

Mineralogical Study on High Volume Silica Fume Concrete at Elevated Temperatures By Xrd Analysis

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Abstract

Waste disposal is one of the major problems being faced by all the nations across the globe. Silica fume is a byproduct of producing silicon metal or ferrosilicon allovs. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolanic. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor. The advancement of concrete technology can reduce the consumption of natural resources and reduce the burden of pollutants on the environment. In this project changes in mechanical and mineralogical properties of high volume silica fume concrete exposed to elevated temperature from 200°C to 800°C at an interval of 200°C for 24hr duration is investigated and compared with conventional concrete. The mechanical properties studied are

shows better results than conventional concrete mix. C85S15 concrete mix has attained the higher residual compressive strength than C90S10, C80S20 and conventional concrete (C100) mixes at all temperatures. C80S20 concrete mix shows Lower % Residual strengths at elevated temperatures, So that fire resistance Decreases with increment of Silica fume content. Weight loss is noticed considerably more in conventional concrete mix compared to fly ash concrete mixes. Cracks are observed in all mixes between 600°C to 800°C. XRD results shows, At 400°C Calcite peaks were completely disappeared and it has decarbonated to form free lime and released CO2 gas. Any available sulphate can react with free lime to form anhydrite. Silica fume mixed samples exhibited change in colour from grey to red -Orange between 600°C to 800°C, which is due to possible formation of Fe-silicates/hematite. At 800°C, water is rapidly lost from cementitious gels and any ettringite present. After heating to 800°C,



major fire resistant and shrinkage were observed in Silica fume concrete. Another new phase Wollastonite is formed due to the reaction of quartz with free lime at CaO: SiO2=2. When CaO: SiO2=3 larnite is formed. The formation of new phases also depends on the ratio of CaO: SiO2.

Key words: XRD analysis,M40,silica fume,fe silicates,CO2 etc.,

1.Introduction

Concrete is the most versatile construction material due to its high compressive strength and mouldability. It is most widely used material and it is estimated that the second highest consumed material in the world. As the consumption of concrete increases day by day, the use of cement also increases tremendously. The increasing scarcity of raw materials and an urgent need to protect the environment against pollution has accentuated the significance of developing new building materials.

The search for alternative binders, or cement replacement materials, has been carried out for decades. Research has been conducted on the use of pozzolans such as Silica fume, or any other materials as cement replacement materials. These materials can also improve the durability of concrete and the rate of liberation of heat, which is beneficial for mass concrete. Pozzolanic concretes are used extensively throughout the world, where oil, gas, nuclear and power industries are among the major users. The applications of such concretes are increasing day by day due to their superior structural performance, environmental friendliness, and energy conserving implications. Although concrete is generally believed to be an excellent fire proofing material, but there is extensive damage or even catastrophic failure at high temperatures. At high temperatures, chemical transformation of the gel weakens the matrix bonding, which brought about a loss of strength of concrete.

Silica fume

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 upto 2,000C produces SiO2 vapours, which oxidizes and condense in the low temperature zone to tiny particles consisting of non- crystalline silica.

Effect Of Silica Fume On Properties Of Concrete:

rheological properties of a fresh cement paste play an important role in determining the workability of concrete. The water requirement for flow, hydration behaviour, and properties of the hardened state largely depends upon the degree of dispersion of cement in water.

X-Ray Diffraction (Xrd)

X-ray diffraction (XRD) is a rapid analytical technique primarily used for phase identification of a crystalline material and can provide information on unit cell dimensions. X-ray diffraction is most widely used for the identification of unknown crystalline materials (e.g. metals, minerals, inorganic compounds). XRD measures the intensities of a reflected X-Ray beam from a small area.

Scope

Limited literature is available on high volume Silica fume concrete at elevated temperatures up to 800°C and mineralogical changes in it. The scope of the project is to study the effect of elevated temperatures on high volume Silica fume concrete (i.e. cement is replaced up to 20% of by its weight) and to study the mineralogical changes by using X-Ray Diffraction Test and comparing with conventional concrete.

Aim And Objective

The main objective of testing is to know the behavior of concrete with replacement of cement with high volume Silica fume at elevated temperatures. The main parameters are residual compressive strength, weight loss and mineralogical changes by X-Ray Diffraction Test.

To study the residual compressive strength of HVSF concrete with replacement levels of 10%, 15%, 20% by mass of cement exposed to elevated temperatures 200°C to 800°C at an interval of 200°C exposed to 24 hours duration and comparing residual compressive strength, weight loss and etc, with normal concrete.

2.Literature Review

N. Bouzouba et al.[11] presented the Self Compacting Concrete Incorporating High-Volumes of Class F Fly Ash. Self-compacting concrete (SCC) has gained wide use for placement in congested reinforced concrete structures with difficult casting conditions. The fresh concrete must possess high fluidity and good cohesiveness. The use of fine materials such as fly ash can ensure the required concrete properties. In this study, cement is replaced by 40, 50, and 60% by Class F fly ash while the water/ cementitious material ratios ranged from 0.35 to 0.45. Tests are carried out on all mixtures to obtain the properties of fresh concrete in terms of viscosity and stability. The mechanical properties of hardened concretes such as



compressive strength and drying shrinkage are also determined. Compressive strength at 40, 50, 60% of fly ash with w/c ratios 0.35, 0.45,0.55 were performed. Concrete developed compressive strengths ranging from 15 to 31 MPa, and from 26 to 48 MPa, at 7 and 28 days, respectively. This investigation shows that it is possible to design a self compacting concrete incorporating high-volume of Class F fly ash, which increases the compressive strength.

Phan et al.[12] reported on effects of elevated temperature exposureon residual mechanical properties of High Performance Concrete (HPC). Heating the 102 x 204 mm cylinders to steady state thermal conditions at a target temperature, and loading them to failure measured residual mechanical properties after the specimens had cooled to room temperature. The test specimens were made of four HPC mixtures with water-cementitious material ratio (w/cm) ranging from 0.22 to 0.57, and roomtemperature compressive strength at testing ranges from 51 MPa to 93 MPa. Two of the four HPC mixtures contained silica fume. The specimens were heated to a maximum core temperature of 450oC, at a heating rate of 5oC/min. Experimental results indicate that HPCs with higher original strength (lower w/cm) and with silica fume retain more residual strength after elevated temperature exposure than those with lower original strength (higher w/cm) and without silica fume. The differences in modulus of elasticity are less significant. However, the potential for explosive spalling increased in HPC specimens with lower w/cm and silica fume. An examination of the specimens heating characteristics indicate that the HPC mixtures which experienced explosive spalling had a more restrictive process of capillary pore and chemically bound water loss than those which did not experience spalling.

3. Experimental Investigation

The various materials used in the experimentation namely cement, three supplementary cementitious materials, coarse aggregate, fine aggregate and Silica Fume have been tested in the laboratory and the results are described. These materials are used for casting concrete in our thesis work. The specifications and properties of these materials were presented in this chapter. All the materials used in the study were tested in accordance to the Indian standards. IS mark OPC 53 grade cement is used for all concrete mixes. The cement used was fresh and without lumps. Testing of cement was done as per IS 4031-1988[26].

Fine Aggregate

The locally available river sand conforming to zone-II of IS 383:1970[27] has been used as fine aggregate. The fine aggregate are clean, inert and free from organic matter, silt and clay.

Coarse Aggregate

The locally available crushed granite stone is used as coarse aggregate. These coarse aggregates having the maximum size of 10 mm and 20mm were used in the present work. The 10mm aggregates used were first sieved through 10mm sieve and then through 4.75 mm sieve and 20mm aggregates were firstly sieved through 20mm sieve. They were then washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested per Indian Standard Specifications IS: 383-1970[27]

Siica Fume

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for **silica fume** is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing **silica fume** can have very high strength and can be very durable.

Mix Design Procedure

The main object of concrete mix design is to select the optimum proportions of the various ingredients of concrete which will yield fresh concrete of desirable properties like workability and hardened concrete possessing specific characteristic compressive strength and durability.

Table 1 Mix Design

| Mn Ne | Mix Design file | Cement (kg/m3-) | Fly ash (kg:m3) | Fine Aggregate | Course aggregate | w/b catle | Comps | evity th (MPa) |
|----------|--------------------|--------------------|--------------------|-------------------|---------------------|-----------|-------|-------------------|
| | | | | (log/mi 3) | (kg/m3.) | 5 | 7days | 28days |
| 1. | C100 | 360 | 0 | 623 | 1084 | 0.40 | 34.1 | 42.3 |
| 2 | C100 | 360 | R : | 702 | 1200 | 0.40 | 31.2 | 49.7 |
| 1 | C100 | .360 | 0 | 674 | 1294 | 0.40 | 32. | 51.1 |
| 4 | CHELE | 324 | 36 | 674 | 1284 | 0.45 | 36. | - 35 |
| 3 | C83815 | 300 | - 54 | 762 | 1200 | 0.40 | -40 | 51.0 |
| 6 | C81820 | 288 | 72 | 734 | 1155 | 8.40 | 32 | 38 |

4 Presentation Of Results

Cement Ordinary Portland cement of 53grade from a single batch was used for entire work and care has been taken that it has to been stored in airtight containers to prevent by atmosphere and humidity. The cement was tested for physical requirements in accordance with IS: 12269: 1987[32] and for

Cement



chemical requirements in accordance with IS: 4032: 1977[33], properties of cement are tabulated in Table 4.1.

Table 2 Physical and Mechanical Properties of Cement

| 8.5% | Furthendare of Test | Tant . | As prevoide | Rafey and Di souls |
|------|-------------------------|-----------|-------------|----------------------------|
| . 4. | Sportfly proving | 3.15 | 3-3.22% | 18 2730 per 103 |
| | Finemen | 8.63 | Adam Tri- | Dil 4007 Lignari Di 214940 |
| . A. | Nossadores | | | an and I span this steer. |
| .4. | Similard contrastory | 3346 | 24-2396 | 04-8031 (part 197): Unite |
| | Internal spinning since | | ~ 30mins | 95 40033 (part V): 49400 |
| | Final setting tites | | < 0000000 | an destroyees why, press |
| | Compression one | nages. | | |
| | and-Dear-chilling | 30 Netaan | 25 | IS 4033 spart Ville 1998 |
| | un 7-Derus Million | an Nimm | - 12.5 | |
| | anth-Deprivation | nd Scheen | = = = | |

Fine Aggregate The river sand, passing through 4.75mm sieve and retained on 600µm sieve, conforming to Zone-II as per IS 383: 1970[27] was used as fine aggregate in the present study. The aggregate was tested for its physical requirements such as specific gravity, fineness modulus and bulk density in accordance with IS 2386: 1963[28].

Table 3 Properties of Fine Aggregate

| | and the second | | | | | |
|--------|---|--------------|--------------------------|--|--|--|
| 5.NO | Particulars of test | Value | Recommended 15 codes | | | |
| 1 | Specific gravity | 2.62 | IS 2386 (Part III): 1963 | | | |
| 2 | Water absorption | 0.4% | 15 2386 (part III): 1963 | | | |
| 3 | Balk density Roddal bulk density Loose bulk density | 1718 1518 | IS 2386 (part III): 1963 | | | |
| - 4. · | Finenesa medaha | 2.69 | IS 2386 (part l): 1963 | | | |
| 5 | Zane | п | 25 383: 1970 | | | |

Coarse Aggregate Throughout the investigations, a crashed coarse aggregate of 20mm size from the local crushing plants was used. The aggregate was tested for its physical requirements such as specific gravity, fineness modulus and bulk density in accordance with IS 2386: 1963[28] and IS 383: 1970[27].

| Table 4 | Properties | Of Coarse | Aggregate |
|---------|------------|-----------|-----------|
|---------|------------|-----------|-----------|

| | A CONTRACT OF A | | 00 0 |
|------|---|--------------|--------------------------|
| S.NO | Particulars of text | Value | Recommended IS codes |
| 1 | Specific gravity | 2.64 | 15 1386 (Part III): 1963 |
| 2 | Water absorption | 0.4% | 15 2386 (part III): 1963 |
| 3 | Bulk density Rodded bulk density Loose bulk density | 1405 1477 | 15-2386 (part 10): 1963 |
| 4 | Finances medulus | 7.357 | 15 2386 (part I): 1963 |
| 5 | Impact value | 17.4% | 15 4031 (part IV): 1996 |
| 6 | Creating value | 26.13% | 18 4031 (part IV); 1996 |
| , | Flakiness Index 20 mm 10mm | 12,81% | 2000 |
| * | Elongation Index 20mm 10mm | 20.5% | |

Silica Fume This Silica fume conforms to the requirement of IS 3812(part I):2003[34]. The specific gravity of Silica fume is found to be 2.1. The particles are in the form of solid spheres with sizes

ranging from less than 1 μ to 100 μ and an average diameter of 20 $\mu.$

Table 5 Chemical Properties Of Silica Fume

| 1.00 | Characteristics | Regularements (%) |
|----------|--|------------------------|
| 000000 | 1 | Silicona (silica fame) |
| 19- C | Silkon dioxide (SO2) + aluminium inside (Al2O3) + iron-oxide (Fu2O3), percent by mass. Mis. | 26.0 |
| 2. | Silicon dowide (SiO2), percent by man, Min. | 35.0 |
| . | Magnesium oxide (MgO), percent by mass, Max | 50 |
| 4. | Total adpliar as addfar trincide (SO3), percent by men, Mas. | 3.0 |
| 9, | Available alkalis as automorale (9/420), provid by mass. Mex. | 1.5 |
| 4. | Loss on Ignition, percent by mass, Max. | 3.0 |
| . 9. | Motetore content, percent by man- | 3.0 |
| | | |

Table 6 Physical Properties Of Silica Fume

| Characteristics | Requirements for silica fume |
|--|--|
| Fineness-specific surface in m ² Ag by Blaine's permutility method, min % | 320 |
| Particles mained on 45µ IS sieve (wet sieving) in present, max % | 34 |
| Line reactivity- average compressive strength in Nimm ² , min % | 4.5 |
| Compressive strangth at 28 days at N/mm ² ,min 76 | Not less than 30% of the drongth of corresponding plais centent montar cubes |
| Soundness by autoclave test expansion of specanes in percant, max % | 0.8 |
| | Characteristics Fineness-specific sarface in m ² /kg by Blaine's permutility method, min % Particles retained on 45µ IS sieve (wet sieving) in protent, max % Line reactivity-average compressive strength in Nitrum ² , man % Compressive strength at 28 days in N/trum ² , min % Soundless by actoclave test explanation of speciment in percent, max % |

Super Plasticizer Conplast - SP430. It has been specially formulated to give high water reductions up to 25% without loss of workability or to produce

high quality concrete of reduced permeability.

Conplast SP430 is non-toxic.

Table 4.6 Properties of Conplast - SP430

| S.No | Characteristics | Value |
|------|------------------|-------------------|
| 1 | Color | Dark brown liquid |
| 2 | Specific gravity | 1.2 |
| 3 | Air entrainment | Max. 1% |

Weight Loss Weight losses of specimens are determined by taking weights before and after keeping specimens into furnace.

Table 7 Weight Losses for 7 Days

| S.No. | Temperature | C100 | C90510 | C85815 | C8052 |
|-------|-------------|------|--------|--------|-------|
| 1 | 27°C | 0 | 0 | 0 | 0 |
| 2 | 200°C | 3.6 | 2.2 | 2.0 | 1.8 |
| 3 | 400°C | 4.1 | 3.9 | 3.7 | 3.6 |
| 4 | 600°C | 4.6 | 4.5 | 4.2 | 3.9 |
| 5 | 800°C | 6.1 | 5.3 | 4.9 | 4.8 |



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Fig1: Comparison of Weight losses at differenttemperaturesofC100,C90S10,C85S15 and C80S20 MIX for 7days.

Weight loss percentages for 28 days are shown in below table:

| Table | 8 | W | eight | Losses | for | 28 | Days |
|-------|---|---|-------|--------|-----|----|------|
| | - | | | | | | |

| S.No | Temperature | C108 | C90510 | C85515 | C8052 |
|------|-------------|------|--------|--------|-------|
| 1 | 27°C | 0 | 0 | 0 | 0 |
| 2 | 200°C | 1.5 | 2.8 | 1.8 | 1.9 |
| 3 | 400°C | 4 | 3,7 | 43 | 4.3 |
| -4 | 600°C | 4.6 | -4.7 | 5.3 | 4.6 |
| 5 | 800°C | 5.4 | 5.7 | 5.7 | 5.5 |

Residual Compressive Strengths Table 9 Residual Compressive Strengths

| 5. NO | TEMPERATUE | | ESIDUAL | COMP | RESSIVI | E STRENGTHS, MPa 28 days | | | | |
|-------|--------------------|------|---------|--------|---------|-----------------------------|--------|--------|------------------------|--|
| | 100404.0A0000 | | | 7 days | | | | | | |
| | 1 | C100 | C90510 | 085515 | Caus20 | C100 | CHENIO | C85515 | 199 41 365 25 | |
| 4 | 27.°C | 39 | 43 | 44,6 | 33 | 50.3 | 50.7 | \$5,4 | 39 | |
| 2 | 200 °C | -41 | 44.4 | 45.5 | 35 | 52.7 | 52.8 | 56.5 | 41 | |
| 3 | 400 ⁰ C | 36 | 40.3 | 39.7 | 30,4 | 43.6 | 41.8 | 49.8 | 36.5 | |
| 4 | 600 ⁰ C | 28 | 22.3 | 23.5 | 22.5 | 32.8 | 30.7 | 32.5 | 25 | |
| 3 | 800 °C | 18 | 17.5 | 13 | 10.5 | 22.3 | 21.6 | 20.8 | 16 | |



Fig2: Comparison of Residual compressive strength Vs Temperature C100,C90S10,C85S15 and C80S20 mix for 7days.



Fig3: Comparison of Residual compressive strength Vs Temperature of C100,C90S10, C85S15 and C80S20 mix for 7days.

Table10 % Residual Compressive Strengths

| 5.NO | TEMPERATUR | % RESIDUAL COMPRESSIVE STRENGTHS | | | | | | | | |
|------|---------------------|----------------------------------|--------|---------|--------|---------|--------|--------|--------|--|
| | | 7 days | | | | 28 days | | | | |
| | | C100 | CHISIO | Citists | CBIN29 | C186 | C96510 | 030515 | C88519 | |
| i | 27 ¹⁶ C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |
| 3 | 200 ⁰ C | 105.12 | 102.32 | 102 | 106.06 | 104.77 | 106.11 | 101,98 | 105.12 | |
| 3 | 400 ⁰ C | 92.3 | 93.72 | 92.12 | 74.78 | 86.35 | 78.86 | 89.89 | 89,02 | |
| .4 | 600 ¹⁰ C | 71.79 | 51.8 | 54,65 | 61.71 | 74.01 | \$7.92 | 38.66 | 68,49 | |
| . 5 | 800 ⁰ C | 46.15 | 40.09 | 29.14 | 29.74 | 44.35 | 41.13 | 37.54 | 64 | |



Fig4.: Comparison of % Residual compressive strength Vs Temperature of C100,C90S10, C85S15 and C80S20 mix for 7days.



Fig5: Comparison of % Residual compressive strength Vs temperature of C100,C90S10, C85S15 and C80S20 MIX at 28days.

X-Ray Diffraction



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Fig6: XRD Testing Machine. X-Ray Diffraction Test results are shown below:



Fig 7: XRD data (phase peak labels) for C100 mix at 27^{0} C.



Fig8: XRD data (phase peak labels) for C100 mix at 400°C.



Graph 9: XRD data (phase peak labels) for C100 mix at 800⁰ C.



Graph 10: XRD data (phase peak labels) for C85S15 mix at 27°C.



Fig11: XRD data (phase peak labels) for C85S15 mix at 400^o C.



Fig 12: XRD data (phase peak labels) for C85S15 mix at 800°C.

Table no 11Quantity of different phases those are present in C100 mix and C85S15mixat different temperatures analysed by XRD

| | CONTENT % | | | | | | | |
|---------------|-----------|-------|----------|------|-------|-------|--|--|
| PHASE NAME | (| 2100 | | SF15 | | | | |
| | 27 C | 400 C | 800 C | 27 Č | 400 Č | 800 C | | |
| QUARTZ | 29.7 | 34 | 22.2 | 23.5 | 36.4 | 12.9 | | |
| PORTLANDITE | 2 | 3 | | 2 | 2 | 1 | | |
| ALITE | 2 | 5 | 7.1 | 2 | 5.1 | 4 | | |
| BELITE | | | | | | | | |
| ALBITE | 6.9 | 9 | 9.1 | 14.3 | 12.1 | 10.9 | | |
| ETTRINGITE | 2 | 7 | <u> </u> | 1 | 5.1 | 2 | | |
| ANHYDRITE | 2 | 2 | 2 | | 1 | 1 | | |
| ANORTHITE | 11.9 | 19 | 19.2 | 22.4 | 24.2 | 24.8 | | |
| AKERMANITE | 1 | 1 | 2 | 1 | 1 | 2 | | |
| CALCITE | 1 | | 3 | 2 | | 2 | | |
| DIOPSIDE | 3 | 6 | 1 | 2 | 12.1 | 2 | | |
| FAYALITE | 1 | 2 | 2 | | 2 | 1 | | |
| LAIHUNITE | | 4 | 4 | 2 | | 2 | | |
| GEHLENITE | 6.9 | | 1 | 1 | | | | |
| HEMATITE | 1 | | 1 | 1 | | | | |
| VATERITE | | | 2 | 5.1 | | 3 | | |
| WOLLASTONIT | 11.9 | 4 | 7.1 | | | 9.9 | | |
| DOLOMITE | | 1 | 1 | 2 | | | | |
| MAGHEMITE | 11.9 | | | | | | | |
| GYPSUM | 3 | | 3 | | | 2 | | |
| LARNITE | 3 | 4 | 10.1 | 3.1 | | 3 | | |
| ORTHOCLASE | | | | | | 16.8 | | |

Comparison of Quantity of different phases those are present in C100 mix and C85S15 mix at 27° C and 400°C analysed by XRD Test



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Fig13: Comparison of Quantity of different phases that are present in C100 mix at 27 C and 400 C analysed by XRD Test.

XRD Comparison of C100 mix at 27oC, 400oC and 800oC is shown below:



Fig15: XRD Comparison of C100 mix at 27°c,400°c and 800°c.

XRD Comparison of C85S15 mix at 27oC, 400oC and 800oC is shown below:



Fig16:XRD Comparison of C85S15 mix at 27°C, 400°C and 800°C is shown below: 5 Posults And Discussions

5 Results And Discussions

Depending on results discussions are prepared. The main aim of testing is to know the behaviour of high volume Silica fume concrete at elevated temperatures and study of mineralogical change in it. So that a result of normal (C100) concrete is compared with results of high volume Silica fume (C90S10, C85S15and C80S

Residual Compressive Strength

In normal mix residual compressive strength increased upto 200°C, after that strength loss occurred. In silica fume mixes residual compressive strength increased upto 200°C then slightly decreases

upto 400°C major strength loss occurred after 600°C. For 7days, Normal concrete shows higher Residual compressive strength than Silica fume mix" s at all temperatures. As the percentage of Silica fume content increases compressive strength decreases gradually. For 7days, Residual compressive strength of C100, C90S10, C85S15 and C80S20mixes increases gradually upto 200oC with an increment of 02%, 05%, 07% and 07%. At 800oC decreases 61.8%, 50%, 59.4% and 66.7% respectively. For 7 days at C100, C90S10, C85S15 and C80S20 mixes decreases 27.6%, 31.9% and 36.1% when compared to C100 mix. For 7 days at 400oC,C90S10,C85S15and C80S20mixes decreases 22.2%,12.72% and18.18% when compared to C100 mix. For 7 days at 800oC, C90S10, C85S15 and C80S20 mixes decreases 5.5%, 27.7% and 44.4% when compared to C100 mix. For 28 days, Silica fume mixes shows impressive Residual compressive strength than normal mix. For 28 days,Residual compressive strength of C100, C90S10, C85S15 and C80S20 mix increases gradually upto 200oC with an increment of 02%,05%,07%,and 07%. At 800oC decreases 60.4%, 59.5%, 57% and 54%. For 28 days at 27oC,C85S15 mix increased 4.9% and C80S20 decreases 4.95%, when compared to C100 mix For 28 days at 400oC C90S10, C85S15 and C80S20 decreases 10.3%, 4.31% and 1.7% when compared to C100 mix. For 28 days at 800oC,C90S10, C85S15 and C80S20 increased 7.5%. 3.5% and 5% when compared to C100 mix. C80S20 mix shows higher percentage increment of Residual compressive strength. So Silica fume mixes shows better percentage increment of Residual compressive strength, when compared to normal concrete mix. C50F50 mix shows higher percentage increment of Residual compressive strength, when compared to all other mixes. So that C80S20 mix have good fire resistance. As the percentage replacement level of Silica fume increases fire resistance will increase. Effect of phase composition on residual compressive strength by XRD. Silica fume mixes show higher compressive strength than normal concrete mix at 27°C this increase in strength due to micro filler effect coupled with pozzolanic reaction with calcium hydroxide (CH). The normal concrete mix show higher residual compressive strength at 200°C due to the drop in calcium hydroxide (CH) and unhydrated (UH) area fraction which is beneficial for the micro structure. And also due to the quantity increment of strength giving phases like quartz, ettringite (before hydration), diopside and etc., Silica fume mixes show increased compressive strength at 400°C. This



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increase in strength may partially be due to the additional hydration of the unhydrated cement grains resulting from stream effect under the condition of internal autoclaving or due to evaporation of free water leading to greater van-der-waal" s forces as a result of cement gel layer moving close to each other. And also due to the quantity increment of strength phases like quartz, ettringite(before giving hydration), diopside and etc.. The decomposition of major hydrate C-S-H is inevitable when the concrete is exposed to 650°C, causing loss of binding property. Moreover, at 800°C all concrete specimens show severe deterioration due to decomposition of C-S-H gel and formation of new phases like laihunite, larnite. ettringite (after hydration). Weight Loss Conventional concrete samples have much higher weight loses compared to Silica fume mix samples. Weight loss increased with the increase of elevated temperature. Mineralogical reason Initial weight losses are due to the evaporation of capillary water followed by escape of adsorbed and inter layered water. Above 400°C, weight loss is due to thermal decomposition of constituents of hydration products. In conventional concrete higher weight losses due to presence of higher quantities of gel H2O, ettringite, calcite and portlandite. Ettringite

(3CaO.Al2O3.3CaSO4.26H2O),Portlandite(Ca(OH)2)) and Gypsum(CaSO4.2H2O) have water content in it. If these are exposed to elevated temperatures water gets evaporated so that weight loss will occur. Calcite will decarbonate to form free lime and co2 gas. In Silica fume mixes eight loss due to oxidation of Fe to Fe2O3 and crystalline change in Fe2O3. And also due to combustion of traces of residual organic matter presence. Weight loss decreased with increase in the replacement level and increased at elevated temperatures.

Colour Changes

Mineralogical Reason Silica fume mix samples exhibited a shifting colour from grey to red-orange between 600°C to 800°C, which was associated with the possible formation of Fe-silicates/hematite. This can be directly linked to Fe present in the majority Silica fume component of the Silica fume cement. No such drastic colour change was observed in the normal concrete. Slightly yellowing at above 800°C is likely to be due to sulphur formation from sulphides in any blast furnace slag present.



Fig 17: C100 mix at 800°C



Fig 18: C80S20 mix at 600°C



Fig 19: C100 mix at 00°C Fig 20: C100 mix at 800°C



Fig 20: Comparison of C100 mix at 200°C and 800°C

Aggregate Crushing The specimens are subjected to 800°C temperature and then allowed to compression test the aggregates are broke down and colour of the aggregates also changed as shown in below figure.



Fig 21: Broken aggregate after testing and colour change of aggregate is observed at 800°C.

Xrd Result The presence of a quartz peak at $27^{\circ} 2\theta$ is a result of MS cement having been blended withminor quantities of unspecified pozzolanic



additions. After treatment at 400°C, the only notable change in crystalline phases was the disappearance of ettringite signals. However. after treatment at 800°C. portlandite peaks disappeared, calcite peaks were greatly reduced and the formation of a dominant broad set of peaks due to poorly ordered crystals diffracting between 30° and 2θ appeared. Diffraction in this 34° particular region corresponds well to alite and belite as well as nonhydraulic phases such as akermanite, gehlenite and etc., е

| Γat | ble | 12: | Role | of | Different | Phases | in | Concrete |
|-----|--|-----|---|----|---|--------|----|----------|
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| S.No | Phase name | Chemical formula | Role | | |
|------|---------------------------|-----------------------------|---|--|--|
| 1 | Quanz | 5102 | It gives hardness to crystalline structure, so that increases the strength. | | |
| 2 | Anorthite | Ca Al2 Si2O8 | Increases crystalline naturo. | | |
| 3 | Wolfastonite | Ca SiO3 | Decreases shrinkage and gas evolution during firing, increases firedstrength, maintains brightness during firing, permits fast firing cracking, and glazedefects. | | |
| | Lailumite and Fayalite | Fe1.6 SiO4 and Fe2 SiO4 | Weight loss, cintering process, Colour changes and strength influence. | | |
| 3 | Portlandite | Ca (OH)2 | Increases bond strength, Weight loss and strength. | | |
| 6 | Calcite | CaCO3 | Weight loss and strength. | | |
| 7 | Albite | 3CaO.SiO2 | Albite forms solid solution with anorthite. This process leads to the transformation of albite layer into the e-s-h gel phase and has improved the strength property. | | |
| * | Ettringite | 3CaO,Al2O3.3CaSO4. 26H2O | Improved the strength and Weight loss and drying shrinkage at lower temperatures. | | |
| | Hematite/ Meghamite | Fe2O3 | Colour changes and weight loss | | |

Calcite peaks were completely dis-appeared only at 400°C. Calcite will decarbonate to form free lime and release CO2 gas. Any available sulphate can react with free lime to form anhydrite. At 800°C, water is rapidly lost from cementitious gels and any ettringite present. After heating to 800°C, major strength gains and shrinkage are observed in Silica fume concrete. All peaks due to calcite or vaterite disappeared and new crystalline phases, potentially corresponding to albite (Al), wollastonite (W) gehlenite(G)and possibly anorthite (a) and diopside (D) are noted. Sintering occurred in Silica fume mix" s but not in normal mix due to presence new crystalline phase laihunitea iron silicate, which plays significant role in sintering process at 600- 800°C. Wollastonite is formed due to the reaction of quartz with free lime at CaO: SiO₂= 2. When CaO: SiO₂=3 larnite is formed. The formation of new phases also depends on the ratio of CaO: SiO2. **6**conclusions

• For 7 days, Normal concrete shows higher Residual compressive strength than all Silica fume mixes at all temperatures. As the percentage of Silica fume content increases compressive strength decreases gradually.

• For 28 days, all Silica fume mixes shows impressive Residual compressive strength than normal mix at elevated temperatures. So high volume Silica fume mixes increases Residual compressive strength with increase in age of concrete.

In normal mix residual compressive strength increased upto 200°C ,after that strength loss occurred. Where as in Silica fume mixes residual compressive strength increased upto 200°C then slightly decreased upto 400°C. Major strength loss occurred after 600°C.

• C85S15 mix shows higher residual compressive strengths than all other mixes at all temperatures.

• C80S20 mix shows lower % residual compressive strength at all temperatures than all other mixes. C85S15 mix acts as better fire resistant than all other mixes. Silica fume mixed concretes acts as good fire resistant than normal concrete at elevated temperatures.

· In Silica fume mixed samples formation of Fesilicates/hematite exhibited a change in colour from grey to red-orange between 600°C to 800°C.

• Weight loss was much more in normal concrete mix compared to Silica fume concrete mixes. Cracks were observed in all mixes between 600°C to 800°C.

• Better cost economy due to lower material cost and highly favorable lifecycle cost.

Further extension of thesis work

• Curing periods can be extended for further 56 and 90 days because Silica fume

strength increases with increase in age of concrete.

• Both air cooling and water cooling methods can bedone to cool down the specimens that are exposed to fire and compared.

• Mineralogical and morphological studies can also be done by SEM- EDX.

Split tensile strength, Flexural strength andYoung" s Modulus can also be calculated.

• There is a scope to use other pozzolanic materials such as Metakaolin, Ceramic powder or Rice husk ash.

REFERENCES

[1] AbidNadeem, Shazim Ali Memonb, Tommy Yiu Lo, "The performance of Silica fume and Metakaolin concrete at elevated temperatures". Construction and building materials 62 (2014) 67-76.



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[2] K.N.Vishwanath, Dr. N Suresh, "Silica fume composite concrete under sustained elevated temperature". International Journal of Engineering Research & Technology (IJERT). ISSN: 2278-0181 Vol. 1 Issue 5, July- 2012.

[3] Shane Donatello a*, CarstenKuenzel b, Angel Palomo a, Ana Fernández Jiménez a, "High temperature resistance of a very high volume Silica fume cement paste". Cement & Concrete Composites 45 (2014) 234–242.

[4] D.K. Soni and JasbirSaini , "Mechanical Properties of High Volume Silica fume (HVSF) and Concrete Subjected to Evaluated 120 °C Temperature". International Journal of Civil Engineering Research. ISSN 2278-3652 Volume 5, Number 3 (2014), pp. 241-248.

[5] HarunTanyildizi ,AhmetCoskun, "The effect of high temperature on compressive and splitting tensile strength of structural lightweight concrete containing Silica fume". Construction and building materials 22 (2008) 2269-2275.

[6] Omer Arioz, "Effects of elevated temperatures on properties of concrete". Fire safety journal 42 (2007) 516-522.

[7] George Mathew and Mathews M. Paul., "Influence of Silica fume and GGBFS in Laterized Concrete Exposed to Elevated Temperatures". Journal of materials in civil engineering, ASCE, March 2014, pp. 411-

[8] Ankur.A.PatelMrs.Deepa.A.Sinha, "An Experimental Investigation On The Effect Of Silica fume And Metakaolin On Steel Fibre Reinforced Concrete At Temperature Up to 200 °c". Proceedings of the National Conference on Recent Trends in Engineering & Technology", 13-14th May, paper Id-101067.

[9] Pavelpadevět, Romanalovichová, "The Changes of Material Properties of the Cement Paste with Fly Ash Exposed to High Temperatures". WSEAS transactionson applied and theoretical mechanics. E-ISSN: 2224-3429. Issue 4, Volume 8, October 2013. PP. 304-312.

[10] Indrajit Patel, C D Modhera, "Study Basic Properties OfFiber Reinforced High Volume Silica fume Concrete". Journal of Engineering Researchand Studies, Vol. I, Issue I, July-Sept. 2010, PP.60-70.