ANALYSIS OF ENGINEERING PROPERTIES OF CONCRETE BY ADDING SILICA FUME

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Abstract - *Due to over increasing population and limited resources of land we have to look to the sky to accommodate this increasing population and for that we are so much focused on making high rise buildings and other mega structures to utilise the resources of land to its fullest, but this cannot be achieved without improving our construction technique and materials. As we know that Concrete is one of the most widely used structural material hence its property and quality influence the construction a lot. Here in my project I have tried to evaluate those properties of concrete and the improvement in those properties by adding silica fume. Silica fume act as a filler material and fills the pores between cement particles, making it more dense and improving the microstructure of concrete and thus improving the mechanical properties of concrete, such as strength, impermeability, durability, elastic modulus and so on. It also improve the concrete by chemically reacting with hydration precipitation of Ca(OH2) and producing hydrated calcium silicate in alkaline conditions thus improving the consistency of concrete and workability. Compressive strength of concrete is the most important property of concrete, because other properties like stress-strain relationship, tensile strength, bond strength, modulus of elasticity, density, impermeability, durability etc. can be inferred from the compressive strength using established correlations. Therefore in this project I have focused on observing the improvement in compressive strength of concrete by adding silica fumes and finding the most optimum proportion of silica fume which gives us the best result. Different mix design are prepared following IS code and different proportion of silica fume (i.e. 0%, 5%, 10%, 15%, 20%) are added and the results of 7 and 28 days compressive strength are found and compared. The result shows a progressive increase in compressive strength of concrete (corresponding to 28 days strength) till 15% of silica fume and then it slightly decreases hence we can correlate that the most optimum proportion of silica fume that should be added in concrete is about 15% of total cementations material. Adding silica fume also improves the early strength of concrete (i.e. 7days strength), durability etc as discussed in the project.*

***Key Words*: consistency of concrete, workability. Compressive strength, tensile strength, bond strength, modulus of elasticity, density, impermeability**

1.INTRODUCTION

Concrete is a mixture of sand, gravel, water and cement to form a hard mass. Concrete has compressive strength but low tensile strength. Its tensile strength is approximately

1 of its compressive strength. Recently, everyone is interested in improving the properties of concrete by mixing/adding various pozzolanic materials to the concrete mix.One of these substances are silica fume. Silica fume is also known as microsilica, concentrated silica fume, "Micropoz"™, silica fume, volatile silica, etc. Mumbai's Bandra worli sea link used fumed he silica concrete primarily to improve durability. Silica fume is a by-product of the production of ferrosilicon and silicon metal in electric arc furnaces. Silica fume extracted in this way is typically composed of over 90% silicon dioxide and trace amounts of other oxides. Silica fume was first collected in his 1947, and trials began in 1961. Silica particles are very small, with a fineness of 15,000 to 30,000 m2/kg and a specific gravity of about 2.22. This is about 100 times less than cement particles, making it easier for microsilica particles to occupy the interstices (voids) left by cement particles.

Constituents of Concrete

CementCement is generally composed of two components.OPC (Common Portland Cement) Components:

Lime (CaO) (62-67%): Gives strength and strength to the cement. If enough is present, the cement becomes unhealthy and difficult to expand. If you don't have enough, the strength of the cement will decrease and it will harden quickly. Strength → resistance to impact and moderate stress Toughness→ resistance to abrasion Hardness → resistance to impact (sudden stress)

Silica (SiO2) (17-25%): also provides strength to the cement. Too much will increase the strength of the cement, but will also lengthen the hardening time of the cement. If initial hardening is desired, ingredients such as (because silica and lime are long hardening ingredients) need to be changed.

Aluminum Oxide (Al2O3) (3-8%): Gives cement quick-setting properties. This acts as a flux and helps reduce the clinker temperature. Exceeding that weakens the cement. The temperature at which cement clinker is formed is called clinker temperature.

Calcium Sulfate (CaSO4) (3-4%): Commonly available in the form of gypsum, it helps extend the initial hardening time of cement.

Iron Oxide (Fe2O3) (3-4%): Provides strength, hardness and color to cement.

Magnesia (MgO) (1-3%): Provides strength, hardness and color to cement.Cement is unsuitable if its amount is greater than necessary.

Sulphur (S) (1-3%): Sulphur in cement causes volumetric changes and therefore unhealthy cement.

Alkalis (Na2O, K2O) (0.2-1%): Alkalis in cement cause stress and efflorescence in structures used in construction.

If these cement components are ground together and burnedThey fuse together to form complex compounds that are not formed at the same time, called Borg compounds. The Borg compounds found in cement are:

Tricalcium aluminate (3CaO.Al2O3) (C3A) (4-14%): known as calcite. Hydrate within 24 hours of adding water to cement. This is responsible for the instant hardening of cement and also leads to changes in cement volume. As a result, it causes the occurrence of cracks. Releases maximum heat of hydration during formation. Hydration by C3A occurs, and shrinkage occurs due to the volume change of the cement.

Tetra Calcium Alumo Ferate (3CaO.Al2O3.Fe2O3) (C4AF) (10-18%): known as ferrite. It also hydrates within 24 hours of adding water. It has been observed to have the worst cement properties. It is of no technical significance as it does not impart any properties to the cement.

Tricalcium silicate (3CaO)SiO2) (C3S) (45-65%): known as alite. After adding water to the cement, it will be hydrated in about a week. It is involved in the development of initial strength of concrete. Therefore, when early strength is required in engineering structures, the C3S content is significantly increased. Examples include cold concrete, paving and prefab construction where formwork is reused for rapid construction. It also increases the cement's resistance to freezing and thawing.

Dicalcium Silicate (2CaO.SiO2) (C2S) (15-35%): Known as Belite. It is responsible for the gradual strength development of cement because it hybridizes within a year of adding water to cement. It also makes cement more resistant to chemical attack. If engineering structures require progressive strength, the C2S fraction is increased accordingly. B. Dams, hydraulic structures, bridges, etc.

Reactions in Concrete

Physical Contribution: Due to the very small size of silica fume compared to cement particles, it acts as a filler, filling the voids present in cement particles and greatly reducing permeability. This phenomenon is known as microfilling. or particle filling, which itself significantly improves the properties of concrete.

Chemical Contribution: Highly amorphous SiO2 from silica fume is a highly reactive pozzolanic material that reacts with CaOH liberated by the cement reaction in concrete to form additional binders in concrete. It forms calcium silicate hydrates that act as hydrates and improve the properties of concrete.

Improves Cohesion: In wet concrete, silica fume increases the cohesion of concrete, making it less likely to separate during placement and compaction. These properties result in improved blowing due to reduced rebound and increased blowing efficiency.

Reduced bleed: Microsilica has a very high surface area and a very low water content is typically used in fumed concrete, which minimizes concrete bleed-out. When bleeding is reduced, the capillaries formed by bleeding are also reduced, making them less permeable and more durable. This bleed reduction allows the finishing process to start earlier, resulting in faster build times and increased build efficiency.

Improving mechanical properties: Initially, microsilicic acid was mainly used to increase the compressive strength of concrete, but other effects such as improving the flexural strength and modulus of high-rise buildings were investigated. rice field.

Reduced Permeability: Durability is also a very important property of concrete that is directly related to permeability. Therefore, adding silica to reduce permeability can increase the durability of concrete and increase the life and maintenance costs of structures.

Chloride attack: RCC fails primarily due to corrosion of rebar. This is caused by chloride ingress into concrete from the sea and other sources. Chlorides penetrate the concrete through the pores present in it and corrode the reinforcement. This is minimized/retarded by adding silica fume to the concrete mix to reduce permeability. Adding silica fume to concrete can add years to the life of a structure.

Workability: Wet concrete containing microsilicic acid has higher cohesion and less segregation than concrete without microsilicic acid. Silica fume has been found to improve the workability of concrete.

2. MATERIALS

All materials used are described in the following sections. Grade 43 made by UltraTech Cement Ltd. The cement meets all American Society for Testing and Materials (ASTM) requirements and is IS 8112:1989 certified.

Ordinary Portland Cement (OPC) is the most commonly used cement for a variety of applications including:

- High Strength Concrete
- Masonry and Plastering
- Medium Strength Concrete
- Pipes and Blocks

Aggregates: The aggregates used are provided by local suppliers in accordance with IS 383 1970 and consist of two types: Consists of Type:

Coarse Aggregate: The coarse aggregate used included two size variations of 10mm and 20mm. 20mm aggregate accounts for 69% of the total coarse aggregate and 10mm aggregate accounts for 31% of the total coarse aggregate.

Fine Aggregate: The fine aggregate used was sand from a nearby river area that passed perfectly through a 4.75mm sieve and was free of clumps and gravel.

Silica Fume: The silica fume used was fresh, supplied by a local supplier, and in fine granular form (powder). Silica fume is a by-product of the manufacture of silicon metal or ferrosilicon alloys in industry. Also known as microsilica, it is an amorphous polymorph of SiO2 and consists of spherical diameters with a particle size of 150 mm. Due to its physical and chemical properties, it is a highly reactive pozzolana.

Additives: Air entertainers, water retardants, water reducers and accelerators are most commonly used. They are added to give special properties to wet or hardened concrete. It can improve the workability, durability, property strength, etc. of certain concrete mixtures.

3. Material Testing

1. CEMENT:-

1. Specific Gravity Test
2. Fineness of Cement:
3. Normal Consistency Test:
4. Setting Time
5. Compressive Strength Test

2. FINE AGGREGATE:-

1. Grading of Fine aggregate
2. Water Absorption Test
3. Specific Gravity Test

4. COARSE AGGREGATE:-

1. Water Absorption Test
2. Bulk Density Test
3. Sieve Analysis
4. Specific Gravity

Table -1: Properties of Cement

Property	Result
Fineness of cement	2% retained
Normal consistency	33%
Specific Gravity	3.15
Setting Time:	
Initial Setting time Final Setting Time	62.0 Minutes 180 Minutes
Compressive Strength	
7 Days	36 N / mm2
28 Days	58 N / mm2

Table -2: Properties of Fine Aggregate

Property	Result
Water Absorption	1.2
Specific Gravity	250%

Table -3: Properties of Coarse Aggregate

Property	Result
Water Absorption	0.59
Bulk Density	1535 Kg / m3
Specific Gravity-	
For 20 mm	2.72
For 10 mm	2.84

4. RESULTS AND DISCUSSIONS

Design grade of concrete used for testing purpose is M40 Percentages of silica fume used in mix are:

- 0%
- 5%
- 10%
- 15%
- 20%

Result of 0% silica fume concrete

Table -4: Result of 0% silica fume concrete

Specimen	Strength (MPa) at 7th day	Strength (MPa) at 28th day
1	30.62	45.71
2	31.57	46.98
3	29.95	44.99
4	28.16	45.1
5	30.95	46.87

Result of 5% silica fume concrete

Table -5: Result of 5% silica fume concrete

Specimen	Strength (MPa) at 7th day	Strength (MPa) at 28th day
1	31.25	48.9
2	32.63	46.26
3	32	47.1
4	33.3	48.35
5	33.67	48.89

Result of 10% silica fume concrete

Table -6: Result of 10% silica fume concrete

Specimen	Strength (MPa) at 7th day	Strength (MPa) at 28th day
1	37.65	50.3
2	38.5	51.85
3	38.2	49.84
4	39.23	52.63
5	39.02	52.18

Result of 15% silica fume concrete

Table -7: Result of 15% silica fume concrete

Specimen	Strength (MPa) at 7th day	Strength (MPa) at 28th day
1	44.26	57.23
2	46.65	59.35
3	44.55	59.02
4	45.52	55.68
5	43.02	55.92

The data so observed in here plotted and compared

Table -8: Average values of cube strength

Percentage of Silica used (%)	Strength (MPa)	
	7 Days	28 Days
0	30.25	45.93
5	32.57	47.9
10	38.52	51.36
15	44.8	57.44
20	39.14	54.37

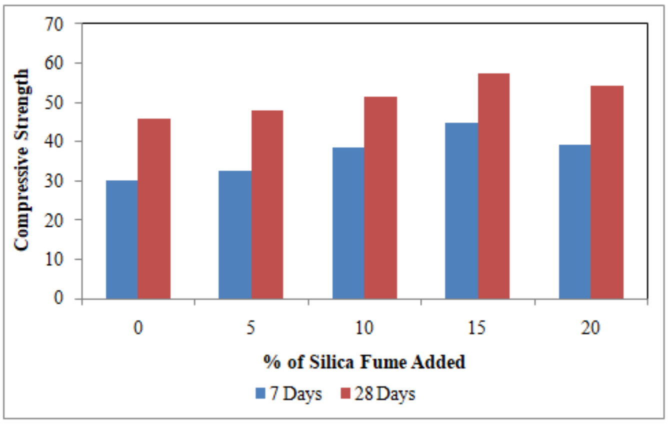

Chart -1: Comparison of compressive strength

3. CONCLUSIONS

Based on this project, we can draw the following conclusions:

1. Both 7 days and 28 days compressive strength increases as percentage of Silica Fume increases.
2. The optimum addition level of silica fume is about 15%.This is the level that gives the best results.

3. Since most concrete properties are found to correlate with compressive strength, other properties such as stress-strain ratio, tensile strength, bond strength, modulus, density, impermeability and durability are dependent on these properties. It is no exaggeration to say that is also improved.

4. 4Due to these effects, fumed silica concrete is widely used around the world to produce high strength and durable concrete.

5. Silica in small amounts can provide so many benefits that it is a very useful adjunct to conventional concrete.

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