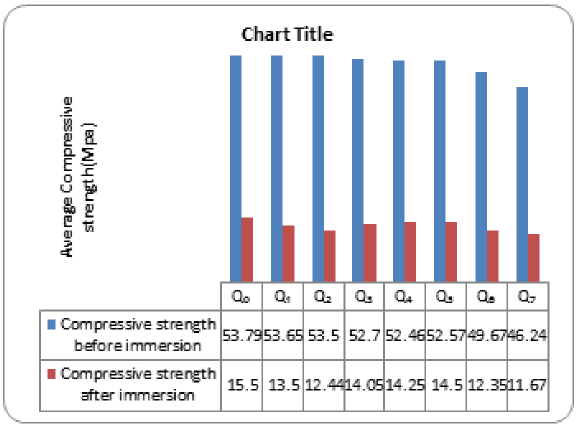

Figure 11: % of partial replacement of Quarry Dust

Table20: M20 average % of 7 days strength deterioration when immersed in HCL

Mix.No	% of Cement	% of Quarry Dust	7days Avg. Compressive Strength before immersion	7days Avg. Compressive Strength after immersion(HCL)	Average % of Strength deterioration
A_2Q_0	100	0	18.45	26.92	-45.9
A_2Q_1	95	5	18.39	29.42	-59.97
A_2Q_2	90	10	18.33	26.14	-42.60
A_2Q_3	85	15	19.47	23.16	-18.9
A_2Q_4	80	20	20.65	22.19	-7.45
A_2Q_5	75	25	21.33	20.20	5.29
A_2Q_6	70	30	17.42	20.20	-15.95
A_2Q_7	65	35	15.37	20.40	-32.72

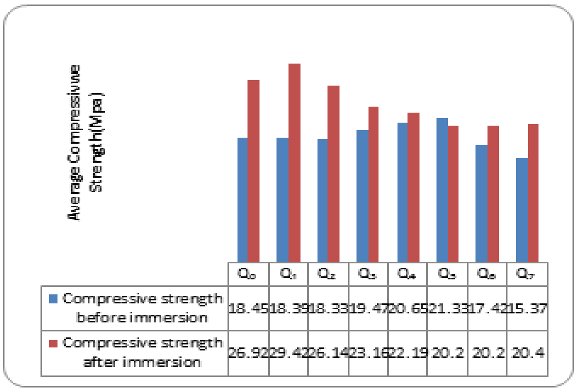

Figure 12: % of partial replacement of Quarry Dust

Table21: M20 average % of 28 days strength deterioration when immersed in HCl

Mix.No	% of Cement	% of Quarry Dust	28days Avg. Compressive Strength before immersion	28days Avg. Compressive Strength after immersion(HCL)	Average % of Strength deterioration
A_2Q_0	100	0	23.69	28.38	-19.79
A_2Q_1	95	5	23.55	31.01	-31.67
A_2Q_2	90	10	23.42	30.42	-29.88
A_2Q_3	85	15	23.70	32.50	-37.13
A_2Q_4	80	20	23.84	29.91	-25.46
A_2Q_5	75	25	24.32	25.37	-4.31
A_2Q_6	70	30	20.64	23.24	-12.59
A_2Q_7	65	35	20.23	21.5	-6.27

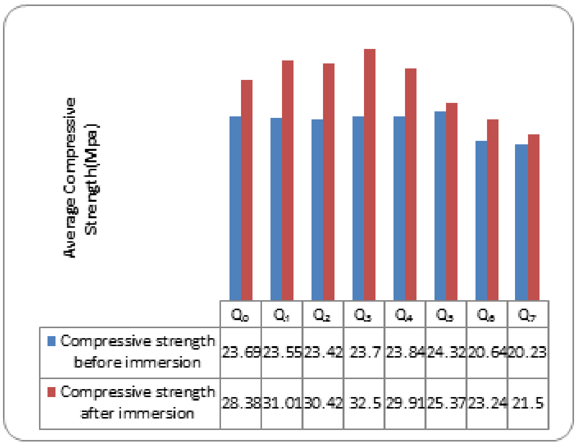

Figure 13: % of partial replacement of Quarry Dust

Table22: M40 average % of 7 days strength deterioration when immersed in HCL

Mix.No	% of Cement	% of Quarry Dust	7days Avg. Compressive Strength before immersion	7days Avg. Compressive Strength after immersion(HCL)	Average % of Strength deterioration
A_4Q_0	100	0	35.51	39.5	-11.2
A_4Q_1	95	5	35.62	40.88	-14.7
A_4Q_2	90	10	35.72	36.3	-1.62
A_4Q_3	85	15	34.35	29.43	14.32
A_4Q_4	80	20	33.57	30.2	10.03
A_4Q_5	75	25	34.13	35.17	-3.04
A_4Q_6	70	30	29.28	29.8	-1.77
A_4Q_7	65	35	27.33	23.89	12.58

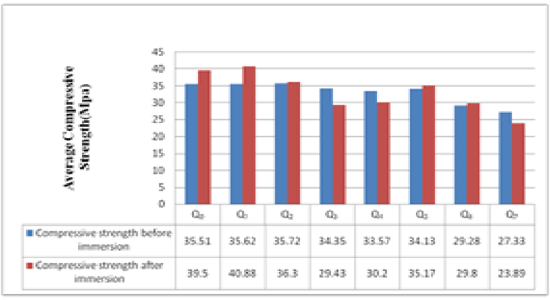

Figure 14: % of partial replacement of Quarry Dust

Table23: M40 average % of 28 days strength deterioration when immersed in HCL

Mix.No	% of Cement	% of Quarry Dust	28days Avg. Compressive Strength before immersion	28days Avg. Compressive Strength after immersion(HCL)	Average % of Strength deterioration
A_4Q_0	100	0	53.79	34.86	35.19
A_4Q_1	95	5	53.65	33.32	37.89
A_4Q_2	90	10	53.50	31.86	40.44
A_4Q_3	85	15	52.70	29.15	44.68
A_4Q_4	80	20	52.46	28.83	45.04
A_4Q_5	75	25	52.57	24.49	53.41
A_4Q_6	70	30	49.67	26.08	47.49
A_4Q_7	65	35	46.24	22.24	51.90

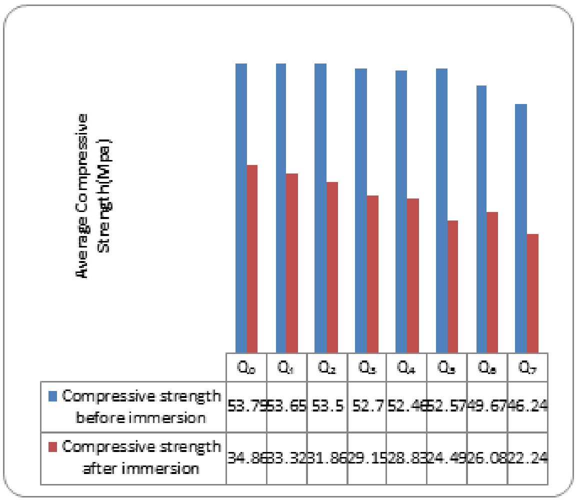

Figure 15: % of partial replacement of Quarry Dust

CONCLUSION

1. From the experiments conducted, replacement of quarry dust can be made for cement, as cement content in concrete can be optimized.
2. No change of W/C ratio was observed by replacement of cement with quarry dust, as quarry dust is a waste material; W/C ratio was compared with cement concrete.
3. At 5% replacement of cement with quarry dust no change mechanical properties of

concrete are observed in comparison with cement concrete.

4. From 10% to 25% replacement of quarry dust with cement the strength properties are increased linearly and from 30% to 35% of replacement of quarry dust, decrease in strength of concrete was observed.

Strength deterioration

1. It was observed that strength loss of specimens is high after immersion in 5% H_2SO_4 of volume of water.
2. It is found that strength loss is more for A40 grade concrete when compared with A30, A20 grades concrete, by the immesion test of concrete cubes in 5% of H_2SO_4 solution of volume of water.
3. It is noted that sulphuric acid reacts with calcium present in cement and gives paste of gypsum which reduces the concrete strength.
4. It was observed that speciAens immersed in 5% HCL of voluAe of water does not effect the strength for 7 days.

Weight loss

1. It is found that weight loss of concrete cubes is more in the immersion of 5% of H_2SO_4 in volume of water when compared with 5% of HCl in volume of water.
2. 2.In 5% of H_2SO_4 solution the weight loss for A20 grade is more when compared with A30 and A40 for 3 days and 7 days.
3. 3.It is observed that their is no effect on specimens for 3 days and 7 days when immersed in 5% HCl in volume of water.
4. 4.Their is an shall weight loss in specimens for 28 days when immersed in 5% HCl solution in volume of water.

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