Sulphate Attack on Blended Cement Mortar – Combination Sulphates

T.Kala Deepthi
P.G Student, Department of Civil Engineering, Visvodaya Engineering College,Kavali, Andhra Pradesh, India.

Dr. T. Suresh Babu
Professor & Head of the Department, Department of Civil Engineering, Visvodaya Engineering College, Kavali, Andhra Pradesh, India.

Abstract – As industries are increasing day by day, so its by-products also increase. We can use these by-products in construction industry to improve certain properties of cement. Blending is the addition of supplementary cementitious materials like fly ash, ground granulated blast furnace slag (GGBS) to the cement. The resulted cement mortar is known as BLENDED CEMENT MORTOR. This will have improved qualities like strength, workability, durability. Ca(OH)2of hydrated cement paste reacts with sulphate ions and forms Calcium Sulphate, which further reacts with C3A to produce ettringite. This is known as SULPHATE ATTACK. Sulphate attack can be either 'external' or 'internal'. External: Due to penetration of sulphates in solution, in groundwater for example, into the concrete from outside. Internal: Due to a soluble source being incorporated into the concrete at the time of mixing. Examples include the use of sulphate-rich aggregate, excess of added gypsum in the cement or contamination. Properties like strength and weight of sulphate attacked cement mortar differs from the normal conventional cement mortar. Here we make an attempt to find out these changes.

Index Terms - Blended Cement, Fly ash, Ground Granulated ettringite, Compressive Strength.

1. INTRODUCTION

Cement has become an indispensable construction material and it is now used in greater quantities than any other material. Ordinary Portland cement has a high calcium base affecting the rehology of concrete and mortar. The interface bond between the cement paste and aggregates can be improved with better pore structure and minimized micro cracks using mineral admixtures like fly ash, granulated blast furnace slag, rice husk, silica fume etc. Out of the above, the use of fly ash has gained prominence due to growing awareness about the economy benefits and easy availability of the good quality fly ash. Ordinary Portland cement is made by grinding Clinker and Gypsum, One ton of clinker requires approximately 1.5 tons of limestone whose reserves are limited. The remedy for the above problem is blended cement. Blended Cement is the cement with a fixed percentage of pozzolans (A mineral admixture that acts as a supplement to "standard" Portland cement hydration products to create additional binder in a concrete mix.) and the Portland cement clinker of the cement mix. Blended cement is usually understood as cement that is blended by a cement manufacturer rather than a ready-mix supplier. Since water helps to form the strength giving cement gel, the quality of water is to be critically monitored and controlled. In practice, very often, great control on properties of cement and aggregate is exercised, but the control on the quality of water is often neglected. Water used for mixing purpose, exceeding the tolerable limits of impurities, may affect not only the strength and durability but also setting time, soundness, efflorescence (deposits of white salts on the surface of structure) and corrosion of reinforcing or pre-stressing steel. Sulphate attack is a complex form of deterioration that has damaged concrete structures throughout the world. Sulphate attack is particularly complex because the source of sulphates can be external or internal (delayed ettringite formation), and the distress can be chemical in nature, due to alteration of hydration of products, or physical in nature, due to phase changes in the penetrating sulphate solution. Most soils contain some sulphate in the form of calcium, sodium, magnesium, ammonium, and ferrous. They occur in soil or ground water. Water behaves as the Main Culprit in the detrition of the structure. It acts as a carrier for deleterious material, leaves vulnerable voids, shrinkage problems, causes cracks, causes segregation, bleeding. Due to the above reasons, an approaching method was carried out in the present investigation to analyse the influence of various individual sulphates such as sodium sulphate, calcium sulphate, and magnesium sulphate, on compressive strength, and percentage of weight loss development at 3days, 7days, and 28days and of fly ash based cement mortar.

2. RELATED WORK

The objective of this project is to study To investigate the role of sulphates and its concentration on sulphate attack on blended cement mortar. To investigate the implication of sulphate attack in the presence of sodium, magnesium, calcium sulphate .The effect of sulphates on cement is studied for 2000 mg/l concentration of the Na_2SO_4+$MgSO_4$, $CaSO_4$+Na_2SO_4,

$CaSO_4$+$MgSO_4$, and Na_2SO_4+$MgSO_4$+ $CaSO_4$ at different ages is carried out in this project. Cubes 70.6mm × 70.6mm × 70.6mm casted and immersed in deionised water.Curing should be properly employed to ensure cementitious materials gain their fully potential strength. At every age the weight of cubes and corresponding compressive strength. To find out normal consistency, initial and final setting time, and also the specific gravity of the blended cement. To find out the fine aggregate specific gravity and particle size distribution. Produce new conservation mixtures containing different amounts of different sulphates.

3. MIX DESIGN

The cubes were cast in the moulds of 70.6 mm size conforming to IS: 10080-1982. All the materials are weighed for each sample in the mix ratio of 1:3 and mixed with the quantity of water obtained by (P/4 + 3.0) percent of combined mass of cement and sand, whether P is the percentage of water required to produce a paste of standard consistency determined as described in IS: 4031 (Part 4) – 1988. For casting of one sample of (4 No's) of cubes, the mould of size is being 7.06 cm. The area of the face of the cube will be equal to 50 Sq cm and the materials were taken as 740 gms of Cement, Fine aggregate2220 gms; and with sulphate concentrations range from 2000 mg/l to 3000mg/l in a non-porous enamel tray and mix them with a trowel for one minute, then add deionised water of quantity 310.8 ml and concentrations of sulphates mixed thoroughly and immediately after mixing, the mortar is filled in to a cube mould and then compacted. The compressive strength and percentage of weight loss is conducted on all samples 3 days, 7 days, and 28 days. The graphical form and tabular form investigation results of 3 days, 7 days, and 28 days compressive strength and percentage of weight loss of mortar cubes of Na2SO4 + MgSO4, CaSO4+ MgSO4, CaSO4+ Na2SO4 and MgSO4+ CaSO4+ Na2SO4 sulphates of 2000mg/l is to be represented. Compression test on cubes is conducted with compression testing machine of 2000KN capacity. The cubes are tested on their sides without any packing between the cube and the steel patens of the testing machine and the load on the cube is applied at a constant rate till to the failure of the specimen and the corresponding load is noted as ultimate load. The mix design procedure as recommended in IS: 2212-1962* is required to be modified to the extent considered necessary and examples of mix design is worked out.

For conventional cubes: Weight of 1 cube mould of concrete = volume × density = 0.07×0.07×0.07×2162 = 0.741 kg, Mix proportion = 1:3, Sum of proportions = 1+3=4 0.741÷4 = 0.185 kg i.e. wt. of cement 0.185×3 = 0.556 kg i.e. wt. of fine aggregate 0.185×1 = 0.18 kg i.e. wt. of Cement, For 4 cubes: Cement content = 0.185×4 = 0.74 kg, Fine aggregates = 0.556×4 = 2.224 kg, Water/Cement ratio = 0.4, Amount of water to be added = 0.4 x 0.74 +(5÷100 x 0.4 x 740) = 310.8 ml. the sulphates are added at a rate of 2000mg/l. The filled moulds are kept in moist closet or moist room for 24 hours after the completion of vibration. At the end of that period, they are removed from the moulds an immediately sub merged in deionized water. Curing period is the addition of sulphates same proportion (2000mg/l) at the time of mixing.

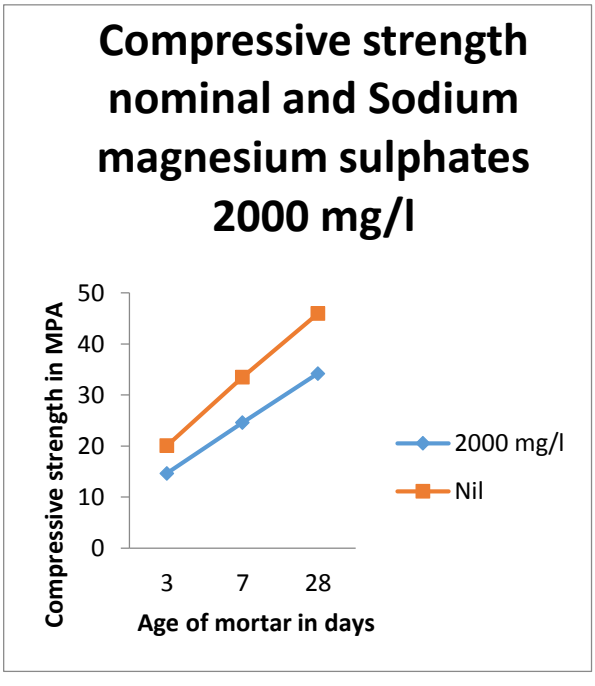
4. RESULTS AND DISCUSSIONS

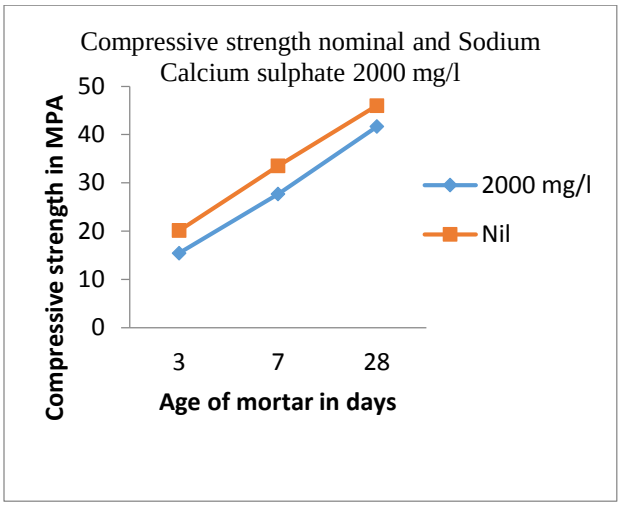
Table 1 shows the compressive strength of various combination of sulphates added to blended cement mortar.

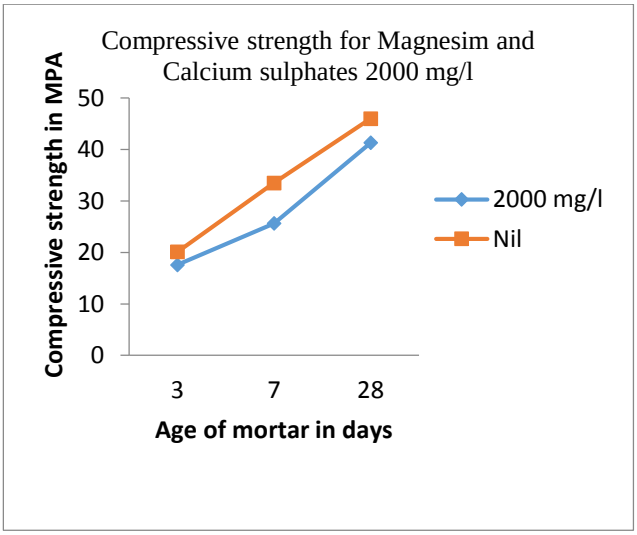
Table 1: Compressive strength

2000 mg/l	Compressive strength MPA		
	3 days	7 days	28 days
Na_2SO_4 + $MgSO_4$	14.68	24.62	34.25
Na_2SO_4 + $CaSO_4$	15.42	27.66	41.67
$CaSO_4$ + $MgSO_4$	17.59	25.64	41.30
Na_2SO_4 + $MgSO_4$ + $CaSO_4$	15.75	21.70	34.30

Fig: Compressive strengths at different concentrations of sulphates







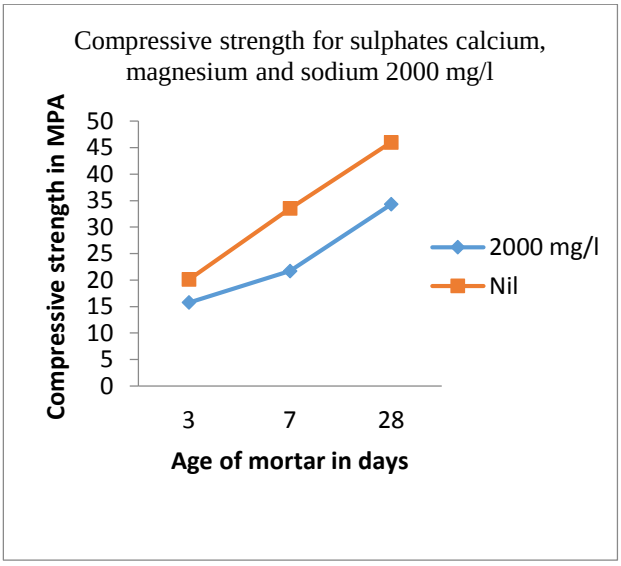
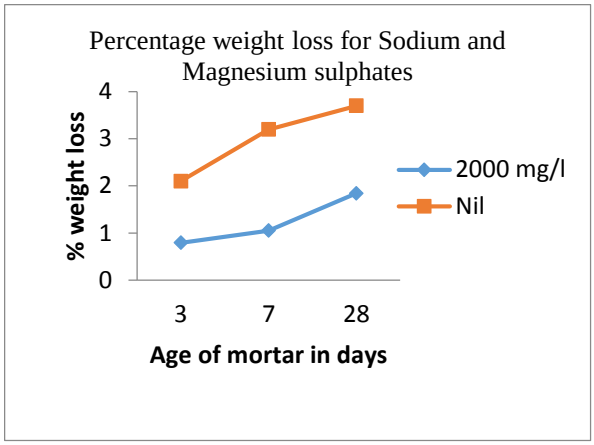
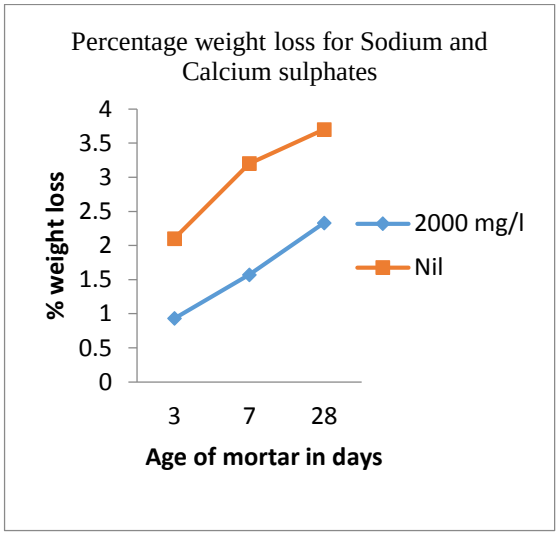
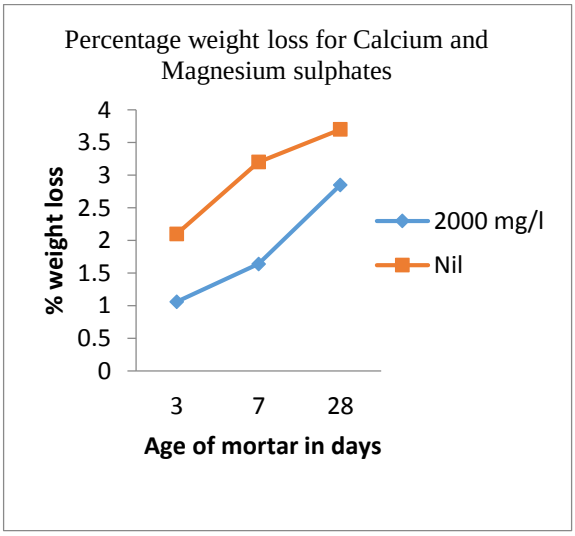


Fig: Percentage weight loss for different combination of sulphates







5. CONCLUSIONS

1. In mixed double concentrations, ($CaSO_4$ + $MgSO_4$, $CaSO_4$ + Na_2SO_4 , $MgSO_4$ + Na_2SO_4) the compressive strength and percentage weight loss increases with increase in concentrations from 2000 mg/l, 2500 mg/l and 3000 mg/l.

In triple combination of sulphates (CaSO4 + MgSO4 + Na2SO4), the compressive strength increases with the increase in curing period i.e. from 3 days, 7 days and 28 days with a concentration of 2000 mg/l.

3. In triple combination of sulphates (CaSO4 + MgSO4 + Na2SO4), the percentage weight loss increases with the increase in curing period i.e. from 3 days, 7 days and 28 days with a concentration of 2000 mg/l.

4. Formation of ettringite is responsible for the attack of sulphates in cement mortar.

REFERENCES

[1] H. L. Swaroop, K. Venkateswararao, Prof P Kodandaramarao / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 3, Issue 4, Jul-Aug 2013, pp.285-289/ Durability Studies On Concrete With Fly Ash & Ggbs.
[2] Al-Amoudi, OSB "Attack on plain and blended cements exposed to aggressive sulphate environments," Cement and Concrete Composites, Vol. 24, pp. 305-316, 2002.
[3] Bensted, J. "Thaumasite - Background and Nature in Deterioration of Cements, Mortars and concretes," Cement & Concrete Composites, Vol. 21, No. 2, pp 117-121, April,1999.
[4] Brown W, Taylor H.: The role of ettringite in external sulphate attack, Materials Science of Concrete: Sulphate Attack Mechanisms, The American Ceramic Society, 1999, pp. 73–98.
[5] Eurocode 2: Design of concrete structures. European Standard EN 1992-1-1 December 2004.
[6] Folliard, K.J. and Sandberg, P., "Mechanisms of Concrete Deterioration by Sodium Sulphate Crystallization," Proceedings, Third International ACI/CANMET Conference on Concrete Durability, Nice, France, pp. 933-945

Author

"T.Kala Deepthi pursuing M.Tech in Structural Engineering"