EFFECT ON THE SETTING, STRENGTH, WATERTIGHTNESS AND LINEAR CHANGES OF MAGNESIUM OXYSULPHATE CEMENT ON MIXING SODIUM SILICATE AS AN ADDITIVE.

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ABSTRACT

Non calcareous Magnesium Oxysulphate cement (Magnesia / Sorel's Cement) is prepared by the reaction of magnesium sulphate, magnesia and dolomite (inert filler) in aqueous solution. It was discovered by Sorel S.T. in 1867 and has many properties superior to those of calcareous Portland cement. Incorporation of additives may improve the properties of magnesia cement by nullifying the harmful effects of the impurities present in the matrix. In this study, sodium silicate is used as an additive and the findings are very encouraging. Incorporation of sodium silicate in Magnesia cement increases final setting periods, improves watertightness and compressive strength of the cement. Insignificant linear changes (within the experimental limits) are also noticed.

Keywords : Magnesium Oxysulphate cement, Sorel's cement, Compressive strength, Moisture ingress, Setting periods, Weathering effects and Linear changes.

1. INTRODUCTION

The substances which are used for fastening or binding purposes are called binders. Inorganic binders are also known as cement. Cementing behavior is attributable to their polymerization and interlocking tendencies (George, 2002). Magnesium Oxysulphate cement was discovered by a French Scientist Sorel S.T. in 1867 (British Cement Association, 2006). It has many properties superior to those of Portland cement (Vangipuram, 2002). Magnesia cement is prepared by the reaction of magnesium sulphate with magnesia in aqueous solution. Dolomite is used as inert filler to absorb the heat evolved during the exothermic formation of Oxysulphate cement. Different compositions of Oxysulphate cement are known but $5Mg(OH)_2.MgSO_4.8H_2O$ composition is most commonly found (Mathur, 1984).

$$MgO + H_2O \longrightarrow Mg(OH)_2$$

$$5Mg(OH)_2 + MgSO_4.7H_2O + H_2O \longrightarrow 5Mg(OH)_2.MgSO_4.8H_2O$$

The strength and durability of Sorel's cement can be further improved by using pure raw materials, their proper proportions, workmanship, proper curing conditions (low temperature and high humidity), post curing measures and maintenance. Additives also play important role to modify the properties of Sorel's cement. In this study, sodium silicate is tried as an additive in Magnesium Oxysulphate cement to improve its quality.

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The chemical composition of sodium silicate is $XNa_2O.YSiO_3.ZH_2O$. Anionic part of sodium silicate (silicates or its polymeric forms) inactivates active lime and other harmful impurities by forming inactive insoluble phases (Vogel,1980). Hence, the author has tried sodium silicate as an additive for Oxysulphate cement.

2. MATERIALS & METHODS

Materials : Magnesium oxide / magnesia of Salem origin (commercial grade), magnesium sulphate / epsamite (technical grade) and dolomite (inert filler) are used for the preparation of Magnesium oxysulphate cement (Satya Prakash, 2005; Indian Standard, 1982; Indian Standard, 1977; Indian Standard, 1962).

Methods :

Various experiments were carried out to investigate the effect of sodium silicate (in varying proportions) on setting characteristics, weathering effects, watertightness, compressive strength and linear changes of Oxysulphate cement (Mathur Ritu, 2008; Mathur Ritu, 2008). 1:2 dry mix was prepared by weight of magnesia and dolomite.

(i) Setting Characterstics : In order to study the effect of sodium silicate on setting characterstics of Oxysulphate cement, it was mixed in the gauging solution (magnesium sulphate) in varying proportions (0%, 5%, 10%, 15%, 20%). The quantity of the additive was calculated by volume of the gauging solution. Dry mixes were gauged with magnesium sulphate solution of 25^o Be having different quantities of additive. For each lot of dry mix, the volume of gauging solution was kept

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constant. Standard procedures were adopted (according to IS specifications) to determine standard consistency, initial and final setting times using Vicat needle apparatus (Indian Standard, 1982). Results are recorded in Table 1.

(ii)Weathering Effects :Variation in weights of the setting time blocks with time were recorded after 24 hrs, 7 days, 30 days and 45 days using chemical balance. Due to different weathering effects, weights of the blocks may increase or decrease with time. Experimental findings are summarized in Table 2.

(iii) Moisture Ingress (Steam Test) : Steam test is carried out to study the effect of sodium silicate on the durability and soundness of the product. All the setting time blocks with different proportions of the additive were first cured for 60 days under identical conditions and then exposed to boiling water for atleast 30 hrs in a closed steam bath. In this way, the moisture sealing efficacies of the blocks were studied. Less the moisture ingress, more the soundness (Chandrawat, 1994; Gupta, 1990). Results are enumerated in Table 3.

(iv)Compressive Strength : The effect of sodium silicate on compressive strength of Oxysulphate cement was studied with the help of standard sized trial blocks (70.6mm× 70.6mm× 70.6mm) prepared from IS consistency pastes having sodium silicate in varying proportions in the gauging solution (calculated by volume of g.s.). Wet mixes were prepared by gauging 1:2 dry mixes with constant volume of gauging solution. Compressive strength of the trial blocks were determined with the help of compressive strength testing machine after one month's of curing as per standard procedure (Indian Standard, 1982). Observations are recorded in Table 4.

(v)Linear Changes : Wet mixes were prepared with different quantities of the additive and then filled in standard sized moulds (200mm× 25mm ×25mm) in order to study the effect of sodium silicate on linear changes of Oxysulphate cement. Trial beams were kept under 90% relative humidity and 30± 2^o C temperature. Initial length of the beams were determined after 24 hrs using micrometer scale. Final lengths were measured after 28 days of curing under identical conditions. Difference between the two reading show the linear change. If the difference is more, less will be the soundness of the product (Mathur Ritu, 1993). Experimental findings are shown in Table 5.

3. RESULTS

1.Sodium silicate increases final setting periods. Decrease in initial periods with initial incorporation of additives (upto 10%) is also observed.

2.Incorporation of sodium silicate contributes to water tightness of the product.

3.Compressive strength is increased by the incorporation of sodium silicate upto an optimum amount (about 5%). Further additions of additive decrease the strength gradually.

4.Minor contraction in volume are observed by incorporation of sodium silicate in Sorel's cement.

4. DISCUSSION

As is evident from Table 1, which reveals the effect of sodium silicate on setting periods, initial addition of sodium silicate (5%) decreases initial setting periods of the cement. Incorporation of sodium silicate causes formation of insoluble solid phases (of silicates) with di-and tri - valent cationic impurities present in the matrix, hence it resists the initial setting needle from touching the base of the Vicat mould. On subsequent additions of sodium silicate, initial and final setting periods are found to increase gradually. The quantity of magnesium sulphate (main component of the cement) decreases with increasing quantities of additive. Reaction of magnesium sulphate (from the gauging solution) with silicate ions forms insoluble solid phase of magnesium silicate (Eq 3). Thus decreasing quantities of magnesium sulphate in the matrix with increasing proportions of the additive reduce the chances of formation of strength giving composition (Magnesium Oxysulphate). Active lime and other harmful impurities accelerate the setting process. Inactivation of these impurities by sodium silicate retards the setting process, hence setting periods are increased (Eq 4).

The effect of sodium silicate on weathering characterstics of Oxysulphate cement are summarized in Table 2. Gradual decrease in weights of the trial blocks with passage of time is noticed upto the 30th day. A lot of uncombined moisture is left in the matrix on account of slow setting and inactivation of calcium and magnesium ions (Eq 4,5). Slow evaporation of this moisture is responsible for decrease in weights. In addition to moisture loss, the alkaline nature of sodium silicate promotes absorption of acidic gases like carbondioxide, sulphurdioxide, etc. These accompanying processes contribute to gain in weights with lapse of time. Such effects are visible only when

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the fast vaporization process has come almost to an end.Experimental data are in harmony with such processes.

Incorporation of sodium silicate improves the watertightness of Oxysulphate cement as is evident from the data shown is Table3. Moisture ingress is retarded by the inactivation of active lime and other harmful impurities present in the matrix into inactive solid phases of polyvalent cationic silicates (Eq 4). As these impurities are responsible for moisture ingress, their inactivation contributes to watertightness.

Sodium silicate improves the strength of the cement. Initial incorporation of sodium silicate (about 5%) increases compressive strength of the cement due to inactivation of active lime and unused magnesium sulphate (Eq 3,4). Decreasing trends in the strength data are observed with further additions of sodium silicate in the gauging solution (Table 4). The reason is that quantities of magnesium sulphate, which is the main component of magnesia cement, decrease with increasing quantities of the additive in the gauging solution. This results in the decreasing chances of formation of Magnesium Oxysulphate which is the main strength giving composition (Eq 6). That is why decreasing trends of strength data are observed.

Table 5 reflects the effect of sodium silicate on volume changes of magnesia cement. Addition of sodium silicate in small quantities (5% to 10%) results in the formation of intercrossing crystals of Magnesium Oxysulphate and polyvalent metal cationic silicates. Such an event results in the formation of a compact rocky mass responsible for contraction in volume. However, excess of sodium silicate promotes rehydration, carbonation, sulphonation, etc. in the structure. Hence compaction of the structure, decreases to some extent, as is evident from the decreasing trends in the contraction data with increasing proportions of sodium silicates.

Table 1 : Effect of Sodium Silicate on Setting Characterstics of Oxysulphate Cement

g.s. = gauging solution

Table 2 : Effect of Sodium Silicate on Weathering Characterstics of Oxysulphate Cement

S.No	Dry Mix Composition (% additive)	Weight of Blocks in gm after			
		24 hrs	7 days	30 days	45 days
1	0%	258.870	251.163	243.322	241.440
2	5%	251.520	238.220	224.230	224.180
3	10%	248.820	232.580	220.980	221.080
4	15%	259.570	238.930	225.950	226.070
5	20%	246.780	223.830	215.950	216.000

g.s. = gauging solution

Table 3 : Effect of Sodium Silicate on Moisturing Ingress Characterstics of Oxysulphate Cement

1	0%	N.E.	N.E.	N.E.	N.E.	C	----
2	5%	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
3	10%	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
4	15%	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
5	20%	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.

g.s. = gauging solution, N.E. = No effect, C = Cracked

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Table 4 : Effect of Sodium Silicate on Compressive Strength of Oxysulphate Cement

Dry Mix Composition	0%	5%	10%	15%	20%
Compressive Strength (kg/cm^2)	275	370	350	340	320

g.s. = gauging solution

Table 5 : Effect of Sodium Silicate on Linear Changes of Oxysulphate Cement

S.No	Dry Mix Composition (% additive)	Length of Beams (mm)		Change in Length (mm)
		Initial	Final	
1	0%	200.00	200.02	0.02
2	5%	200.00	199.52	0.48
3	10%	200.00	199.58	0.42
4	15%	200.00	199.74	0.26
5	20%	200.00	199.82	0.18

g.s. = gauging solution

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