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A STUDY ON COMPRESSIVE STRENGTH OF M-20 GRADE CONCRETE USING SILICA FUME AS PARTIAL REPLACEMENT FOR CEMENT

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Abstract
The capacity to regularly and commercially make silica fume modified concrete that is flowable in nature but still cohesive, which results in high early and later age strength including resistance to harsh conditions, had a significant impact on industries. This investigation explores the characteristics of silica fume and how they affect the characteristics of recently-poured concrete. The strength properties of concrete have been examined when cement has been partially replaced by silica fume. Prior to studying the strength parameters of concrete with silica fume partial replacement, the compression testing machine (CTM) was used to study the strength parameters of concrete without any partial replacement.

For both the cube and the cylinder, silica fume was utilised to replace 0% to 15% of the cement, by weight, at intervals of 5%. The results demonstrated that the compressive strength of the cube and split tensile strength of the cylinder were significantly affected by the partial replacement of cement with silica fume. Concrete gains strength quickly when its silica fume level is raised, and at 10% replacement, it reaches its maximum compressive strength. Like the split tensile strength, which grows up to 10% before beginning to decline under uniform load conditions of 2 KN, it starts to decline after 10% under conditions of 4 KN.

Keywords: Compression Testing Machine, Compressive Strength, Silica Fume, Cohesive Strength.

I. Introduction

The use of cementitious materials in concrete has received considerable attention in recent years due to their ability to improve the strength and durability properties of concrete. Silica fume, a highly reactive pozzolanic material, has shown promising results when partially replacing cement in concrete mixes. This study aims to study the effect of silica fume as a partial replacement of cement on the compressive strength of concrete grade M-20. The research method involves the preparation of concrete mixes of grade M-20 with different percentages of silica fume as a partial replacement for cement. The control mix consists of ordinary Portland cement with no substitutes.

Silica fume is added in different proportions, from 5% to 20% by weight of cement. Concrete samples were poured and cured under standard laboratory conditions. The compressive strength of concrete samples was determined at different ages such as 7 days, 28 days and 56 days using standard compression test methods. The results were analyzed to evaluate the influence of silica smoke on the development of compressive strength of concrete. The results of this study will provide insight into the potential benefits of incorporating silica fume as a partial replacement of cement in M-20 grade concrete. The research results will contribute to the understanding of the optimal dosage of silica fume and its influence on the compressive strength properties of concrete. This knowledge can be invaluable in designing and manufacturing concrete with improved strength and durability properties, leading to cost-effective and sustainable construction methods.

Concrete is a widely used building material recognized for its strength and durability. Incorporation of additional binding materials, such as silica fume, has attracted attention in the construction industry to improve the properties of concrete. Silicon fume is a by-product of silicon iron and silicon alloy production and has highly reactive puzzolanic properties. This study focuses on investigating the effect of using silica fume to partially replace cement on the compressive strength of concrete grade M-20. It is expected that the addition of silica fume to partially replace cement in grade M-20 concrete will have a positive effect on the compressive strength of concrete.

The results of the study will provide information on the optimal dosage of silica fume and its effect on compressive strength at different curing ages. This information can be valuable in optimizing concrete mix design, reducing cement consumption, and promoting sustainable building practices. The results of the study will contribute to the body of knowledge regarding the use of silica fume in concrete technology and its potential to improve the performance of concrete structures. Silica vapor refers to the gaseous form of silicon dioxide (SiO2), commonly known as silica. Silica is a chemical compound composed of silicon and oxygen atoms. The main chemical characteristics of silica vapor are as follows:

- Chemical Formula: The chemical formula of silica vapor is SiO2, indicating that it consists of one silicon atom bonded to two oxygen atoms.
- Molecular Structure: Silica vapor is composed of individual SiO4 tetrahedral units. Each tetrahedron consists of one silicon atom at the center, surrounded by four oxygen atoms.
- High Melting and Boiling Points: Silica has a high melting point (around 1,600°C or 2,912°F) and a high boiling point (approximately 2,230°C or 4,046°F). As a result, it typically exists as a solid or liquid at normal temperatures and pressures, rather than a gas.
- Volatility: Silica vaporizes at very high temperatures, such as those found in specialized industrial processes or extreme natural environments like volcanic eruptions. It forms as a gas when silica-containing materials are heated to temperatures above its boiling point.

- Reactivity: Silica vapor is relatively chemically inert under normal conditions. However, it can react with certain chemicals, such as alkalis or strong acids, to form various compounds.
- Density: Silica vapor is less dense than its solid or liquid forms. As a gas, it is lighter than air.
- Refractive Index: Silica vapor has a refractive index higher than that of air. This property is utilized in various applications, such as optical fibers and lenses.

Table 1 shows the physical properties of the Silica Fume with specific gravity. The main characteristics of silica fume include the examination of each of these attributes follows. Notably, the standard standards for silica fume include the key physical characteristics that were previously described.

- Particle size. Over 95% of the particles in silica fume are less than 1 m (one micrometre), which is an incredibly small size. Silica fume is concrete as per the chemical and physical properties and its particle size is crucial. Figure 2.1 displays a picture of silica fume and portland cement granules.
- Bulk density. It's just another way of saying unit weight. The metal produced in the furnace and how the furnace is operated both affect the bulk density of the smoke produced. Transporting silica fume over large distances is not particularly cost-effective because its bulk density is usually relatively low. For a description of the different forms of silica fume products, see Chapter 5.
- Specific gravity. Specific gravity is a measurement that compares the density of a substance to the density of a reference substance, usually water. It is a dimensionless quantity and provides an indication of how much denser or lighter a substance is compared to water. The specific gravity of a material is determined by dividing its density by the density of water at a specific temperature.
- Specific surface. Specific surface, also known as surface area, refers to the total area of the surface of a material per unit mass or unit volume. It represents the measure of the external surface exposed by a given quantity of material. Specific surface is typically expressed in units of square meters per kilogram (m^2/kg) or square meters per cubic meter (m^2/m^3). Specific surface area can be measured using various techniques, such as the Brunauer-Emmett-Teller (BET) method, gas adsorption techniques (e.g., nitrogen adsorption), or mercury intrusion porosimetry. These methods involve determining the adsorption or intrusion of gases or liquids onto the material surface and calculating the corresponding surface area.

Table- 1 PHYSICAL PROPERTIES OF SILICA FUME	
Particle size (typical):	**< 1 µm**
Bulk density: (as-produced): (densified):	**130 to 430 kg/m^3 480 to 720 kg/m^3**
Specific gravity:	**2.2**
Specific surface:	**15,000 to 30,000 m^2/kg**

The major objectives of the current research are as follows:

- The main objective of this work is to increase strength properties and durability of concrete by reducing cement by using silica fume.
- To analyses the maximum uses of silica fume in place of cement in a concrete.

II. Literature Review

Literature review has been presented in different forms of paper and thesis briefly. Hence, the efforts have been made to relate the following literature to the topics, to an extent possible. The current study seeks to investigate the impact of silica fume on concrete by partially substituting cement with silica fume at levels of 0%, 10%, 20%, 30%, and 40%. The impact of silica fume on various properties of concrete at various ages and for various grades of concrete has already been the subject of numerous research projects. This document reviews some research studies and presents them.

A by-product of industry, silica fume is silica that has been finely separated. It is incorporated into the concrete mix as an additive, and the qualities of the finished product are significantly changed as a result. In order to boost intensity and durability, silica fume can simultaneously be used in the creation of porcelain and refectories. It can also improve the material's overall performance when used as a filler for covering high molecular weight materials like resin, paint, rubber, and others.

For silica fume concrete with water-to-cementitious material (w/cm) ratios ranging from 0.3 to 0.42 and silica fume replacement percentages ranging from 5 to 30, a mathematical model was created using statistical approaches (Bhanja and Sengupta, 2002). For statistical modelling, the strength findings of 26 concrete mixes on more than 300 test specimens have been examined. The amount of silica fume substitution has been linked to the compressive strength ratios between silica fume and control concrete. Because the equation is developed using strength ratios rather than absolute strength numbers, it can be used with any type of specimen and is not dependent on the specimen's properties. When comparing the model's predictions to those of earlier studies, it was found that they were accurate to within 7.5% of the empirically determined values for both cube and cylinder findings. An experimental investigation on self-compacting concrete (SCC) with two cement contents is presented by (Heba A. Mohamed, 2011).

Three different types of mixes are used in the work: the first one utilises silica fume in varying percentages (FA), the second one uses silica fume in varying percentages (SF), and the third one employs a combination of FA and SF. Nine-cylinder examples are cast and cured following the preparation of each mix. Three specimens undergo a 28-day water curing process, three undergo a 7-day water curing process, and three undergo a 28-day air curing process. The slump and V-funnel tests are carried out on freshly poured SCC, and the concrete's compressive strength values are computed. The results show that SCC with 15% of SF yields compressive strength values that are higher than those with 30% of FA, and that the specimens with the highest values were those that were water cured for 28 days. (2011) Abdullah et al. Silica fume is a highly reactive pozzolana that is used in concrete because it has small particles, a large surface area, and a high SiO2 content.

(Pawade.P et. al. 2011) concluded regarding the effect of silica fume on Portland Pozzolona cement with and without steel fibres. In this study, concrete mixes with 0%, 4%, 8% and 12% silicon fume content were supplemented with bent steel fibers with two diameters of 0.5 mm and 1.0 mm and the best aspect ratio. consistency is 60 at different percentages as low as 0%, 0.5% and up to 1.5% by weight of concrete for concrete grade M30. To determine the effect of mineral admixture as a substitute for cement with and without steel fiber on mechanical quality, a comparison between conventional concrete and silica fume concrete was performed. 28 days after curing, the compressive strength of the control concrete increased by 7.46%, 11.17%, 11.91% and 9.83% respectively at 4%, 8%, 12% and 16% respectively. cement is replaced by silica. Smoke. Optimum combination of 1.5% steel fiber and 8% silica fume in conventional concrete. The greatest increase in compressive strength for 0.5 mm and 1.0 mm steel fibers was 15.38% and 18.69%, respectively, after 28 days of curing. Bending strength increased to a maximum of 17.13% and 24.02%. The combined effects of silica fume at 4% and 12% and steel fibers at 0.5%, 1.0% and 1.5% of both 0.5 mm and 1.0 mm diameters are shown in Fig. different hardness.

(Dilip Roy and Amitava Sil, 2012) investigated the properties of SF and its effect on both freshly poured and hardened concrete. In this work, an attempt was made to test the strength properties of concrete in which part of the cement was replaced by SF. Not many, if any, jobs use silica fume in place of cement. Furthermore, no attempt has been made to replace cement with silica fume in low and medium quality concrete (M20, M25). For different combinations of compositional mixtures, the properties of hardened concrete, such as ultimate compressive strength, flexural strength, and tensile strength, have been established. These values are then compared with those of conventional concrete. The purpose of the ongoing survey is to educate practicing civil engineers about the benefits of these innovative concrete mixes.

Theo (Debabrata Pradhan et. al, 2013), the addition of silica fume to conventional concrete leads to complex mix measurement and extensive design parameters. In this article, we will look at the compressive strength, coefficient of compression and slump of concrete with silica fume added. In this study, 5 (five) concrete mixes containing silica fume were poured for testing. Different amounts of silica fume were used in place of cement to conduct these experiments with a single fixed ratio of water to cementitious material while keeping other design parameters of the mixture constant. The compressive strength of all mixtures at the age of 24 h, 7 d, and 28 d was determined using 100- and 150-mm blocks. The levels of cement replacement with silica fume with a constant water/cement material ratio (w/cm) of 0.50 are 0%, 5%, 10%, 15% and 20%. For the five different types of concrete mixes, other properties such as compressibility and slump are also evaluated in addition to compressive strength. According to T. Shanmugapriya and Dr. R.N. Finding Uma (2013). The byproduct of the metallurgical process used to make silicon and silicon iron is silicon smoke (SF). The water binder ratio (W/B) was chosen to be 0.32 and the superplasticizer used was CONPLAST SP 430. Molded specimens such as blocks, beams and cylinders were tested at 7, 14 and 28 days of age. by different mixing ratios.

Research shows that silica fume can partially replace cement in construction projects to produce sufficient compressive strength, flexural strength and tensile strength for construction works.

Silica fume (SF), chemically polycarboxylate and plynaphthalene, was added to self-consolidating concrete (SCC) with 15% cement, two different Portland cement (PC) and two superplasticizers. different. Aggregates used are sand (SC, SF), coarse and fine (AG 3/8 mm, AG 8/15 mm), The dosage of each superplasticizer is determined after testing on each composition of self-compacting concrete. Recent concrete test results, including stratification resistance and L-box strength, agree with the results described by the French civil engineering organization. In addition, the results of the compressive strength and separation test procedures are used to describe the mechanical properties.

III. Proposed Methodology

A total of 36 square blocks of 150 mm x 150 mm were produced to conduct the experimental survey. To test the compressive strength of conventional concrete without fly ash, 6 cubes were cast. To test the compressive strength respectively for 10%, 20% and 30% silica fume cement replacement, each set of 6 blocks was cast in the same way. Three of these six cubes are used to calculate the compressive strength of concrete after 7 days of curing and the remaining three cubes are used to calculate the compressive strength of concrete after 28 days. The total compressive load acting on concrete at different ages is calculated using a compression testing machine with a capacity of 2000 Kn. The compressive strength of concrete is obtained by dividing the maximum load by the cross section of the cube (150 mm x 150 mm). The following list includes laboratory tests that have been performed on the physical properties of cement, fine aggregates, coarse aggregates, silica fume, and water used in the design of concrete mixes M20 mark. The cement used was OPC 43. Cement possessed all the characteristics specified in IS269:1976. The table 2 lists the physical characteristics of the cement that was used.

Table-2.: Portland cement physical properties

Properties	Test Values
Specific Gravity	3.05
Consistency (%)	31%
Initial Setting Time	150 min.
Final Setting Time	240 min.

The detailed test observation is shown below.

3.1 CONSISTENCY TEST

Table- 3.: Consistency Test

Water added	Penetration
29%	12 mm
30%	9 mm
31%	6 mm

A. INITIAL AND FINAL SETTING TIME

Water=300 x 0.85 x 31% = 79.05

Cement= 300 gm

Table-4.: Initial and Final setting time

Time	Penetration (mm)
09:30 am	0
10:00 am	1
10:30 am	2
11:00 am	3
11:30 am	3
12:00 pm	5
01:30 pm	Final Setting Time

Initial Setting Time = 150 min.

Final Setting Time = 240 min.

B. COMPRESSIVE STRENGTH TEST

Ratio = 1:1:1:1 Cement = 200 gm.

Sand Grade 1 = 200 gm.

Sand Grade 2 = 200 gm.

Sand Grade 3 = 200 gm.

Water required = (P/4 + 3) x 8 = 86 gm.

Table-5.: Compressive Strength test observation

Date of Casting	Date of Testing	No. of Cube	Cube Age	Load in KN.	Compressive Strength	Average Compressive Strength
18/02/2019	21/02/2019	1	3 Days	180	36.12	36.79
		2		190	38.12	
		3		180	36.12	
18/02/2019	25/02/2019	4	7 Days	200	40.13	41.46
		5		210	42.13	
		6		210	42.13	
18/02/2019	18/03/2019	7	28 Days	240	48.15	49.49
		8		250	50.16	
		9		250	50.16	

C. Fine Aggregate

Sand that passed through a 4.75mm IS filter size and was readily accessible locally was employed as fine aggregate. The table below lists the physical characteristics of the fine aggregates:

Table-6.: Fine Aggregates Physical Property

Properties	Test Values
Specific gravity	2.06
Water Absorption	0.5%
Fineness Module	2.5

Table-7.: Sieve Analysis of Fine aggregate (Total weight of the sample = 2000 gms.)

IS Sieve Size (mm)	Wt. Retained (gm)	Cumulative wt. Retained (gm)	Cumulative % Retained	% Passing	Permissible limit as per IS 383
10.00	0	0	0	100	100
4.75	96	96	4.80	95.20	90-100
2.36	380	476	23.8	76.20	75-100
1.18	360	836	41.80	58.20	55-90
600 micron	372	1208	60.40	39.60	35-59
300 micron	406	1614	80.70	19.30	8-30
150 micron	290	1904	95.20	4.80	0-10
PAN	96				

D. Coarse Aggregate

According to Indian standards, coarse aggregates with nominal maximum aggregate sizes of 20 mm (60%) and 10 mm (40%) were employed. The table below lists the physical characteristics of coarse aggregates.

Table-8.: Coarse Aggregate Physical Properties.

Properties	CA-20	CA-10
Type	Crushed	Crushed
Specific Gravity	2.80	2.85
Water Absorption	0.50%	0.50%

Table-9.: Sieve Analysis of 20 mm aggregate (Total weight of the sample = 5000 gms.)

IS Sieve Size (mm)	Wt. Retained (gm)	Cumulative wt. Retained (gm)	Cumulative % Retained	% Passing	Permissible limit as per IS 383
40	0	0	0	100	100%
20	734	734	14.68	85.32	85-100%
10	3746	4480	89.60	10.40	0-20%
4.75	398	4878	97.56	2.44	0-5%
PAN	122				

Table-10.: Sieve Analysis of 10 mm aggregate (Total weight of the sample = 5000 gms.)

IS Sieve Size (mm)	Wt. Retained (gm)	Cumulative wt. Retained (gm)	Cumulative % Retained	% Passing	Permissible limit as per IS 383
20	0	0	0	0	100

10	200	200	4.00	96.00	85-100
4.75	180	380	7.60	92.40	0-100
2.36	4570	4950	99.00	1.00	0-5
PAN	50				

E. Water

The Silica fume used with Specific Gravity of 2.10. The water used for experiment was potable water.

3.2 METHODS

A. CALCULATION OF FINAL PROPORTION OF M20 MIX CONCRETE

STEP 1: Targeted strength

Target mean strength = Characteristic strength + 1.65 x Standard deviation F'ck = Fck x S

= 20 + 1.65 X 4

= 26.6 N/mm2

STEP 2: Selection of Water Cement Ratio as per IS 456:2000

Maximum water cement ratio is 0.50. We take it 0.48 < 0.50 Hence OK.

STEP 3: Selection of Water content from table 2 of IS 10262:2009

Maximum water content = 186 kg (for nominal maximum size of aggregate -20mm) & (for Slump 25-50mm)

To achieve Slump value of 75mm 191.5 liter of water is necessary. (If slump value is more than 50mm then for every 25mm slump water is increased by 3% i.e., 3/100 x 186 = 191.5 liters)

There is no chemical admixture hence no change in water content so 191.5 liter is OK

STEP 4:

Cement content = water content / water cement ratio

= 191.5/0.48

= 398.96 kg

From table 5, IS 456:2000

Minimum cement content = 300 kg as per clause 8.2.4.2 of IS 456:2000

Maximum cement content = 450 kg/m3

300< 398.96 < 450, Hence OK

STEP 5:

Estimation of coarse aggregate proportion from table 3 of IS 10262:2009

For Nominal maximum size of aggregate = 20mm

Zone of fine aggregate = ZONE II

Volume of coarse aggregate / unit volume of total aggregate = 0.62

Volume of fine aggregate = 1-0.62 = 0.38

STEP 6: Mix calculation
Volume of concrete = 1 m3
Volume of cement = (Mass of cement / specific gravity) x 1/1000 = 0.131 m3
Volume of water = (Mass of water / specific gravity of water) x 1/1000 = 0.192m3
Volume of total aggregate = a-(b+c) = 0.677 m3
Mass of Coarse aggregate = d x vol. of C.A. x specific gravity of C.A. x 1000
= 0.677 x 0.62 x 2.8 x 1000 = 1175.27 kg/m3
Mass of Fine aggregate = d x vol. of F.A. x specific gravity of F.A. x 1000
= 0.677 x 0.380 x 2.06 x 1000 = 530 kg/m3

STEP 7: Quantities of material
Cement = 398.96 kg / m3
Fine aggregate = 530 kg/ m3
Coarse aggregate = 1175.27 kg / m3
Water = 191.5 kg/ m3

STEP 8: Quantity of 1 cube Cement = 0.003375 x 398.96 = 10.8 kg
Therefore for 8 cubes, 1.168 x 8 = 9.344
Similarly, others can be calculated in the same manner
Water = 0.646 x 8 = 5.168 kg
Sand = 1.79 x 8 = 14.32 kg
C.A. = 3.97 x 8 = 31.73 kg
After preparing the concrete the most important property or characteristic of the concrete is observed which is called Workability.

IV. Concrete Test

A. Slump Test for Concrete

The test should be redone if shear slump or collapse slump happens. From the one genuine slump, we can determine the outcome. In accordance with the slump value, we can group the outcome into a few categories.

1. Extremely poor workability: slump value of 0 to 25 mm or 0 to 1 inch
2. Low workability: slump value of 25 to 50 mm, or 1 to 2 inches.
3. Medium workability: 50-100mm or 2-4 inch slump value
4. High workability: 100-175mm or 4-7 inch slump value

According to P. Bartos' 'Fresh Concrete', slump results fall into the following categories:

1. Slump value of 0 mm or inch indicates no slump
2. Extremely Low: sump value of 5–10 mm (0.25-0.50 inches).

3. Minimal: sump value of 15–30 mm (0.75–1.25").
4. Medium: sump value of 1.5–3 inches or 35–75 millimetres.
5. High: sump value of 80–155 millimetres (3.25–6 inches).
6. Extremely High: collapse caused by sump vaue180 mm or 6.25 inch

Although there are other ways to classify workability, the general guideline is that a low slump value suggests a low level of workability and a high sump value indicates a high level of workability.

B. VEE-BEE CONSISTOMETER TEST

The Vee-Bee Consistometer test, also known as the V-B Consistometer test, is a laboratory test used to determine the workability and consistency of fresh concrete. It measures the time taken for concrete to undergo a specified degree of deformation under vibration. The test provides an indication of the internal friction and cohesion of the concrete mix. Here is an overview of the Vee-Bee Consistometer test procedure:

1. Sample Preparation: Collect a representative sample of fresh concrete from the batch, ensuring it is adequately mixed. Take enough of the sample to fill the Vee-Bee Consistometer apparatus.

2. Apparatus: The Vee-Bee Consistometer apparatus consists of a cylindrical container with a vibrating arm, a stopwatch or timer, and a slotted disc that sits on top of the concrete.

3. Filling the Container: Fill the cylindrical container with the fresh concrete sample, ensuring it is evenly distributed and free from air pockets.

4. Placing the Slotted Disc: Place the slotted disc on top of the concrete, ensuring it is centered and resting on the surface.

5. Starting the Test: Start the vibration of the apparatus by switching on the vibrating arm. The vibration causes the slotted disc to sink into the concrete, inducing deformation.

6. Measuring the Time: Measure the time taken for the slotted disc to penetrate a predetermined depth into the concrete. Typically, the depth is around 5 mm or 10 mm. Use a stopwatch or timer to record the time accurately.

7. Repeating the Test: Repeat the test with additional fresh concrete samples to ensure consistency and obtain an average time for penetration.

8. Calculation and Reporting: Calculate the Vee-Bee time by averaging the times recorded

from multiple tests. The Vee-Bee time is the average time taken for the slotted disc to penetrate the specified depth into the concrete.

The Vee-Bee time represents the workability and consistency of the concrete. A shorter Vee-Bee time indicates a higher degree of workability, while a longer Vee-Bee time suggests lower workability and increased resistance to deformation.

Fig. 1 - Vee-Bee-Consistometer Test Apparatus

C. COMPARISON OF WORKABILITY MEASUREMENTS BY VARIOUS METHODS

Table-11.: Comparative Analysis

Workability Description	**Slump in mm**	**Vee-bee Time in Seconds**	**Compacting Factor**
Extremely dry	–	32 – 18	
Very stiff	–	18 – 10	0.70
Stiff	0 – 25	10 – 5	0.75
Stiff plastic	25 – 50	5 – 3	0.85
Plastic	75 – 100	3 – 0	0.90
Flowing	150 – 175	–	0.95

D. Compressive Strength Test

The compressive strength test is one of the most common and important tests conducted on concrete to determine its strength and quality. It measures the ability of concrete to resist compression forces and is used to assess the load-bearing capacity of concrete structures. Here is an overview of the compressive strength test procedure:

- Sample Preparation: Collect representative samples of fresh concrete from the batch. The samples should be obtained in accordance with the relevant standards or specifications. The size and number of samples required depend on the project requirements.
- Curing: Place the fresh concrete samples in a curing environment that mimics the intended in-service conditions. Typically, curing is done in a water bath or a moist curing room at a controlled temperature to ensure proper hydration and strength development.
- Sample Preparation: Prepare cylindrical or cubical specimens from the fresh concrete samples. The dimensions and shape of the specimens are specified by testing standards, such as ASTM C39 or EN 12390-3. The specimens are typically cast in molds, compacted, and finished to achieve a smooth surface.
- Curing Period: Allow the specimens to cure for a specified period, usually 28 days, to achieve the desired strength development. However, different curing periods may be specified based on project requirements or early-age strength evaluation.
- Testing Setup: Place the cured specimens individually in a compression testing machine. The machine consists of two platens, an upper and a lower platen, that apply compressive forces to the specimen. The load is gradually applied until the specimen fails, recording the maximum load at failure.
- Compressive Strength Calculation: Calculate the compressive strength of the concrete specimen by dividing the maximum load at failure by the cross-sectional area of the specimen. The result is expressed in units of force per unit area, such as pounds per square inch (psi) or megapascals (MPa).

Reporting Results: Report the compressive strength test results for each specimen tested. Typically, the average compressive strength of multiple specimens is reported to provide a representative value for the concrete mix.

V. Results and Discussion

Each set of three cubes of M20 Grade concrete were tested in a compression testing machine with 0%, 10%, 20%, 30%, and 40% replacement of cement with silica fume to determine the compressive strength after 7 and 28 days of curing. The average of these three numbers yields the average compressive strength of concrete. The average compressive strength of cubes at 7 and 28 days of age decreased to 17.20 N/mm2 and 25.14 N/mm2, respectively, when silica fume was replaced for 30% of the cement, compared to 17.04 N/mm2 and 28.59 N/mm2, respectively, for typical concrete without silica fume. Below is a table of M20 grade concrete's compressive strength for various silica fume concentrations after 7 and 28 days of curing.

Table-12.: Compressive strength of concrete of grade M20 for various concentrations of silica fume at age seven.

Mix	Load (KN)	Compressive Strength (N/mm2)	Average Compressive strength (N/mm2)
0% Silica fume	390 360 400	17.33 16.00 17.78	17.04
10% Silica fume	406 390 410	18.04 17.33 18.22	17.86
20% Silica fume	482 460 454	21.42 20.44 20.18	20.68
30% Silica fume	380 395 386	16.89 17.56 17.16	17.20
40% Silica fume	340 346 360	15.11 15.38 16.00	15.50

Table-13.: Compressive strength of concrete of grade M20 for various concentrations of silica fume at age 28.

Mix	Load (KN)	Compressive Strength (N/mm2)	Average Compressive strength (N/mm2)
0% Silica fume	665 625 640	29.56 27.78 28.44	28.59
10% Silica fume	630 648 655	28.00 28.80 29.11	28.64
20% Silica fume	670 672 680	29.78 29.87 30.22	29.96
30% Silica fume	567 580 550	25.20 25.78 24.44	25.14
40% Silica fume	516 520 510	22.93 23.11 22.67	22.90

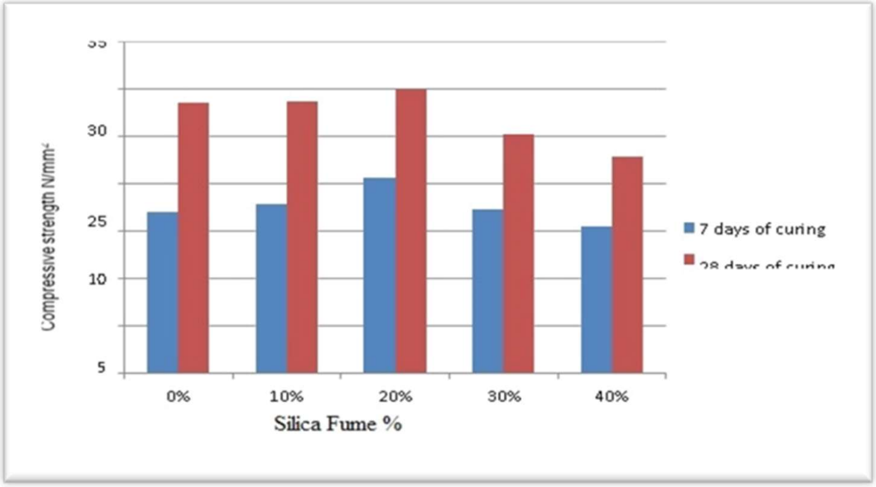

Fig. 4.1 - Compressive Strength (N/mm2) for different proportions of silica fume after 7 and 28 days of curing.

VI. Conclusion

According to the study, strength improves as silica fume concentration increases up to a certain point, after which strength starts to decline as silica fume concentration grows. Concrete's workability will increase as the cement content in the mixture lowers and the amount of silica fume that can enter the reaction is reduced, making cement behave more like fine aggregate. For the four test groups, 20% of cement is the silica fume concentration that works best. The following results were reached from the experimental work done for M20 grade of concrete by partial replacement with 0%, 10%, 20%, 30% and 40% of silica fume.

- Up to 20% of the OPC in OPC concrete can be replaced with silica fume without affecting the concrete's compressive strength.
- Workability declines as replacement level rises.
- As the amount of silica fume in cement rises, so does its consistency. This occurs because silica fume molecules are more minute than cement molecules, which affects cement's consistency.

If we replace more than 20% of the cement, the compressive strength of the concrete may be significantly reduced.

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