Use of Silica Sand as Fine Material in Concrete

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Abstract— concrete made from silica sand as partial replacement of fine aggregate will be studied for workability, compressive strength, tensile strength, and modulus of elasticity. I will use silica sand as partial replacement of fine aggregate by different percentage for making concrete of grade M-20.. The percentage replacement will be 0%, 10%, 20%, 30%, 40%, 50%, 60%, & 70% with natural fine aggregate by its weight. I will prepare cubes, cylinders, beams and finally slump test, compressive strength test, splitting tensile strength test and flexural strength test will be conducted to obtain the necessary results. A large no. of trial mixes are required to select the desired optimum replacement of fine aggregate by silica sand.

Key words: modulus of elasticity, compressive strength, tensile strength

I. INTRODUCTION

Each year thousands of tons of waste materials are disposed on the valuable land which results in the occupation and degradation of valuable land. Decreasing of natural resources is a common phenomenon in developing countries like India due to rapid urbanization & industrialization involving construction of infrastructures.

Currently waste handling is big problem. Therefore, many investigations are carried out in order to utilize industrial, constructional and domestic waste for concrete mix. There are many investigations are carried out on the using of rubber of tyres, plastic waste, bottom ash, fly ash, copper slag, quarry dust, tiles waste, recycled aggregate, waste glass etc.

A. Silica Sand:

Silica sand is obtained from the raw material. After washing the raw material the silica sand is separated by sieve size 1.18 of raw material. Raw material is washed for taking out the clay material which is useful for making the tiles. In the raw material about 10% is clay which is supplied to the ceramic factories.

From the raw material different size of silica sand are separated by different size of sieve. Sand size of 30 mesh to 80 mesh (500 micron) is used in the glass industries. Sand size 1.18mm to 600 micron can be used in making concrete mix as the partial replacement of fine aggregate. Nearly about 200 tones of silica sand is obtained daily after washing the raw material. Sometimes it is used in the glass factories otherwise they dump them back into the mines.

Silica is the composition of silicon and oxygen. Silicon and oxygen are the earth's two most abundant elements. Silica is one of the earth's three most common rock forming material. Silica occurs in three main crystalline forms. It is a very durable material resistant to heat and chemical attack.

The first industrial uses of crystalline silica were probably related to metallurgical and glass making activities a few thousand years BC. It is a key raw material in the industrial revolution especially in glass, foundry and ceramic industries. Now a day's silicon is used in information technology products like plastic of computer mouse and providing the raw material for silicon chips. For industrial pure deposits of silica sand capable of yielding products of at least 95% silica are required.

B. Uses of Silica Sand:

- Glass
- Foundry casting
- Ceramics
- Filtration
- Specialist building applications
- Sports and leisure
- Sand blasting and other abrasives.
- Pigments

Fig. 1: Silica sand

C. Objective and Need of the Study:

- Partially Replacement of fine aggregate with silica sand by volume.
- To investigate the fresh and hardened properties (slump test, compressive strength, Tensile strength & Flexural strength) of concrete for M20-M30 grade of concrete mix.
- To investigate the hardened properties of concrete made with partial replacement of fine material with silica sand
- The properties of silica sand and silica sand concrete is examined and the use of silica sand in construction is tested.
- Use of waste silica sand as the fine material in concrete can reduced the demand of natural sand.

II. LITERATURE REVIEW

A. Research Paper:

1) P. Aggarwal, Y. Aggarwal, S.M.Gupta, (2007):

They had studied the effect of use bottom ash as a replacement of fine aggregate. The coarser material, which falls into furnace bottom in modern large thermal power plants and constitute about 20% of total ash content of the coal fed in the boilers. The various strength properties

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studied consist of compressive strength, flexural strength and splitting strength. The strength development for various percentages (0 to 50%) replacement of fine aggregate with bottom ash can easily be equated to the strength development of normal concrete at various ages. The bottom ash concrete gains strength at a slower rate in the initial period and acquires strength at faster rate beyond 28 days, due to pozzolanic action of bottom ash. It is observed that 'M4' which is equal to the 50% replacement of fine aggregate gives comparable flexural strength at the age of 90 days that can be used for pavement application. The rate of increases of splitting tensile strength decreases with the ages.

2) B. Ahmadi, W. Al-Khaja, (2000):

They had studied the physical and chemical properties of the paper waste sludge were studied. Concrete mixes containing various contents of the waste were prepared and basic strength characteristics, such as compressive strength, splitting; flexural, water absorption and density were determined and compared with a control mix. Five concrete mixes containing various contents of the waste, 0, 3, 5, 8 and 10% as a replacement to the fine sand were prepared with ratios of 1:3:6 by weight of cement, sand and aggregate. A maximum of 5% content of the waste as a replacement to the fine sand in concrete mix can be used successfully as construction materials, such as in concrete masonry construction with a compressive strength of 8 MPa, splitting strength of 1.3 MPa, water absorption of 11.9%, with a density of 20 KN/m^3.

3) L. Evangelista, J. De Brito, (2007):

They had studied on the use of fine recycled aggregates to partially or globally replace natural fine aggregates in the production of structural concrete. Six concrete mixes containing various contents of the fine recycled concrete 0, 10, 20, 30, 50, and 100% as a replacement to the fine sand were prepared. The results of the following tests are reported: compressive strength, split tensile strength, modulus of elasticity and abrasion resistance. From the result, it is reasonable to assume that the use of fine recycled concrete aggregates does not jeopardize the mechanical properties of concrete, for the replacement ratios up to 30%.

4) Rafat Siddique, Geert De Schutter, (2009):

They had studied on the use of used foundry sand in large volume; research is being carried out for its possible large-scale utilization in making concrete as partial replacement of fine aggregate. They evaluate the mechanical properties of concrete mixtures in which fine aggregate was partially replaced with used foundry sand. Fine aggregate was replaced with three percentages 10, 20 and 30% by weight. Compressive strength, splitting, flexural strength and modulus of elasticity were determined at 28, 56, 91 and 365 days. Increased in compressive strength varied between 8% and 19% depending upon UFS percentage and testing age, whereas it was between 6.5% and 14.5% for splitting – tensile strength, 7% and 12% for flexural strength and 5% and 12% for modulus of elasticity.

5) Her-Yung Wang, (2009):

They had studied the use of LCD glass as the Partial replacement of fine aggregate in concrete. The different mix designs were regulated by the ACI method with 0, 20, 40, 60 and 80% LCD glass sand replacements investigation: their engineering properties were determined. Test results revealed that, when compared to the design slump 15cm, the 20% glass sand concrete for the three different mix designs kept good slump and slump flow. Furthermore, a slump loss ranging from 7 to 11 cm was observed for specimens with 60% and 80% glass sand replacements were higher of 28 and 35 MPa. The test results indicate that the addition of 20% LCD glass sand to concrete satisfies the slump requirements and improves the strength and durability of concrete.

6) Farid Debieb, Said Kenai, (2008):

They had studied recycling and reuse of building rubble present interesting possibilities for economy on waste disposal sites and conservation of natural resources. Either natural sand, coarse aggregates or both were partially replaced 25, 50, 75 and 100% with crushed brick aggregates. Compressive and flexural strengths up to 90 days of age were compared with those of concrete made with natural aggregates. Porosity, water absorption, water permeability and shrinkage were also measured. The result indicates that it is possible to replace 25% of coarse aggregate and 50% of fine aggregate gives results similar to natural aggregate.

7) Khalifa S. Al-Jabri, Makoto Hisada, Salem K. Al-Oraimi, Abdullah H. Al-Saidy, (2009):

They had studied the use copper slag as a replacement of sand on the properties of high performance concrete. Eight concrete mixtures were prepared with different proportions of copper slag ranging from 0% to 100%. Concrete mixes were evaluated for workability, density, compressive strength, tensile strength, flexural strength and durability. The results indicate that there is slight increase in the (HPC) density of nearly 5% with increase of copper slag content. The workability increased rapidly with increase in copper slag percentage. Addition of 50% of copper slag as sand replacement yielding comparable strength with that of the control mix. At the 80% and 100% replacement gives 16% lower than the strength of control mix. The results also shows that water absorption decreased as copper slag quantity increased up to 40% replacement. Therefore it is recommended that 40% of copper slag can used as replacement of sand in order to obtain HPC with good durability and strength.

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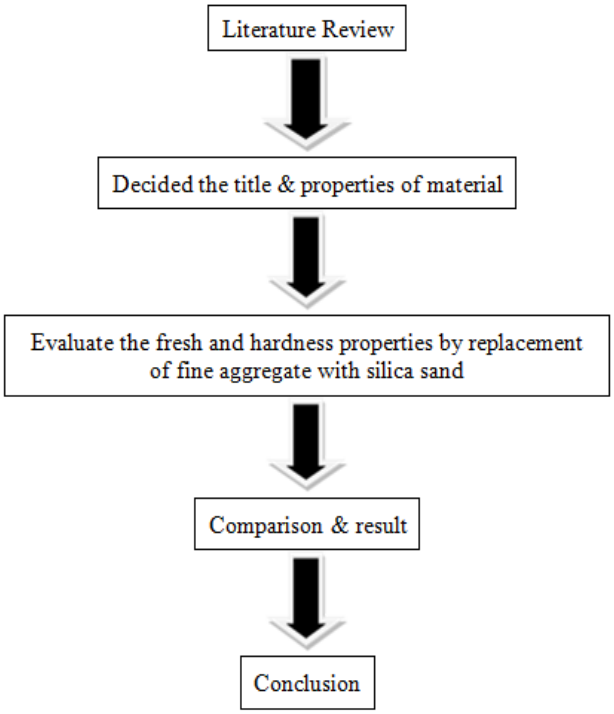
III. OVERVIEW OF METHODOLOGY

A. *Flow Chart:*



B. *Work Plan in This Semester:*

Sr. No.	Task	July	Aug.	Sept.	Oct.	Nov.	Dec.
1.	Literature review						
2.	Site visit						
3.	Decided the topic name and material						
4.	Testing of material						
5.	Pilot test (Trial mix)						

Table: Work Plan in This Semester

IV. MIX DESIGN & EXPERIMENTS

A. *Mix Design:*

1) Design Stipulations:

1) 1 Compressive strength required for 28 days = 20 Mpa
2) 2 Max size of aggregate = 20mm
3) 3 Degree of workability = 0.90 compacting factor

2) Test Data for Materials:

1) Sp. gravity of cement = 3 .15
2) Sp. gravity of fine agg. = 2.55
3) Sp. gravity of coarse agg. = 2.85
   Target strength of concrete mean strength = 20 + (1.65*4) = 26.6
4) Water cement ratio Adopt cement water ratio = 0.5

3) Water and Content:

- From table 4 of IS 10262, f or 20mm aggregate, sand conforming to grading is 186 kg sand content of total aggregate by absolute volume = 35 %
- Therefore required sand content = 33%
- Required water content = 186+5.58 = 191.6 /m3

4) Cement Content:

- Water cement ratio = 0.50
- Water = 191.6
- therefore, cement = 383kg/ m3

5) Coarse Aggregate and Fine Aggregate Contents:

As per clause 3.5.1 on pg 11, fine aggregate is obtained from the equation.

Putting the values in this equation, we have

$$V = [W + \frac{C}{S_c} + \frac{1}{P}\frac{f_a}{s_{fa}}]\frac{1}{1000}$$

$$0.98 = [191.6 + \frac{383}{3.15} + \frac{1}{0.33}\frac{f_a}{2.55}]\frac{1}{1000}$$

Fa = 561 kg/m3

Similarly

6) Coarse Aggregate:

$$Ca = (\frac{1-P}{p}) \times f_a \times \frac{S_{ca}}{S_{fa}}$$

$$= (\frac{1-0.33}{0.33}) \times 561 \times \frac{2.85}{2.55}$$

= 1273 kg/m3

- Mix proportion becomes
- Water: cement: fine aggregate: coarse aggregate
- 191.6: 383: 561: 1273
- Mix proportion 0.5: 1:1.465:3.324

B. *Experiments:*

1) Fresh Concrete:

a) Slump Test:

Fig. 2: Slump test apparatus

Slump is the most commonly used test for measuring workability of concrete at site as well as in the laboratory. The apparatus for slump test consists of a metallic mould in the form of a frustum of a cone with internal dimension as follows, Bottom dia. = 20cm, Top dia. = 10cm, Height = 30cm. Internal surface of mould is thoroughly cleaned and kept it on horizontal surface. Filled the concrete in four layer and tapper it with 16mm dia. rod. The mould is removed by lifting it slowly and carefully in a vertical direction. This

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allows the concrete is measured. This difference in height in mm is taken as slump of concrete.

2) Hardened Concrete:

a) Compressive Strength:

Compressive strength is the most common test conducted on hardened concrete. It is very easy and simple to perform and partly because many of the desirable properties of concrete are qualitatively related to its compressive strength. Compression test specimens are used: cubes, cylinder and prisms. Take required quantities of material and mixed it by hand or by machine mixing**.** Concrete should be filled in mould in three equal layers. Each layer should be compacted for 25 times with a 16mm dia. rod. After hardened the specimens are taken out and cured in clean, fresh water. Curing is done until the required days of testing. The test should be carried out immediately upon the removal of specimen from water curing and after that finding out the compressive strength by compressive machine.

Fig. 3: Compressive testing machine

b) Flexural Strength:

Fig. 4: Universal testing machine

The normal tensile stress in concrete, when cracking occurs in a flexure test is known as modulus of ruptures, i.e. flexural strength. The standard test specimen is a beam of size 150mm × 150 mm × 700mm size. The specimen should be should be cast and cured in the same manner as for casting of cubes. The specimens should be immediately tested on removal from the water. The flexural strength can be finding out by universal testing machine. The flexural strength can be found out by central loading as well as the load is applied through two similar rollers mounted at the third point of the supporting span. The flexural strength can be found out by formula as follows

$$F_{cr} = (P.L)/bd^2$$

- Where, P = Fracture load for beam
- L = Span
- b = Width of the beam
- d = Depth of the beam

c) Tensile Strength:

Tensile stress is likely to develop in concrete due to drying, shrinkage, corrosion of steel reinforcement or due to temperature gradients. The determination of flexural tensile strength is essential to estimate the load at which the concrete members may cracks. It is of a great importance while designing liquid retaining structures and prestressed concrete structures. The cylinder is placed with its axis horizontal between the platens of a testing machine, and the load is increased until failure by splitting along the vertical diameter takes place. Narrow packing of plywood strip or rubber is used to reduce the magnitude of high compressive stress immediately below load. if such strips are not provided then the observed stress will be reduced for up to 8%.

- Horizontal Tensile Stress = $\frac{2P}{\pi LD}$
- Where, P = Compressive load on the cylinder
- L = Length of cylinder
- D = Diameter of cylinder

V. TESTING OF MATERIALS

A. Cement:

Initial setting time		125 min
Final setting time		240 min
Compressive strength	3 days	32.3 N/mm^2
	7 days	41.9 N/mm^2
	28 days	59.5 N/mm^2
Soundness		1.9 mm
Fineness (90 um sieve)		1.7 %
Standard consistency		31.5 %

Table 1: Test result of cement

B. Coarse Aggregate:

Sieve size (mm)	**Weight retain (gms)**	**Cumulative weight retain (gms)**	**Cumulative percentage weight retain (%)**	**Cumulative percentage weight passing**
40	0.0	0.0	0.0	100
20	315	315	6.3	93.7
10	4475	4790	95.8	4.2
4.75	120	4910	98.2	1.8

Table 2: Sieve analysis of coarse aggregate (20mm)

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Coarse aggregate	Aggregate Impact value	12.4
	Aggregate Crusher Value	14.3
	Aggregate Abrasion Value	16.3
	Specific Gravity	2.85
	Water Absorption	0.94%
	Gradation	Falls in 20 mm size
	Combined Flakiness Index, Elongation Index	22.9 %

Table 3: Test value of coarse aggregate

C. Fine Aggregate:

Sieve size (mm)	Weight retain (gms)	Cumulative weight retain (gms)	Cumulative percentage weight retain (%)	Cumulative percentage weight passing
10	0	0	0	100
4.75	118	118	5.9	94.10
2.36	68	186	9.3	90.7
1.18	296	364	24.10	75.9
600 micron	332	694	40.70	59.3
300 micron	874	1568	84.40	15.6
150 micron	146	1714	91.70	8.3

Table 4: Sieve analysis of fine aggregate

Fine aggregate	Gradation	Fall in Zone II
	Moisture content	1.4%
	Fine modulus	2.55
	Silt content	0.78%

Table 5: Test value Result of fine aggregate

Sr no	Description	Value
1	Weight of pcynometer (W1) gms	675
2	Weight of pcynometer + soil (W2) gms	875
3	Weight of water + pcynometer + soil (W3) gms	1572
4	Weight of pcynometer + water (W4) gms	1450
5	Apparent Specific Gravity $= \frac{w2 - w1}{(w4-w1)-(w3-w2)}$	2.55

Table 6: Specific Gravity of fine aggregate

D. Silica Sand:

Sieve size (mm)	Weight retain (gms)	Cumulative weight retain (gms)	Cumulative percentage weight retain (%)	Cumulative percentage weight passing
10	0	0	0	100
4.75	2	2	0.1	99.9
2.36	14	16	0.8	99.2
1.18	146	160	8.1	91.9
600 micron	846	1002	50.4	49.6
300 micro	948	1950	97.4	2.2
150 micro	28	1978	99.2	0.8

Table 7: Sieve analysis of Silica sand

Fine aggregate	Gradation	Fall in Zone II
	Moisture content	1.36%
	Fine modulus	2.56
	Silt content	0.72%

Table 8: Test value Result of silica sand

Sr no	Description	Value
1	Weight of pcynometer (W1) gms	675
2	Weight of Water + soil (W2) gms	875
3	Weight of water + pcynometer + soil (W3) gms	1568
4	Weight of pcynometer + water (W4) gms	1445
5	Apparent Specific Gravity $= \frac{w2 - w1}{(w4-w1)-(w3-w2)}$	2.60

Table 1: Specific Gravity of silica sand

E. Chemical Test Result:

Sr. No.	Tests	Sample : Silica sand	Unit
1	SiO_2	97.03	% By Weight
2	CaO	0.36	% By Weight

Table 10: Chemical test result

VI. TRIAL MIX

A. Trial Mix Proportion:

Trial Mix No.	W/C ratio	Cement (kg/m^3)	Silica sand (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)
1.	0.5	383	0	572	1261
2.	0.5	383	286	286	1261
3.	0.5	383	572	0	1261
4.	0.45	425	0	560	1236
5.	0.45	425	280	280	1236
6.	0.45	425	560	0	1236

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B. Trial Mix Result:

Trial Mix. No.	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
1.	14.66	17.77	23.51
2.	13.03	15.55	19.33
3.	12.29	11.04	16.44
4.	13.21	15.86	21.32
5.	12.15	14.66	18.30
6.	11.63	10.22	15.55

VII. PROPOSED WORK PLAN

A. Work Plan:

Sr. No.	Task	Jan.	Feb.	Mar.	Apr.	May	June
1.	Casting, curing & testing of specimen having w/c ratio 0.5 with silica sand as partial replacement of fine aggregate						
2.	Casting, curing & testing of specimen having w/c ratio 0.45 with silica sand as partial replacement of fine						
3.	Thesis Writing						

B. Experiment Program:

1) Concrete Grade M20:

Mix No.	W/C	Silica sand	Fine aggregate	Cube	Cylinder	Beam
1.	0.5	0%	100%	9	9	9
2.	0.5	10%	90%	9	9	9
3.	0.5	20%	80%	9	9	9
4.	0.5	30%	70%	9	9	9
5.	0.5	40%	60%	9	9	9
6.	0.5	50%	50%	9	9	9
7.	0.5	60%	40%	9	9	9
8.	0.5	70%	30%	9	9	9
				Total Specimen = 216		

2) Concrete Grade M20:

Mix No.	W/C	Silica sand	Fine aggregate	Cube	Cylinder	Beam
1.	0.45	0%	100%	9	9	9
2.	0.45	10%	90%	9	9	9
3.	0.45	20%	80%	9	9	9
4.	0.45	30%	70%	9	9	9
5.	0.45	40%	60%	9	9	9
6.	0.45	50%	50%	9	9	9
7.	0.45	60%	40%	9	9	9
8.	0.45	70%	30%	9	9	9
				Total Specimen = 216		

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