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Investigation on Strength and Durability Properties of Concrete Using Quarry Dust

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ABSTRACT :

Concrete is the most widely used composite material today. The constituents of concrete are coarse aggregate, fine aggregate, binding material and water. Rapid increase in construction activities leads to acute shortage of conventional construction materials. It is conventional that sand is being used as fine aggregate in concrete. For the past two years, the escalation in cost of sand due to administrative restrictions in India, demands comparatively greater cost at around two to three times the cost for crusher waste even in places where river sand is available nearby. The function of the fine aggregate is to assist in producing workability and uniformity in the mixture. The river deposits are the most common source of fine aggregate. Now-a-days the natural river sand has become scarce and very costly. Hence we are forced to think of alternative materials. The Quarry dust may be used in the place of river sand fully or partly. A comparatively good strength is expected when sand is replaced partially or fully with or without concrete admixtures. It is proposed to study the possibility of replacing sand with locally available crusher waste without sacrificing the strength and workability of concrete. In the context of increased awareness regarding the ill effects of the over exploitation of natural resources, eco –friendly technologies are to be developed for effective management of resources. The cost effectiveness in construction will be achieved only if we are thinking from every corner of construction materials. Concrete is a composite material formed by the combination of Cement, Aggregate and Water, in particular proportion in such a way that the concrete meets the need as regards its workability.

Introduction:

CEMENT APPLICATIONS:

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

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Various treatments and additives can make cement set and harden at different rates, and various types of Portland cement also posses different properties which effect the rate of setting and hardening.

MATERIAL SELECTION

Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. 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.

Physical property of cement 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)	150 min	As per IS:4031-1968, Max:600min
Specific gravity	3.15	As per IS: 2383-(part-3)1963

The most frequently used apparatus is the Blaine, which is a standard test method. The test is carried out as perIS: 4031(II) 1999 for characterizing the fineness of cement by air permeability. The specific surface of cement is 413m^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. All the values obtained are within the limits given by IS 8112: 2007.

Chemical properties of cement

% by mass as per IS 4032-1968	Cement
Loss on Ignition	3.65
Silica as SiO2	21.5
Iron as Fe2O3	0.55
Aluminum as Al2O3	5.50
Titanium as TiO2	Nil
Calcium as CaO	63.5
Magnesium as MgO	2.15
Sodium as Na2O	0.85

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 3.4.1 gives the range of percentage passing for each zone.

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

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Zone I sand is the coarsest and Zone IV is the finest while sand in Zone II and Zone III are moderate. It is prescribed that fine totals fitting in with evaluating zone II or Zone III can be utilized as a part of fortified cement.

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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

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Design of concrete (M40)

1) Determine the target mean strength
fck'=fck+1.65(S)
= 40+1.65*5
= 48.25N/mm^2

2) Selection of water-cement ratio (W/C) = 0.4
Max water content =180kg
(Nominal max size of aggregates 20mm)

3) Cement content from W/C = 180/0.4
Cement = 450kg

4) Valve of all in aggregates

a) Percent of CA as total aggregates = 0.62

b) Change of W/C = 0.4-0.5=0.1

C) CA in all aggregates = (0.1/0.05)*0.01=0.02

d) Total all in aggregates (e') =0.62+0.02=0.64

5) Value of all fine aggregates (e') = 1-0.64=0.36

6) The mix of calculation as per unit volume

e) Volume of cement
= (mass of cement / specific gravity)*(1/1000)
= (450/3.15)*(1/1000)
= 0.143 m^3

f) Volume of water
= (mass of water / specific gravity)*(1/1000)
= (180/1)*(1/1000)
= 0.180

g) Volume of admixture = nil

h) Volume of all in aggregates = (1-0.143-0.180)
= 0.677

i) Mass of coarse aggregates
= (e'* volume of CA*sp.gravity*1000)
= (0.64*0.677*2.75*1000)
=1191.52 kg

j) Mass of fine aggregates
= (e'* volume of FA*sp.gravity*1000)

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= (0.677*0.36*2.49*1000)
= 606.86 kg

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

ANALYSIS

PRECAUTIONS

The water for curing should be tested every 7days and the temperature of water must be at 27+-2oC.

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 closet 0.2mm

(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 blocks 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 the outcomes are recorded for further examination. Examples are tried at every age to register compressive strength = P/A

Where, P: ultimate compressive heap of cement (KN)
A: Surface zone in contact with the platens (mm^2)

Compressive strength

Mix. No	W/C	% of F.A	% of Quarry Dust	7 Days Compressive Strength(Mpa)
A_2Q_0	0.44	100	0	18.33
A_2Q_1	0.44	95	5	18.45
A_2Q_2	0.44	90	10	19.47
A_2Q_3	0.44	85	15	19.98
A_2Q_4	0.44	80	20	20.62
A_2Q_5	0.44	75	25	21.33
A_2Q_6	0.44	70	30	19.76
A_2Q_7	0.44	65	35	19.01

Compressive strength

Mix. No	W/C	% of F.A	% of Quarry Dust	28 Days Compressive Strength(Mpa)
A_2Q_0	0.44	100	0	20.42
A_2Q_1	0.44	95	5	21.96
A_2Q_2	0.44	90	10	22.02
A_2Q_3	0.44	85	15	22.46
A_2Q_4	0.44	80	20	23.12
A_2Q_5	0.44	75	25	23.83
A_2Q_6	0.44	70	30	22.62
A_2Q_7	0.44	65	35	22.15

Strength deterioration factor (SDF)

The deterioration of concrete cube specimens was investigated by measuring the strength deterioration factor exprssed in percentage and it was calculated by ussing the equation [11-12]. SDF = $[f_{cw}-f_{ca}]/[f_{cw}]*100$ where, few is the avarage compressive strength of concrete cubes cured in water and f_{ca} is the average compressive strength of cubes immersed in acid solutions. the compressive strength test was carried out for each specimen in both the solutions after 7 days ,28 days ,60days ,90 days and 120 days of immersion period . in each test period , the average value specimens were tested and reported.

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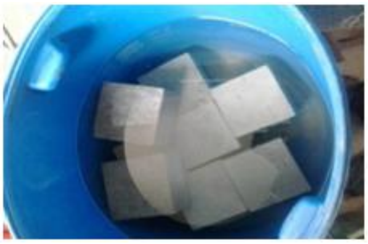
The response is 10-50 times slower than that of higher water/bond proportion concrete. It has as of now been demonstrated that low water/bond proportion cements are less delicate to carbonation influence, as opposed to higher water/concrete proportion on cement. Strength of the solid may be comprehended as its capacity to oppose weathering, scraped area, compound assault or any procedure of crumbling, if this solid is said to be sturdy it has hold its unique structure, quality and serviceability when presented to its workplaces. Out of the considerable number of variables impact the solidness of solid synthetic assault is a fascinating element which is in charge of decay of structures. When we concentrate on the synthetic activity on solid we should need to study sulfate assault, soluble base – total response, carbonation, corrosive assault and impact of ocean water.

Cubes immersed in H_2SO_4



Cubes immersed in HCL

Drying of cubes after immersion

Percentage weight loss of F.A Replacement with Quarry dust in 5% HCL

Mix.no	% of F.A	% of Quarry dust	3 Days % of weight loss	7 Days % of weight loss	28 Days % of weight loss
A_3Q_0	100	0	1.23	2.09	1.11
A_3Q_1	95	5	0.12	0.81	1.18
A_3Q_2	90	10	1.05	2.32	2.34
A_3Q_3	85	15	1.01	1.35	0.32
A_3Q_4	80	20	0.62	1.56	1.82
A_3Q_5	75	25	0.68	1.42	0.24
A_3Q_6	70	30	0.84	1.86	2.65
A_3Q_7	65	35	1.08	2.14	0.39

Percentage weight loss of F.A Replacement with Quarry dust in 5% H_2SO_4

Mix.no	% of F.A	% of Quarry dust	3 Days % of weight loss	7 Days % of weight loss	28 Days % of weight loss
A4Q0	100	0	1.98	6.61	9.97
A4Q1	95	5	1.74	6.29	11.61
A4Q2	90	10	2.01	6.86	11.23
A4Q3	85	15	2.5	9.69	12.42
A4Q4	80	20	2.12	6.86	11.46
A4Q5	75	25	1.96	5.11	12.69
A4Q6	70	30	2.22	6.86	11.69
A4Q7	65	35	2.37	7.42	11.04

RESULTS

Compressive strength of Quarry dust concrete (M20)

Mix ID	% Of NSQD (NS+QD)	Average Cube Compressive Strength(Mpa)				
		7Days	28Days	60Days	90Days	120Days
NSQ 0	100+0	18.33	20.42	23.98	23.98	29.02
NSQ 5	95+5	18.45	21.96	24.16	24.16	29.92
NSQ 10	90+10	19.47	22.02	24.96	29.13	30.16
NSQ 15	85+15	19.98	22.46	25.02	29.76	30.65
NSQ 20	80+20	20.62	23.12	25.89	30.26	31.12
NSQ 25	75+25	21.33	23.83	26.06	30.98	31.70
NSQ 30	70+30	19.76	22.62	25.98	29.87	30.67
NSQ 35	65+35	19.01	22.15	25.65	29.06	29.99

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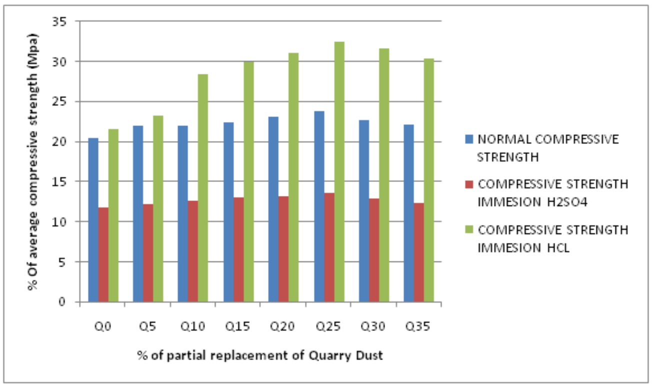
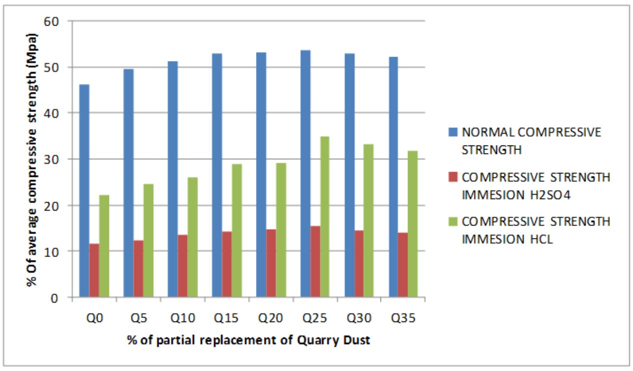


Table 7.3 Compressive Strength of Concrete before and after immersed in 5% H_2SO_4 & HCL Solution (28 days)

Mix ID	% Of NSQD (NS+QD)	Compressive Strength (Mpa) For 28 days		
		M40		
		Normal compressive strength	Immersion in H_2SO_4	Immersion in HCL
NSQ0	100+0	46.24	11.67	22.24
NSQ5	95+5	49.67	12.35	24.49
NSQ10	90+10	51.23	13.5	26.08
NSQ15	85+15	52.92	14.25	28.83
NSQ20	80+20	53.24	14.78	29.15
NSQ25	75+25	53.7	15.5	34.86
NSQ30	70+30	52.96	14.56	33.32
NSQ35	65+35	52.16	14.05	31.86



Graph Compressive Strength of Concrete (28Days) before and after immersed in H_2SO_4 & HCL Solution(M40)

CONCLUSION:

Non availability of sand at reasonable cost as finer aggregate in cement concrete for various reasons, search for alternative material stone crusher dust qualifies itself as a suitable substitute for sand at very low cost.No change of W/C ratio was observed by replacement of F.A with quarry dust, as quarry dust is a waste material; W/C ratio was compared with cement concrete. At 5% replacement of F.A with quarry dust no change mechanical properties of concrete are observed in comparison with cement concrete. From 20% to 25% replacement of quarry dust with F.A 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:

It was observed that strength loss of specimens is high after immersion in 5% H_2SO_4 of volume of water. It is found that strength loss is more for M40 grade concrete when compared with M30, M20 grades concrete, by the immesion test of concrete cubes in 5% of H_2SO_4 solution of volume of water. It is noted that sulphuric acid reacts with calcium present in cement and gives paste of gypsum which reduces the concrete strength.It was observed that speciaens immersed in 5% HCL of voluAe of water does not effect the strength for 7 days.

Weight loss:

It is found that weight loss of concrete cubes is more in the immersion of 10% of H_2SO_4 in volume of water when compared with 5% of HCL in volume of water. In 5% of H_2SO_4 solution the weight loss for M20 grade is more when compared with M30 and M40 for 7days and 28days.It is observed that their is no effect on specimens for 7 days and 28days when immersed in 5% HCL in volume of water.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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