



**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH
TECHNOLOGY**

**STRENGTH PROPERTIES OF CALCINED KAOLIN AND SILICA FUME AS
PARTIAL REPLACEMENT OF CEMENT**

Anil Kumar Chakrawarti*, Prof. Anubhav Rai

* Gyan Ganga Institute of Technology & Science Jabalpur (M P)
Assistant Professor , Gyan Ganga Institute of Technology & Science Jabalpur (M P)

ABSTRACT

Silica fume (SF) is a byproduct of the smelting process in the silicon and ferrosilicon industry. The reduction of high-purity quartz to silicon at temperatures up to 2,000°C produces SiO₂ vapors, which oxidizes and condense in the low temperature zone to tiny particles consisting of non-crystalline silica. By-products of the production of silicon metal and the ferrosilicon alloys having silicon contents of 75% or more contain 85–95% non-crystalline silica. The by-product of the production of ferrosilicon alloy having 50% silicon has much lower silica content and is less pozzolanic. Therefore, SiO₂ content of the silica fume is related to the type of alloy being produced. Silica fume is also known as micro silica, condensed silica fume, volatilized silica or silica dust. The American concrete institute (ACI) defines silica fume as a “very fine noncrystalline silica produced in electric arc furnaces as a byproduct of production of elemental silicon or alloys containing silicon”. It is usually a grey colored powder, somewhat similar to Portland cement or some fly ashes. It can exhibit both pozzolanic and cementitious properties.

KEYWORDS: calcined kaolin, silica fume, cement.

INTRODUCTION

Silica fume has been recognized as a pozzolanic admixture that is effective in enhancing the mechanical properties to a great extent. By using silica fume along with super plasticizers, it is relatively easier to obtain compressive strengths of order of 100–150 MPa in laboratory. Addition of silica fume to concrete improves the durability of concrete through reduction in the permeability, refined pore structure, leading to a reduction in the diffusion of harmful ions, reduces calcium hydroxide content which results in a higher resistance to sulfate attack.

Improvement in durability will also improve the ability of silica fume concrete in protecting the embedded steel from corrosion.

AVAILABILITY AND HANDLING

Silica fume is available in two conditions: dry and wet. Dry silica can be provided as produced or densified with or without dry admixtures and can be stored in silos and hoppers. Silica Fume slurry with low or high dosages of chemical admixtures are available. Slurried products are stored in tanks.

APPLICATIONS OF SILICA FUME

High Performance Concrete (HPC) containing silica fume for highway bridges, parking decks, marine structures and bridge deck overlays which are subjected to constant deterioration caused by rebar corrosion current, abrasion and chemical attack. Silica fume will protect concrete against deicing salts, seawater, road traffic and freeze/thaw cycles. Rebar corrosion activity and concrete deterioration are virtually eliminated, which minimizes maintenance expense.

- High-strength concrete enhanced with silica fume provides architects and engineers with greater design flexibility. Traditionally used in high-rise buildings for the benefit of smaller columns (increasing the usable space) high strength concrete containing silica fume is often used in precast and prestressed girders allowing longer spans in structural bridge designs. Silica-fume Shotcrete delivers greater economy, greater time savings and more efficient use of sprayed concrete. Silica fume produces superior shotcrete for use in rock stabilization; mine tunnel linings, and rehabilitation of deteriorating bridge and marine columns and piles. Greater bonding

strength assures outstanding performance of both wet and dry process shotcreting with less rebound loss and thicker applications with each pass of the shotcrete nozzle.

- Oil Well Grouting whether used for primary (placement of grout as a hydraulic seal in the well-bore) or secondary applications (remedial operations including leak repairs, splits, closing of depleted zones); the addition of silica fume enables a well to achieve full production potential. Besides producing a blocking effect in the oil well grout that prevents gas migration, it provides these advantages such as
 - i. Improved flow, for easier, more effective application;
 - ii. Dramatically decrease permeability, for better control of gas leakage;
 - iii. Light weight
- Silica fume is used in a variety of cementations repair products. Mortars or grouts modified with silica fume can be tailored to perform in many different applications overhead and vertical mortars benefit from silica fume's ability to increase surface adhesion. Silica fume significantly improves cohesiveness making it ideal for use in underwater grouts, decreases permeability in grouts used for post-tensioning applications and increases the resistance to aggressive chemicals.

VARIOUS STAGE OF PROCESS



Figure. 1. Mixture of cement



Figure. 2. Taking the weight of mixture of cement



Figure. 3. Frame of blocks



Figure. 4. Testing machine of blocks

CALCULATION

**FIRST TRIAL
 MIX DESIGN
 AS PER IS 10262 :2009**

Step

1 Design stipulation

1	Grade of concrete	fck	:-	40	n/sqmm
2	Type of cement		:-	43	grade OPC
3	Maximum nominal size		:-	20	mm
4	Minimum cement content		:-		
5	Maximum water cement ratio		:-	0.45	
6	Workability		:-		
7	Exposure condition		:-	Moderate	
8	Degree of supervision		:-	Good	
9	Type of aggregate		:-	Crushed angular aggregate	
10	Maximum cement content		:-		
11	Chemical admixture		:-	Not used	

Step

2 Test data for Material

1	Cement used		43	grade OPC
2	Specific gravity of cement		3.15	
3	Specific gravity of aggregate			
a	Coarse aggregate		2.81	20 mm
b	Fine aggregate		2.65	
4	Water absorption			
a	Coarse aggregate		0.7	%
b	Fine aggregate		0.9	%
5	Sieve analysis			
a	Coarse aggregate		Confirming ti table -2 of IS 383-1970	
b	Fine aggregate		Confirming ti zone -II of IS 383-1970	

Step 3 Target strenth for mix proportioning (ft)

$$f_t = f_{ck} + K_s$$

$$k = 1.65$$

s = 5
ft = 48.25

Where

k = Tolerance factor

= 1.65 (From table no. 39 of IS 383 - 1970)

s = Standard deviation

For M 30

S = 5 (From IS 10262 -2009 table no. 1 page 2

Step

4 Selection of water cement ratio

From table (5) p/20 of IS 456 : 2000 max. water cement ratio

For M30 grade of concrete 0.45 Max.

so adopting W/C 0.45

Step

5 Selection of water cement

From table 2 of IS 10262- 2009 max. water cement ratio

(for 20 mm aggregate) = 186 kg

Where take slump 25 to 50 mm

Step

6 Calculation of cement content

Water cement ratio 0.45

Water content 186 kg

Cement content 413.3333 kg/ cum >320 kg/ cum

From table 5 of IS 456-2000 min. cement content for moderate exposure condition = 320 kg/ cum hence OK

Step

7 Proportion of volume of coarse aggregate and fine aggregate content

From table 3 of IS 10262: 2009 volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (zone II)

For water cement ratio = 0.45 is 0.63

0.62+ 0.01

0.63 (From table 3 IS code 10262: 2009)

Step 8

Mix calculation

The mix calculation per unit volume of concrete shall be as follows

- 1 Volume of concrete = 1 cum
- 2 Volume of concrete = $\frac{\text{mass of cement}}{\text{sp. Gravity of cement}} \times 0.001$

- Volume of concrete = $\frac{413.3333}{3.15} \times 0.001$
- Volume of concrete = 0.131217 cum

- 3 Volume of water = $\frac{\text{Mass of water}}{\text{sp. Gravity of water}} \times 0.001$

- Volume of water = $\frac{186}{1} \times 0.001$
- Volume of water = 0.186 cum

- 4 Volume of all in aggregate = 0.682783 cum

- 5 Volume & wt. of coarse agg. = (0.71x vol.of coarse agg. X sp. Gravity of coarse agg.)x 100

- Volume & wt. of coarse agg. = 1208.731 Kg

- Volume of fine agg. = 1-0.63
 0.37 (As per IS code 10262: 2009 p/6)

- 6 Volume of fine aggregate = (.71x Vol. of fine agg.x sp. Gravity of fine agg.)x1000
- Volume of fine aggregate = 669.4688

- 7 Mix proportion for trial numbers
 - a Cement = 413.3333 kg
 - b Sand= 669.4688 kg
 - c Agg. =

20 mm	725.2385
10 mm	<u>483.4923</u>
Total	1208.731

d	Water =	186	kg			
		Cement		Sand		Aggregate
	Ratio	1	:	1.619683	:	2.924349
						Total
						5.544031

**SECOND TRIAL
 MIX DESIGN
 AS PER IS 10262 :2009**

Step

1 Design stipulation

1	Grade of concrete	fck	:-	30	n/sqmm
2	Type of cement		:-	43	grade OPC
3	Maximum nominal size		:-	20	mm
4	Minimum cement content		:-		
5	Maximum water cement ratio		:-	0.45	
6	Workability		:-		
7	Exposure condition		:-	Moderate	
8	Degree of supervision		:-	Good	
9	Type of aggregate		:-	Crushed angular aggregate	
10	Maximum cement content		:-		
11	Chemical admixture		:-	Not used	

Step

2 Test data for Material

1	Cement used		43	grade OPC
2	Specific gravity of cement		3.15	
3	Specific gravity of aggregate			
a	Coarse aggregate		2.81	20 mm
b	Fine aggregate		2.65	
4	Water absorption			
a	Coarse aggregate		0.7	%
b	Fine aggregate		0.9	%
5	Sieve analysis			
a	Coarse aggregate		Confirming ti table -2 of IS 383-1970	

b Fine aggregate Confirming ti zone -II of IS 383-1970

Step 3 Target strength for mix proportioning (ft)

$$\begin{aligned} f_t &= f_{ck} + K_s \\ k &= 1.65 \\ s &= 5 \\ f_t &= 38.25 \end{aligned}$$

Where
k = Tolerance factor
= 1.65 (From table no. 39 of IS 383 - 1970)
s = Standard deviation
For M 30
S = 5 (From IS 10262 -2009 table no. 1 page 2

Step 4 Selection of water cement ratio

From table (5) p/20 of IS 456 : 2000 max. water cement ratio
For M30 grade of concrete 0.45 Max.
so adopting W/C 0.45

Step 5 Selection of water cement

From table 2 of IS 10262- 2009 max. water cement ratio
(for 20 mm aggregate) = 186 kg

Where take slump 25 to 50 mm

Step 6 Calculation of cement content

Water cement ratio	0.45		
Water content	172	kg	
Cement content	382.2222	kg/ cum	>320 kg/ cum

From table 5 of IS 456-2000 min. cement content for moderate exposure condition = 320 kg/ cum hence OK

Step 7 Proportion of volume of coarse aggregate and fine aggregate content

From table 3 of IS 10262: 2009 volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (zone II)

For water cement ratio = 0.45 is 0.63

$$0.62 + 0.01$$

$$0.63 \quad (\text{From table 3 IS code 10262: 2009})$$

Step 8

Mix calculation

The mix calculation per unit volume of concrete shall be as follows

- 1 Volume of concrete = 1 cum
- 2 Volume of concrete = $\frac{\text{mass of cement}}{\text{sp. Gravity of cement}} \times 0.001$

- Volume of concrete = $\frac{382.2222}{3.15} \times 0.001$
- Volume of concrete = 0.12134 cum

- 3 Volume of water = $\frac{\text{Mass of water}}{\text{sp. Gravity of water}} \times 0.001$

- Volume of water = $\frac{172}{1} \times 0.001$
- Volume of water = 0.172 cum

- 4 Volume of all in aggregate = 0.70666 cum

- 5 Volume & wt. of coarse agg. = (0.71x vol.of coarse agg. X sp. Gravity of coarse agg.)x 100

- Volume & wt. of coarse agg. = 1251 Kg

- Volume of fine agg. = 1-0.63
- 0.37 (As per IS code 10262: 2009 p/6)

- 6 Volume of fine aggregate = (.71x Vol. of fine agg.x sp. Gravity of fine agg.)x1000
- Volume of fine aggregate = 692.8797

- 7 Mix proportion for trial numbers

- a Cement = 382.2222 kg

b	Sand=	692.8797	kg
c	Agg. =		
	20 mm	750.5997	
	10 mm	<u>500.3998</u>	
	Total	1251	

d	Water =	172	kg
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	Cement		Sand		Aggregate	Total
Ratio	1	:	1.812767	:	3.2729638	6.085731

CONCLUSION

From the results obtained on the various type trial under study, it is evident that silica-fume concrete exposed for 5-6 years to severe environmental conditions behaved as satisfactorily as the corresponding concrete without silica fume. It appears, however, that silica-fume concrete seems to suffer somewhat more from field placing and curing conditions than nonsilica-fume concretes. We find out the Total weight 5.544031 Kg in one mix during first trial of mix design and Total weight 6.085731 Kg in one mix during second trial of mix design.

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