Effects of Elevated Temperature on Cement Mortor by Adding Sodium Silicate

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ABSTRACT :

The main aim of our project is to increase the fire resistance in mortar by adding certain chemicals which has high fire resisting property. We are adding a chemical called sodium silicate in two different proportions. Then heating the mortars at various temperature such as 300^0 C, 600^0 C. Generally, sodium silicate is a glass forming aggregate. Sodium silicate is the common name for compounds with the formula $Na_2(SiO_2)_nO$. A well known member of this series is sodium Metasilicate, Na_2SiO_3. Also known as waterglass or liquid glass, these materials are available in aqueous solution and in solid form. The pure composition are colourless or white, but commercial samples are often greenish or blue owing to the presence of iron-containing impurities.

Cement mortar treated with a sodium silicate solution helps to reduce the porosity in most masonry products. A chemicals reaction occurs with the excess $Ca(OH)_2$ (portlandite) present in the cement mortar that permanently binds the silicates on the surface and making them more durable and water repellent. It gives passive fire protection. The reason for choosing this chemical is that it is expensive. While making a mortar cube of 1% and 2% of sodium silicate, we can found the glassy layer formed on all sides of mortar cube. On testing these specimens it was found that adding 1% and 2% of sodium silicate was giving more fire resistance, but compressive strength was reduced to some extent. So the optimum content of the percentage of sodium silicate has to be added.

Key words: *cement mortar, sodium silicate, portlandite, liquid glass.*

i. INTRODUCTION

Concrete and cement has excellent properties in regards of fire resistance compared with other materials and can be used to shield other structural materials such as steel. Effects of high temperatures on mechanical properties of concrete and cement have been investigated as early as the 1920s. in the 1960s and 1970s fire research was mainly directed to study the behavior of concrete structural element. There was relatively little information on the concrete properties during and after fire.

During fire the mechanical characteristics of the concrete are charging. During the cooling process concrete is not able to recover its original characteristics. Deterioration of concrete at high temperature has two forms: local damage in the material itself and global damage resulting the failure of the elements. Recent results indicated that in some situation a part of the strength can be recovered. Concrete is well known for its capacity to endure high temperatures and fire owing to its low thermal conductivity and high specific heat. However, it does not mean that fire or high temperature, do not affect concrete at all. Its colour changes, while its compressive strength, modulus of elasticity, concrete density and the appearance of its surface become significantly affected by temperatures. Exposure to high temperature during fire is one of the most damaging environmental effects for concrete structures. Although concrete is a non combustible material, its chemical, physical and mechanical properties changes once exposed to high temperature.

Glass is an amorphous solid (non-crystalline) material that exhibits a glass transition, which is the

reversible transition in amorphous materials (or in amorphous regions within semicrystalline material) from a hard and relatively brittle state into a molten or rubber-like state. There are many types of glass some are fused silica glass and vitreous silica glass and vitreous silica glass in which silica (SiO_2) has very low thermal expansion. It is very hard and resist high temperature (1000^0-1500^0 C). It is used for high temperature applications such as furnace tubes, melting crucibles, etc. the glass forming aggregate are those which on high temperature change their phase into glass. These materials are available in aqueous solution and in solid form. As above mentioned the aggregate such as sodium silicate has the ability to form glassy layer and can act as fire resistant.

In this project is proposed to enhance the fire endurance property of cement mortar cubes by employing glass forming aggregate like sodium silicate in small composition. The ultimate aim is that the improvement in fire resistance nature of cement due to impregnation of glass forming aggregate without compromising strength, setting and hardening property of cement. In order to prove the aim many tests have to be carried out, the test can be classified into two categories: material testing and element testing. The results of materials testing provide information on the effect of temperature on the mechanical properties of concrete such as concrete compressive and tensile strength, modulus of elasticity, etc., while the results from element testing is used to assess the fire resistance of concrete in structural element (such as beam, column, slabs).

ii. PROPERTIES OF SODIUM SILICATE

Sodium silicate is the common name for compounds with formula $Na_2(SiO_2)_nO$. a well known member of this series is sodium metasilicate, Na_2SiO_3. Also known as water glass or liquid glass, these materials are available in aqueous solution and in solid form. The pure composition are colourless or white, but commercial samples are often greenish or blue owing to the presence of iron containing impurities.

They are used in cements, passive fire protection, textile and lumber processing, refractories, and automobiles. Sodium carbonate and silicon dioxide react when molten to form sodium silicate and carbon dioxide.

$$Na_2CO_3 + SiO_2 \rightarrow Na_2SiO_3 + CO_2$$

Sodium silicate is a white powder that is really soluble in water, producing an alkaline solution. It is one of a number of related compounds which include sodium orthosilicate, Na_4SiO_4 , Sodium pyrosilicate, $Na_6Si_2O_7$, and others. All are glassy, colourless and soluble in water. Sodium silicate is stable in neutral and alkaline solutions. In acidic solutions, the silicate ion react with hydrogen ions to form silicic acid, which when heated and roasted forms silica gel, a hard, glassy substance. Concrete treated with a sodium silicate solution helps to significantly reduce porosity in most masonry products such as concrete, stucco, plasters. A chemical reaction occurs with the excess $Ca(OH)_2$ (Portlandite) present in the concrete that permanently binds the silicates with the surface making them for more durable and water repellent. It is generally advised to apply this treatment only after the initial cure has taken place (7 days or so depending on conditions).

iii. MTHODOLOGY

A. Preparation of cement specimen

Two shapes of specimens have to be prepared in order to perform various tests they are
Cubical and cylindrical specimen.

Cubical specimen:

The specimen of measurements 7.06*7.06*7.06 cm^3 of cement cube will be formed with water/cement ratio of 0.5 and the ratio of cement and sand will be taken as 1:3.

B. Preparation of cement cube with 1 and 2 % wt of sodium silicate

The cement cube will be prepared with the measurements described in step 1 and by blending with 1 and 2 % wt of sodium silicate.

C. Heat treatment:

Various combination of cement cubes prepared will be immersed in water for about 21 days for complete curing. After that heat treatment tests will be conducted.
Control cement cubes, sodium silicate blended cement cubes will be heated in muffle furnace at 300^0 C, 600^0 C. Separately for about 1-2 hours.

Similarly fire treatment test will be conducted on the other set of cement concrete cubes by exposing into LPG fired flame (directly by Bunsen burner).

iv. TESTING OF CEMENT SPECIMEN

A. Compression test:

The heat/fire treated specimen cement cubes will be plced in Universal Testing Machine, and will be made to compress by increasing the load. At one point the cement/concrete will deteriorate under increasing load applied is the compressive strength of the specimen. Compression strength for each composition will be obtained and the graph will be plotted.

B. Thermal stability test:

The thermal stability of control cement cubes glass aggregate blended cement will be evaluated by recording their respective DSC and TG curves using differential scanning calorimeter, and thermo gravimetric balance.

C. Fire / heat resistance test:

Fire resistance test will be conducted on the cement cubes with blended aggregates by exposing into LPG fired flame (directly by Bunsen burner). The graph will be plotted for time and different composition of aggregate added.

v. TEST RESULTS

Controlled specimen:

S.No	Controlled specimen without heat	Compressive strength (N/mm^2)
1	Cube 1	20.36
2	Cube 2	20.15
3	Cube 3	20.73

S.No	Controlled specimen 300^0 C	Compressive strength (N/mm^2)
1	Cube 1	18.30
2	Cube 2	18.66
3	Cube 3	18.34

S.No	Controlled specimen 600^0 C	Compressive strength (N/mm^2)
1	Cube 1	15.84
2	Cube 2	16.03
3	Cube 3	15.78

S.No	Controlled specimen 800^0 C	Compressive strength (N/mm^2)
1	Cube 1	11.84
2	Cube 2	12.03
3	Cube 3	10.78

By adding 1 % of sodium silicate

S.No	Controlled specimen without temperature	Compressive strength (N/mm^2)
1	Cube 1	14.58
2	Cube 2	15.21
3	Cube 3	14.90

S.No	Controlled specimen 300^0 C	Compressive strength (N/mm^2)
1	Cube 1	13.74
2	Cube 2	13.93
3	Cube 3	14.14

S.No	Controlled specimen 600^0 C	Compressive strength (N/mm^2)
1	Cube 1	9.07
2	Cube 2	8.50
3	Cube 3	8.19

S.No	Controlled specimen 800^0 C	Compressive strength (N/mm^2)
1	Cube 1	5.28
2	Cube 2	6.10
3	Cube 3	5.96

By adding 2% of sodium silicate

S.No	Controlled specimen without temperature	Compressive strength (N/mm^2)
1	Cube 1	13.55
2	Cube 2	13.76
3	Cube 3	13.73

S.No	Controlled specimen 300^0 C	Compressive strength (N/mm^2)
1	Cube 1	12.91
2	Cube 2	12.68
3	Cube 3	12.57

S.No	Controlled specimen 600^0 C	Compressive strength (N/mm^2)
1	Cube 1	8.10
2	Cube 2	7.85
3	Cube 3	7.69

S.No	Controlled specimen 800^0 C	Compressive strength (N/mm^2)
1	Cube 1	4.64
2	Cube 2	5.30
3	Cube 3	4.73

vi. CONCLUSION:

On adding 1 , 2 % of sodium silicate, the following results were obtained.

Fire resistance of cement mortar cube blended with sodium silicate increases when it is compared with controlled specimen.

Without heating, compressive strength off cement mortar cubes blended with 1 , 2% sodium silicate is lesser than the compressive strength of controlled specimen.

Adding of sodium silicate in mortar cubes can withstand upto 800^0 C. But the compressive strength will be decreased.

When both the compressive strength are compared, the compressive strength of sodium silicate added mortar cubes is lesser than compressive strength of controlled specimen.

Some other materials can be added with sodium silicate further to increases the compressive strength.

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