Determination of strength characteristics of concrete by partial replacement of cement material by silica fumes.

Priyanka Lohiya

Department of Civil Engineering

Galgotias University, Greater Noida ,Uttar Pradesh, India

Dr. Suprakash Biswas

Department of Civil Engineering

Galgotias University, Greater Noida ,Uttar Pradesh, India

Abstract: The basic application of nanotechnology is seeking to improve performance by means of new content. The microstructure is important to change on the properties of the concrete due to the limited size of nanomaterial. With this analysis too, there was substantial change in the strength of the early stresses and overall pressure resistance of the concrete. If the level of silica falls, the intensity increases. Now and in the future, the material is true. The materials network researched in the 21st century was typically used from the house to the factory and from the airport bridge. Concrete consistency and longevity will be urgently strengthened. The composition and attachment of various materials used for concrete construction plays an important part of cement. Now and in the future, the material is true. The materials network researched in the 21st century was typically used from the house to the factory and from the airport bridge. Concrete consistency and longevity will be urgently strengthened. The composition and attachment of various materials used for concrete construction plays an important part of cement. A reinforcement system was then suggested and suggested to increase concrete quality. The compressive strength is observed to increase (both 7 days, 14 days and 28days) as the gases in silica raise to a certain level for ceramic silica restoration. When the amount again grew after 6 percent, Silica Fume displayed a significant decline. And for concrete assembly, 6 percent is the right number. According to our studies, silica fume is used as cement content, and is mixed with percentage substitution varying from 0.2,4,6,8,10 per cent to different experiments and findings and graphs is collected accordingly.

Keywords: high performance, concrete, silica fumes, tests

I. INTRODUCTION

Concrete is a combination of clay, fine aggregates, coarse aggregates and water. In the plastic process it can be shaped in any shape. The relative number of components tested the wet and hardened stages of the concrete output.Two or three decades ago, in fact, without looking at the future of concrete structures, using OPC to produce concrete for construction can easily get the concrete composition regardless of quality. Nowadays, with recent investigations conducted by engineers and scientists over the past two to thirty years, with the structural stability of the structure, high quality concrete is needed while improving strength, durability and other characteristics. The need for these properties led to the search for complementary cement materials. Look for any suitable material in terms of local replacement of cement in order to achieve global sustainable development and reduce impact on the environment. Concrete cement is the majority of building materials today. It can be said that we live in a concrete era. Beton is simple to manufacture, but concrete is a complex material, in reality. It is a matter produced in the field because, because of the usage of other natural materials than cement, its consistency, efficiency because output will significantly improve. Medium standard and lower value cement are also widely used for the accelerated growth of the country's infrastructure. Over the process of the study, the highest quality and most widely used cement products were silicone powder, fly ash, loose granule furnaces etc. A common usage of agricultural materials will also conserve resources and prices, beyond following environmental protection requirements. The most viable manufacturing component was found to be silica volcanic ash which could be used as a part-alternative to cement in concrete. In India and abroad, many experiments are being undertaken to research the impact of replacing cement with such pozzolan products, and the findings are promising. Adding silica smoke to concrete has numerous benefits, such as strong power, good resilience and decreased production of cement.

1.1 High performance concrete

Concrete with a high performance is a concrete blend with a greater strength and durability than conventional concrete. This cement comprises one or more cement ingredients. High-performance concrete is therefore not a specific concrete type. This uses the same ingredients as standard cement. Through utilizing such chemical and mineral blends including silica smokes and super plasticizers, energy, resilience and processing capacities can be dramatically improved. While the initial expense of high-performance concrete is greater than standard concrete, it is inexpensive because high quality cement will prolong the product 's life so less harm is done to the construction that decreases the cost overall.

Concrete is a long-lasting and versatile building tool. It's not only durable, inexpensive, and depends on the shape, but aesthetically pleasurable. Nonetheless, experience indicates that concrete will quickly deteriorate without taking preventive precautions during construction and manufacturing. For this, the impact of components on concrete efficiency and the processing of concrete substances in closely regulated tolerances must be recognized.It has been found that traditional Portland cement has lacking in the following aspects:

- Durability in harsh environments (shorter life and frequent maintenance)
- Construction time (slower density increase)
- Energy absorption capacity (for seismic structures)
- Repair and renovation work.
- Materials Selectivity Process
- Following is the steps of production of concrete selection.
- Choose the correct concrete composition with the required rheology, strength, etc.
- Determine the relative amount of components to create durability.
- Carefully control quality at every stage of the concrete manufacturing procedure.

It is necessary to use sand and gravel from the water. In order to reduce porosity, sand particles must also accumulate, as the test findings indicate a need for more blended water for higher porosity.By setting the maximum substrate size and making the transition area stronger, this reduces the strength of the concrete. Through the use of mineral additives, cement concrete becomes more homogeneous, and the strength and durability properties of concrete can be greatly improved. The strength of high-performance concrete can be controlled by the strength of coarse aggregate, which is not usually the case with conventional cement concrete. In the end, extra water is only used for unnecessary voids in the concrete slurry, minimizing the volume of water compared to that which is necessary in order for the chemical reaction of anhydrous cement. Inhibitors help reduce the initial moisture rate of cement, thus keeping fresh concrete more useful for a lengthier period.

1.2 Behavior of Fresh Concrete

There is no inherent gap in the efficiency of fresh high presentation concrete from traditional concrete. Although several high-level concretes display rapid hardening and early strength development, other concretes may be held longer and have fewer early strength. Usability using the same raw materials is typically greater than standard concrete. While some high-performance concretes with strong early solidity properties are less processing prone, high-performance concrete treatment varies fundamentally from traditional concrete.

1.3 Workability

Even in low stagnation conditions, the high performance concrete is generally very good, and high performance concrete is usually well pumped due to the presence of large amounts of cement materials and chemical mixtures. High performance concrete was successfully pumped to 80 layers. An emergency pump failure plan should be developed when pumping concrete. Superior concrete can fill parts of high-performance reinforced steel without creating internal or exterior disturbances, displacement and wide voids. It is also a valuable method to determine the mixture's consistency. Not all high-performance concrete needs, of course, liquid concrete, so the operability is typically not difficult.

1.4 Setting time

The processing time varies be contingent on the submission, the attendance of the processing rate and the proportion of mortar consisting of Portland cement. Using a large amount of a water reducing agent will significantly lengthen the preparation time and thus reduce its very early strength, even if the strength is higher than 24 hours may be relatively high. Mixtures containing large quantities of mineral additives should be used to closely monitor the doses to avoid excessive addition of Portland cement while adding chemical additives based on the entire cement substance.

1.5 Applications

In a vast range of construction applications in several countries, the solid and excellent toughness of high performance concrete has been utilized. Two uses of high-performance concrete are Bridges, High-rise building, Tunnels and Nuclear Structure.

1.6 Silica Fume

The concept of Silica Fume: The American Concrete Institute (ACI) describes silica fume as "extremely finely not made, in electric arc furnaces, crystalline silicon as an additive to the manufacture of silicon or silicon-containing alloys." This is typically a gray material.

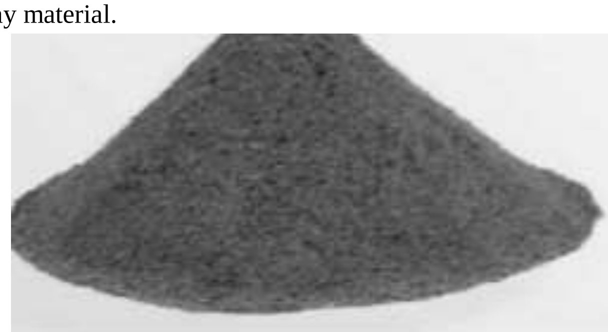

Figure 1. Silica Fume

1.6.1 Silica Fume Properties and Reactions in Concrete

1.6.1.1Chemical Properties

A crystalline concrete content, which is chemical identical to silica dust, is available. This is the volatile substance that burns silica. Additional silica fume compounds may be dependent on the product that the gases are produced from in the smelter. In general, the production of silica fume in hormigon is not influenced by this content. Some products in this group can be restricted by regular requirements.

1.6.1.2Physical Properties

The table displays the main physical features of silica gases. A discussion on each of these features follows.

1.6.1.3Particle size

Silica gases are very tiny and about 95% of the particles are smaller than 1µm. The emissions are very tiny.

1.6.1.4Bulk density

It is just another unit weight word. The amount of the silica fume produced depends on the metal produced in the oven and how the oven works. As the volume density of the processed fume is usually very small, transportation over long distances is not very economical.

1.6.1.5Specific gravity

A relative amount that shows how fume of silica with a basic gravity of 1.00 is comparable with vapor. This is seen in construction proportioning. Silicon smoke is much thinner than Portland cement, and is much more than 2.2, with a common magnitude of about 3.15.

It is the average surface of a specified substance density. The surface area is very growing since silica fume particles are very tiny. When the particles become smaller, we realize that the need for water rises for air, as does silica fume. Therefore, silica fume must be used in conjunction with an additional mixture or super plasticizer that eliminates vapor. For the calculation of the precise surface of a silica fume, a procedure called BET or nitrogen adsorption process shall be used. Relevant surface measures are less important for silica smoking dependent on the application of sieve or air permeability studies.

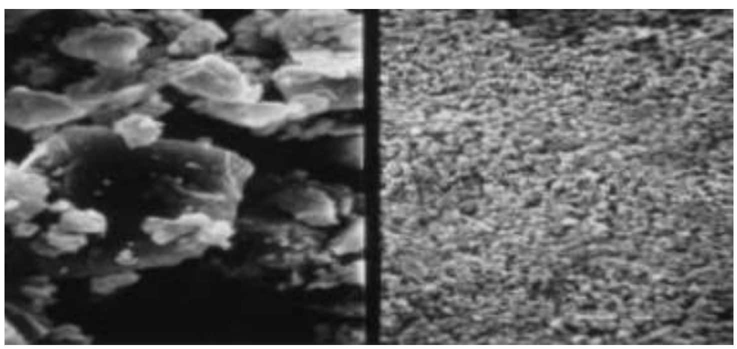

Figure 2: Photo Micrograph of Portland cement

Form	Agglomerated
Particles Color/ Appearance	Grey
Specific Gravity	2.20
Size of particles	0.1 µ
Dosage	2 - 10 % by weight of cement
Chloride content	Nil

Figure 3: Physical Properties of Silica Fume

II. SILICA FUME USED IN CONCRETE.

2.1Silica fume and fresh concrete

Two different results occur: the construction becomes more uniform with no leakage from the ground. Although certain endorsers may find this to make it easier to position and finish the concrete, they are simply benefits for fresh and hardened concrete.

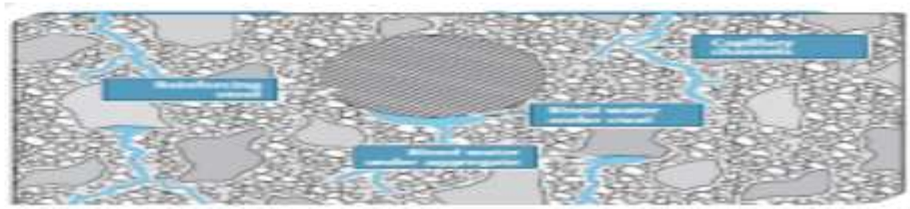

Figure 4: Effects on Hardened Concrete

2.2Silica fume and hardened concrete

The impact of silica fume on hardened concrete is seen in the chart. Two distinct results are present: improved mechanical properties, including resistance and elasticity board, and decreased permeability, which increases longevity directly. The paragraph addresses all these impacts.

III. RESEARCH BACKGROUND

1. Saini &Nayak (2019) published a paper on “To Study Effects On The Mechanical Properties Of Concrete After Partially Replacing Cement By Silica Fume” The main purpose of this study is to use silica fume as a mineral admixture mixed into concrete to partially replace ordinary 43 ° Portland cement (OPC) in order to study silica fume’s influence on M55 & M60 grades of concrete that are currently widely used in high-gain construction. There were 50, 30 and 30 sets of tubes, cylinders and beams set for the research for Silica Fume effect on concrete. Such concrete experiments were thoroughly healed in water at natural air temperature
2. Jagan, S. (2019) published a paper “Effect on blending of supplementary cementitious materials on performance of normal strength concrete” they emphasizedmainly sustainability, scarcity, permeability, M-sand, silica fume, fly ash and steel slag. The two main issues with successful usage of renewable products are resilience and shortages of capital in the present scenario.
3. Shaikh, F. U. A. (2017) this paper describes the influence of silica fume (SF) on the mechanical characteristics of early and long-term recycled slag-containing aggregate concrete. Six mixes are taken into consideration in this study.
4. Khan, A. G., & Khan, B. (2017) published a paper “Effect of partial replacement of cement by mixture of glass powder and silica fume upon concrete strength.”Construction products are the most widely used in the entire world. The mixture of cement, aggregates and water is well-known to be concrete. Taking into account environmental pollution that can lead to serious health problems, it is therefore necessary to use pozolanic materials, which are locally available, as a partial substitute for cement, because they are economic in comparison with cement from Portland, and also environmentally friendly without sacrificing on concrete quality.
5. Kumar, R., & Dhaka, J. (2016) The purpose of the present study is to evaluate the output of Silica Fume as a concrete mixture in the light of the rising demand of the industry in concrete which is leading to large-scale cement production leading to environmental problems and natural resources degradation on the one side, and that costs, on the other.

6. Pedro et al. (2017),analyze the Fly ash and super plasticizer (SP) have also been included in the concrete formulations in addition to natural silica fume. Each type of concrete is made up of a Referring Bet (RC) and 3 recycled (RAC) mixture of fine natural aggregate (FNA) fine recycled (FRA) substitution proportion (in volume) and cough natural aggregated (CNA) blends of 50/50, 100 and 100/100 coarse recycled aggregate(CRA) respectively. Taking into consideration the technical strength and resilience of concrete mixtures, the findings show that large amounts of FRA and CRA may be added.
7. Soliman&Tagnit-Hamou (2017),the nature of ULT depends essentially on the packing density and distribution of its ingredients in the packing density and particle size (PSD). The cement PSD has a micro-scale division and must be packed with thinner products, including silica fume (SF). For this gap to be filled only with SF, high SF levels (25 to 30 percent by wt. of cement) are required because of their intense finesse. Concrete rheology is adversely influenced by large SF concentrations.

8. Ardalan et al. (2017), this article presents the findings of an experimental analysis to test the efficiency of mixtures creating self-compacting concrete (SCC) in various amounts utilizing pumice-containing mixtures. Pumice has pozzolanic qualities as a volcanic substance which can be applied to the concrete mixture efficiently.

3.1 Conclusion from literature Review

a. Use of Silica Fume & results in an increase in the compressive strength of concrete

b. With increase in compressive strength the workability of concrete gets reduced with the use of silica fume, as a result, admixtures are used to enhance workability.

IV. EXPERIMENTAL OUTCOME

4.1 Test Results

Table . 1: Test Results

Workability		
Slump value (mm)	**Compacting factor**	
80	**0.92**	
Compressive strength		
7-day strength	**Mpa**	
Cube_1	**26.9**	**27.05**
Cube _2	**26.45**	
Cube _3	**27.8**	
Average compressive strength	**27.05**	
14-day strength	**Mpa**	
Cube_1	**30.03**	**30.89**
Cube_2	**31.23**	
Cube_3	**31.43**	
Average compressive strength	**30.89**	
28-day strength	**Mpa**	
Cube_1	**36.2**	**37.2**
Cube_2	**37.3**	
Cube_3	**38.2**	
Average compressive strength	**37.2**	

Table . 2: Trial Mix2

Date of Casting: Feb -2020							
Grade of Concrete: M30.							
Target Mean Strength: 38.25 MPa.							
W/C Ratio: 0.45.							
20mm: 10mm-60:40.							
Description	**Cement (Kg)**	**Sand (Kg)**	**CA-10mm (Kg)**	**CA-20mm (Kg)**	**Water**	**Silica Fume Dosage (kg)**	
Standard Design per m3	**415.88**	**674.17**	**459.16**	**688.74**	**197**	**5%**	**21.88**
Moisture Content	**-**	**6.31**	**2.12**	**1.79**	**-**	**-**	
Water Absorption	**-**	**1.4**	**1.1**	**0.47**	**-**	**-**	
% of Adjustment	**-**	**4.91**	**1.02**	**1.32**	**-**	**-**	
Correction Required	**-**	**33.101**	**4.68**	**9.0913**	**46.87**	**-**	
Corrected Quantity	**415.88**	**707.27**	**463.84**	**697.83**	**150.72**	**21.88**	

Table . 3: Test results

Workability		
Slump value (mm)	**Compacting factor**	
63	**0.89**	
Compressive strength		
7-day strength	**Mpa**	
Cube_1	**26.00**	**27.81**
Cube _2	**29.44**	
Cube _3	**28.00**	
Average compressive strength	**27.81**	
14-Days Strength	**Mpa**	
Cube_1	**31.22**	**31.25**
Cube _2	**32.32**	
Cube _3	**30.21**	
Average compressive strength	**31.25**	
28- day strength	**Mpa**	
Cube_1	**39.65**	**39.02**
Cube _2	**39.16**	
Cube _3	**38.25**	
Average compressive strength	**39.02**	

Table . 4:Trial mix3

Date of Casting: Feb 2020							
Grade of Concrete: M30.							
Target Mean Strength: 38.25 MPa.							
W/C Ratio: 0.45.							
20mm: 10mm-60:40.							
Description	**Cement**	**Sand**	**CA-10mm**	**CA-20mm**	**Water**	**Silica Fume Dosage**	
Standard Design per m3	**393.99**	**674.17**	**459.16**	**688.74**	**197**	**5%**	**32.83**
Moisture Content	**-**	**6.31**	**2.12**	**1.79**	**-**	**-**	
Water Absorption	**-**	**1.4**	**1.1**	**0.47**	**-**	**-**	
% of Adjustment	**-**	**4.91**	**1.02**	**1.32**	**-**	**-**	
Correction Required	**-**	**333.101**	**4.683**	**9.09**	**46.87**	**-**	
Corrected Quantity	**393.99**	**707.27**	**463.84**	**697.831**	**150.72**	**21.88**	

Table 5: Test results

Workability		
Slump value	**Compacting factor**	
40	**0.84**	
Compressive strength		
7-day strength	**Mpa**	
Cube_1	**31.0**	**30.4**

Cube _2	29.5	
Cube _3	30.9	
Average compressive strength	30.4	
14-Days Strength		
Cube_1	35.45	35.45
Cube _2	34.67	
Cube _3	35.90	
Average compressive strength	35.45	
28- day strength		
Cube_1	40.04	40.78
Cube _2	40.5	
Cube _3	41.8	
Average compressive strength	40.78	

Table 6: Trial Mix4

Date of Casting: Feb 2020						
Grade of Concrete: M30.						
Target Mean Strength: 38.25 MPa.						
W/C Ratio: 0.45.						
20mm: 10mm-60:40.						
Description	Cement	Sand	CA-10mm	CA-20mm	Water	Silica Fume Dosage
Standard Design per m3	372.05	674.17	459.16	688.74	197	5%
Moisture Content	-	7.8	0.7	0	-	-
Water Absorption	-	1.4	1.1	0.47	-	-
% of Adjustment	-	6.4	-0.4	-0.47	-	-
Correction Required	-	43.14	-1.836	-3.237	38.07	-
Corrected Quantity	372.05	717.32	457.324	685.502	159.08	21.885

Table 7Test Results

Workability		
Slump value	Compacting factor	
25	0.8	
Compressive strength		
7 day strength		
Cube_1	31.5	Mpa
Cube _2	32.6	Mpa
Cube _3	33.0	Mpa

Average compressive strength	32.5	Mpa
14 Days Strength		
Cube_1	39.05	Mpa
Cube _2	38.90	Mpa
Cube _3	41.56	Mpa
Average compressive strength	39.83	
28 day strength		
Cube_1	44.7	Mpa
Cube _2	46.4	Mpa
Cube _3	47	Mpa
Average compressive strength	46.1	Mpa

Table 8: Trial mix5

Date of Casting: Feb 2020							
Grade of Concrete: M30.							
Target Mean Strength: 38.25 MPa.							
W/C Ratio: 0.45.							
20mm: 10mm-60:40.							
Description	Cement	Sand	CA-10 mm	CA-20mm	Water	Silica Fume Dosage	
Standard Design per m3	350.17	674.17	459.16	688.74	197	5%	21.885
Moisture Content	-	2.56	0	0	-	-	
Water Absorption	-	1.4	1.1	0.47	-	-	
% of Adjustment	-	1.16	-1.1	-0.47	-	-	
Correction Required	-	7.82	-5.5	-3.24	-0.47	-	
Corrected Quantity	350.17	681.99	454.11	685.5	197.47	21.885	

Table 9: Conclusion based on results

S.no	Dosage of Silica Fume (%)	7 day strength (Mpa)	14days (Mpa)	28 day strength (Mpa)
Trial no. 1(TM 1)	0	27.05	29.09	30.58
Trial no. 2(TM 2)	2	27.81	29.03	33.05
Trial no. 3(TM 3)	4	28.00	30.02	34.80
Trial no. 4(TM 4)	6	29.58	32.53	35.59
Trial no. 5(TM 5)	8	28.01	31.04	35.28
Trial no. 6 (TM 6)	10	27.00	27.99	33.30

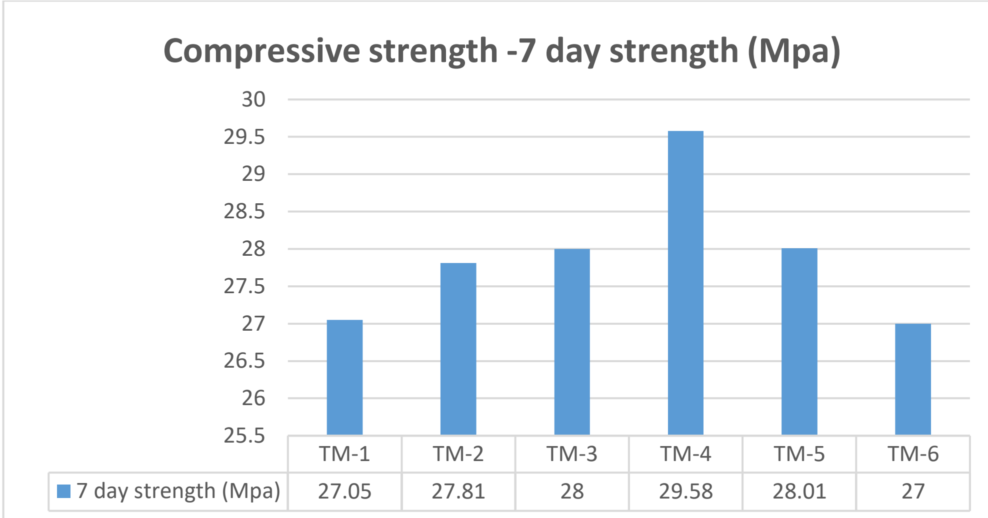

Figure 5: Compressive strength of concrete in seven days

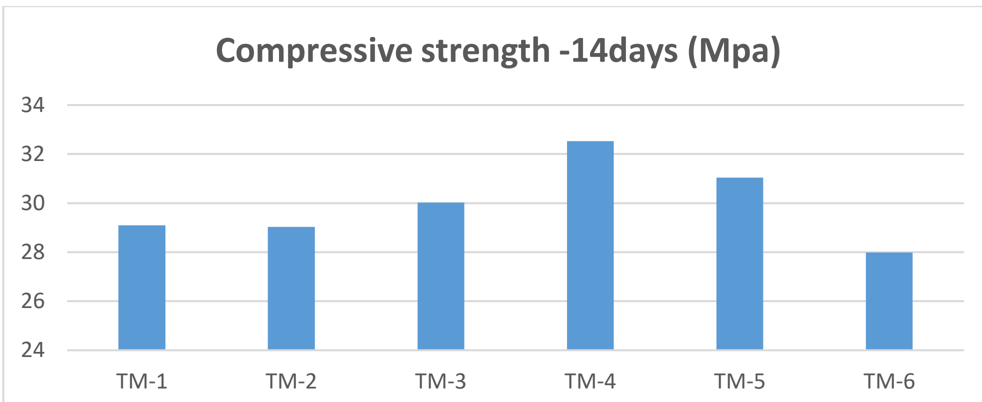

Figure 6: Compressive strength of concrete in 14 days

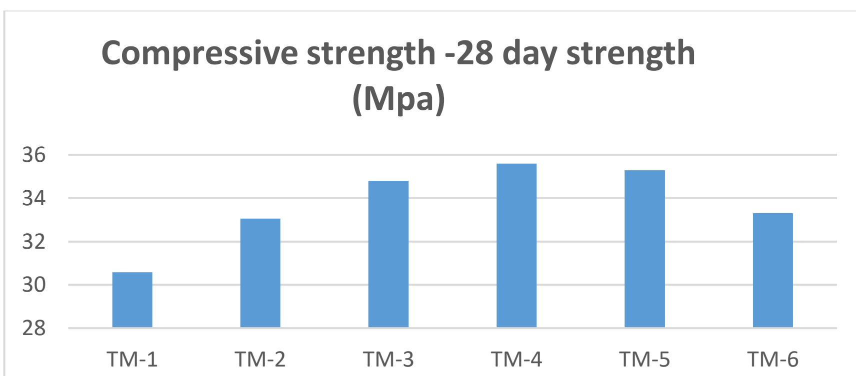

Figure 7 Compressive Strength after 28 Days

Table 10: The net results considering workability criteria

Sr. No	Dosage of Silica Fume(%)	Slump value (mm)	Compacting factor (cf)
Trial no. 1	0	80	0.92
Trial no. 2	2	63	0.89

Trial no. 3	4	40	0.84
Trial no. 4	6	32	0.82
Trial no. 5	8	25	0.80
Trial no. 6	10	24.99	0.79

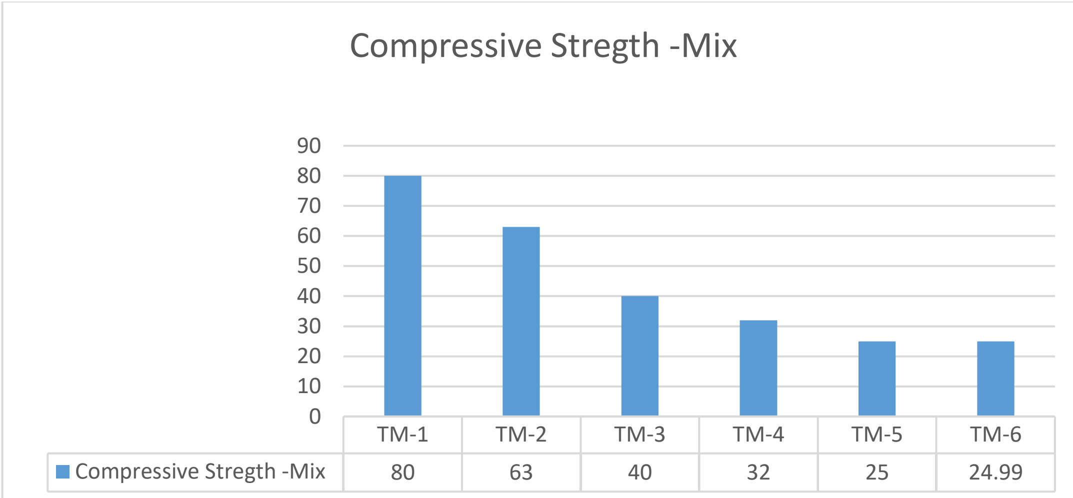

Figure8: Workability for Trial Mixes

V.CONCLUSION AND FUTURE WORK

5.1 Discussion of Test Results

The test findings indicate that the compressive strength for silica fume concrete (both 7 days, 14 days and 28 days of compressive intensity) is improved relative to the compressive strength of standard concrete. The tests are very simple. Compression strength is shown to have increased (both 7 days,14 days and 28 days) with a rise in the dosage of silica fume up to a certain cement substitution limit, and when the dosage of silica fume has been increased by 6 percent, it shows an abyss in Silica Fume and Becrete Compression Quality. The relation of the concrete in any event decreased the solids' functionality. The test findings indicate very clearly that the compressive content of silica rage concrete (7 days, 14 days and 28 days of compressive strength) is-as contrasted with the compressive quality of standard cement. The tests show very strong performance. It has been found that compressive quality has expanded with the expansion of silica intake to certain farthest ranges in concrete substitution by silica seethe and (both for 7,14Days, 28 days and several days). When the measurements were further expanded after 6 percent, they showed plunge into Silica Fume's compressive quality. 6% is the optimal dosage of concrete joining in such sides. However, the incorporation of the strong into concrete reduced its utility.With 6% substitution of silica fume, the compressive force increased up to 12% (Approx). An incremental rise in silica fume slowly decreases intensity and up to 10% replacement may be used as an incremental element in béton degree M30.

The addition of silica fume increases the strength of different forms of binder mixes by denser.

The addition of silica fume to any binder blend reduces capillary absorption and porosity since silica fumes react with lime in concrete and in the form of hydrate dancer and compositionally crystalline particles The findings above indicate that concrete class M30 can be built with a material of up to 6% Silica Fume. The analysis found that Silica Fume concrete exhibited less strength in its early stages, and that its strength improved by six percent with age. With the increase in replacements, the workability of Silica Fume concrete has decreased. If the concrete is to use Silica Fume it will prove cost-effective as it is free of usable waste. The use of Silica fume in concrete protects natural resources used in concrete production so that the building industry in concrete is sustainable.

VI.FUTURE SCOPE

Research shows that silica fume in concrete can be used. More work could be extended in several areas:
Some durability tests, such as water permeability, chlorides ion resistance, steel reinforcement corrosion, sulphate attack resistance to marine life, etc., with silica-fume, are required.

REFERENCES

[1] Saini, M. L. K., &Nayak, M. J. R. (2019). To Study Effects On The Mechanical Properties Of Concrete After Partially Replacing Cement By Silica Fume.

[2] Jagan, S. (2019). Effect on blending of supplementary cementitious materials on performance of normal strength concrete. *International Review of Applied Sciences and Engineering*, *10*(3), 253-258.

[3] Shaikh, F. U. A. (2017). Mechanical properties of recycled aggregate concrete containing ternary blended cementitious materials. *International Journal of Sustainable Built Environment*, *6*(2), 536-543.

[4] Khan, A. G., & Khan, B. (2017). Effect of partial replacement of cement by mixture of glass powder and silica fume upon concrete strength.

[5] Kumar, R., & Dhaka, J. (2016). Review paper on partial replacement of cement with silica fume and its effects on concrete properties. *International Journal for Technological Research in Engineering*, *4*(1).

[6] Pedro, D., De Brito, J., & Evangelista, L. (2017). Evaluation of high-performance concrete with recycled aggregates: Use of densified silica fume as cement replacement. *Construction and Building Materials*, *147*, 803-814.

[7] Soliman, N. A., &Tagnit-Hamou, A. (2017). Partial substitution of silica fume with fine glass powder in UHPC: Filling the micro gap. *Construction and Building Materials*, *139*, 374-383.

[8] Ardalan, R. B., Joshaghani, A., & Hooton, R. D. (2017). Workability retention and compressive strength of self-compacting concrete incorporating pumice powder and silica fume. *Construction and Building Materials*, *134*, 116-122.

[9] Ganjian, E., Ehsani, A., Mason, T. J., &Tyrer, M. (2018). Application of power ultrasound to cementitious materials: Advances, issues and perspectives. *Materials & Design*, *160*, 503-513.

[10] Gedam, B. A., Bhandari, N. M., &Upadhyay, A. (2016). Influence of supplementary cementitious materials on shrinkage, creep, and durability of high-performance concrete. *Journal of Materials in Civil Engineering*, *28*(4), 04015173.

[11] Zhang, J., & Zhao, Y. (2017). The mechanical properties and microstructure of ultra-high-performance concrete containing various supplementary cementitious materials. *Journal of Sustainable Cement-Based Materials*, *6*(4), 254-266.

[12] Srivastava, V., Atul, I. A., Mehta, P. K., &Satyendranath, M. K. (2018). Supplementary cementitious materials in construction an attempt to reduce CO2 emission. *J Environ Nanotechnol*, *7*, 31-6.