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TO STUDY THE LIMITS OF SULPHATE IN CEMENT MORTAR MIXING WATER

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ABSTRACT

Structures deteriorate when sulfate ions are present in groundwater, soils, and mixtures in excess of what is acceptable. The issue of excessive sulfate concentrations was caused by a number of variables, including the kind of cement, the sulfate cat ion, and the length of sulfate exposure. Water is a necessary component of mortar or concrete, as is well known. However, several standards provided varying acceptable amounts of sulphate in mixing water for regular Portland cement. For instance, AS 1379 has a 1000 mg/l, IS:456-2000 has a 400 mg/l, BS EN:1008-2002 has a 2000 mg/l, and ASTM C94-1992 has a 3000 mg/l. CaSO4, MgSO4, Na2SO4, (NH4)2SO4, and Fe2SO4 are the most common sulphates found when combining water, soils, and ground water. In the natural world, sulphates can be found in surface water, soils, and ground water as one compound, two compounds, or more. Despite the fact that the aforementioned codes provided broad limitations on sulphates in mixing water for regular Portland cement, they did not specify the maximum amount of a specific sulphate or combination of sulphates that is permitted in mixing water for blended cement.

KEYWORD: Blended Cement, Sulphates, Water, Soils, Mortar

1. INTRODUCTION

Cement Cement, sand, and water are all components of mortar, which is a composite substance. When pozzolinic materials, such as fly ash, metakaolin, slag, and silica fume, are combined with readily available ordinary Portland cement, which acts as the binding agent for aggregate, the dry composite material is transformed into a properly shaped, solidified object with high strength through the hydration process. Utilizing drinkable water is also crucial for building strength. Intriguing case stories where the strength and durability of concrete constructions were irreparably damaged by polluted water were published in the literature.

Mortar's strength, durability, setting time, and soundness are all impacted when the water used to mix the mortar contains more contaminants than is acceptable. Use of salt water results in efflorescence, which is the deposition of white salts on the surface of mortar. While it is generally true that water appropriate for drinking can be used to prepare mortar, this is not always the case.

1.1 SCOPE OF THE WORK

Generally speaking, cement mortar mixing water must adhere to British Standards (BS 3148-1980), ASTM Standards, or Indian Standards (IS 456-2000). The guidelines set forth for various characteristics of water do not accurately reflect their effects on cement mortar's ability to generate strength. Furthermore, the standards outlined in IS 456-2000 are rather strict in terms of alkalinity. Most of the available ground water in the world, and especially in India, has greater alkalinity than what is required by the standard rules. Additionally, a survey of the literature reveals that there has been very little research on the impact of contaminants including various sulphate compounds or salts that may be present in water.

The current study focuses on several water quality factors that affect cement mortar properties including hardening and strength development. In the current inquiry on compressive strength and various durability investigations, the chemical components sodium sulphate, magnesium sulphate, calcium sulphate, ammonium, and ferrous sulphate are taken into consideration with diverse concentrations.

The factor taken into consideration is cement mortar, which is likely to be affected by the various chemicals contained in water at variable quantities. These include a variety of chemical compounds, such as the sulfates Na2SO4, MgSO4, FeSO4, and CaSO4. Based on the fact that a particular substance is present in both surface water and ground water, the higher limit of concentration of that substance was determined. The specimens cast with neural water are compared to the results of the compressive strength test. Only when the test samples are contrasted with the deionized water control sample can the impact of certain substances at varying concentrations be evaluated. If the control samples are made with local water, comparisons become challenging because the attributes vary based on the location and the time. The requirements outlined by IS 456-2000, as well as available research and knowledge, are used to interpret the results.

Tropical and subtropical water bodies have varying quantities of sulfate chemical compounds in both surface and ground water. The different sulfate chemical compounds found in water, including calcium sulfate, magnesium sulfate, sodium sulfate, ammonium sulfate, and iron sulfate, are typically grouped and classified into (i) individual sulphates, (ii) double sulphates combinations, (iii) triple sulphates combinations, (iv) four sulphate combinations, and (v) five sulphate combinations. These aforementioned sulphate compounds are taken into account in the current experiment to evaluate their impact on fly ash blended cement setting times, compressive strength, and chloride ion permeability of blended cement mortars.

Based on the fact that a particular substance is present in both surface water and ground water, the higher limit of concentration of that substance was determined. Comparisons are made between the compressive strength test findings and the reference specimens cast in neutral water. The same test solutions are also used for tests on the start and final setup times, which are then compared to those of the deionized water. Only when the test samples are contrasted with the control sample of deionized water can the impact of certain substances at various concentrations be evaluated. Along with the XRD analysis, tests for the FBCM's chloride ion permeability were also undertaken in addition to the aforementioned.

1.2 NEED OF THE STUDY

Many sulphates, including those of calcium, sodium, potassium, magnesium, ammonia, and iron, are present in most soils and groundwater. Sulphates in their solid state have no direct impact on mortar, but when sulphate chemicals are combined, they have easy access to porous mortar and can react with the products of hydrated cement. A sign of sulphate assault is a property of white surfaces. Because of the progressive buildup of sulphate from water evaporation on mortar surfaces, sulphate attack problems are a potential source for water coming from cooling towers.

Many sulphate compounds, such as calcium, magnesium, sodium, ammonium, and ferrous, are typically found in dissolved form in soils, ground water, home and industrial waste water. They have no trouble getting within the cement mortar's porous structure where they can easily react with the hydrated cement compounds. The development of a whitish surface on mortar surfaces is a sign of sulphate attack. According to J. Prasad, the sulphate concentration range begins at 150 to 6000 ppm from a practical standpoint when sulphate assaults unprotected concrete. Therefore, it is crucial to research the maximum concentration of these sulfate compounds, either alone or in combination with other chemicals, in water used to prepare mortar.

It was necessary to consider a more logical strategy because drinking water standards can vary from one area to another. In India, it's also fairly uncommon for projects to be started in places where there isn't enough drinkable water to meet the increased demands of development. The best and careful use of high-quality water at project construction sites, in addition to human consumption, prevents the problem of water scarcity. As a result, it is frequently necessary to use whatever water is available from natural sources, without much concern for its quality, to mix concrete. Only a more exact specification could fit water under these conditions, at which point it is suited for mixing purposes. Making comparison tests between water of proven quality and the water under consideration for cement mortar's compressive strength and setting durations is a realistic way to assess the effects of utilizing water of dubious quality.

The impact of various individual sulfate substances, including calcium sulphate, magnesium sulphate, sodium sulphate, ammonium sulphate, iron sulphate, and their various combinations of sulfates, are evaluated experimentally in the current study to determine how compressive strength develops at ages 7, 28, 90, and 180 days of blended cement mortar using fly ash (FBCM). For all of these sulfate combinations, the influence of setting times (Initial and Final) and 28-day chloride ion permeability is investigated, along with XRD analysis, and compared to reference samples made with deionized water.

2. OBJECTIVE OF THE STUDY

1. The impact of the mixing water's quality on the initial and ultimate setting times of fly ash blended cement (FBC).
2. Fly ash Blended Cement Mortar (FBCM) modifications or compression strength development for both short- and long-term use.

3. REVIEW OF LITERATURE

Jianming Gao [2020] investigated the deterioration of concrete subjected to sulfate assault while subjected to flexural loads and drying and wetting cycles. The changing microstructure and corrosion products of inner concrete were examined using ESEM, MIP, and XRD. The findings show that and when compared with the sulphate attack's single damaging procedure. Flexural stress, drying, and wetting cycles can all hasten the deterioration of concrete that has been attacked by sulfates. The level of stress determines how flexural loading affects concrete deterioration. Additionally, it was discovered that the use of admixtures can enhance the concrete's capacity for sulphate resistance when it is put under mechanical load and goes through cycles of drying and wetting.

Kamile Tosun, [2020] The impact of C3A content on the sulphate resistance of cements including limestone has been researched. Limestone inclusion ratios of 5%, 10%, 20%, and 40% have been employed with blended cements with two distinct C3A concentrations (4.6% and 11.2%). Following one month of water curing, standard mortar samples made of 50x50x50 mm cubes and 25x25x285 mm prisms were exposed to various sulphate solutions (Na2SO4 and MgSO4) and temperatures (5 oC and 20 oC) for six months. The findings of the tests revealed that when limestone-cement mortars were exposed to both Na2SO4 and MgSO4 solutions, increasing C3A content accelerated the rate of deterioration. At larger limestone replacement ratios and lower temperatures, this scenario is more important. Microstructural analyses showed that the C3A content and cation type of sulphate solutions affect how limestone blended samples deteriorate under sulphate assault. From the perspective of sulphate, limestone replacement rates at and above 20% will pose a significant challenge for mortars including high C3A content.

Linglin Xu[2019] investigated the synthesis of ettringite at lower temperatures in the ternary hydrates of Portland cement, calcium aluminate cement, and calcium sulphate. The findings demonstrated that temperature increases minimize initial and final setting times and improve compressive and flexural strength. In comparison to mortars with hemihydrates, those with anhydrite produce stronger bonds between 0 and 10 oC but weaker bonds at 20 oC. Additionally, anhydrite pastes set up more quickly than hemihydrate pastes. It is also discovered that temperature and the type of calcium sulfate affect the rate and quantity of ettringite formation.

Using 5% Na2SO4 for two years as a chemical activator in the 50% slag blend, K.K. ***Veiga[2019]*** tested the sulphate resistance of a white Portland cement (WPC) comprising 0%, 50%, or 70% granulated blast furnace slag as a partial cement replacement. The findings demonstrated the advantages of using slag in both cements and an increase in its percentage of sulphate resistance. Comparatively to combinations without chemical activation, chemical activation decreased the expansion. All of the WPC mixes shown less expansion after prolonged exposure than the similar blends with PC. Ettringite and gypsum were determined to be the primary degradation products through microstructure analysis.

R.El.Hachem[2018], This research intends to aid in the construction of concrete structures that can withstand external sulfate attack (ESA). The findings of the tests shed light on the fundamental elements of the mechanism of degradation, such as the central role of leaching and diffusion in the sulphate assault process. Because the microstructure of the mortar with a low w/c ratio is less porous, it is more resistant to sulphate assault. Reducing the C3A component reduces macro-cracking but does not stop expansion, suggesting that other expansive materials, like gypsum, may also be contributing to ESA damage.

3.1 RESEARCH GAP

A survey of the literature reveals that there is little research on the subject of the combined presence of specific sulphate compounds and their maximum permitted limits in mixing water and how those chemicals affect blended cement and mortar. The goal of the current work is to better understand how different sulfate compounds affect the setting times, compressive strengths, and permeability of blended cement made with fly ash (FBC) and blended cement mortar made with fly ash (FBCM).

4. RESEARCH METHODOLOGY

This investigation describes the physico-chemical characteristics of the water, fine aggregate, and fly ash-based blended cement that was employed in the experiment the usual consistency, initial, and final setting times on fly ash blended cement (FBC) were determined using the conventional experimental protocols outlined in IS regulations. Fly ash blended cement mortar (FBCM) cubes' compressive strength and chloride ion permeability are also provided. To identify different compounds, X-ray diffraction (XRD) examination was performed in accordance with the instructions provided in the X-ray diffractometer's manual.

5. RESULTS AND DATA INTERPRETATION

Both tabular and graphical representations of the results of the investigation into the compressive strength, setting time, and chloride ion permeability of various types of individual sulphates, double sulphate combinations, triple sulphate combinations, four sulphate combinations, and five sulphate combinations on flyash blended cement and flyash blended cement mortar (FBCM) are provided. With reference to the standards laid out by IS 456-2000, the results' relevance is evaluated.

TABLE-1: SETTING TIMES OF FLY ASH BLENDED CEMENT (FBC) CORRESPONDING TO CASO4 CONCENTRATIONS

Sl.No	Water sample	Setting time in minutes, Percentage change in setting times& Difference of setting time in minutes					
		Initial	% change	Difference	Final	% change	Difference
1	Deionised						

	water(control)	85	0	0	260	0	0
2	1.0 g/l	103	21.18	18	280	7.69	20
3	1.5g/l	110	29.41	25	285	9.62	25
4	2.0g/l	114	34.12	29	288	10.77	28
5	**2.5 g/l***	**122**	**43.53**	**37**	**300**	**15.38**	**40**
6	3.0 g/l	130	52.94	45	313	20.38	53
7	3.5 g/l	133	56.47	48	318	22.31	58
8	4.0g/l	135	58.82	50	323	24.23	63

In the form of a table and figures, the impact of calcium sulphate on the beginning and ultimate setting times of fly ash blended cement (FBC) was displayed. It was shown that when the concentration of calcium sulphate increased, both setting times also increased. For various concentrations of calcium sulphate in the range of 1 to 4 g/l with an increment of 0.5 g/l, the range of increase in percentage change of initial setting times is 21.18% to 58.82%, and that of final setting times is 7.69% to 24.23%. as the calcium sulphate concentration is 2.5g/l, the beginning and final setting times differ by 37 minutes and 40 minutes, respectively (which is more than 30 minutes and is regarded as significant as per IS 456 code), as compared to the control mix. When the calcium sulfate content is 2.5 g/l, the initial setting time and ultimate setting increase by 43.53% and 15.38% correspondingly when compared to the control mix. The setting times therefore increased as calcium sulphate concentrations increased, according to the results of the current experimentation investigation.

TABLE-2: COMPRESSIVE STRENGTH OF FBCM CORRESPONDING TO CASO4 CONCENTRATIONS

Sl.No	Water Sample	Flyash Blended Cement Mortar (FBCM)							
		Compressive Strength(MPa)				% variation			
		7 days	28 days	90 days	180 days	7 days	28 days	90 days	180 days

i	Deionised water(Control)	25.60	40.42	46.84	50.31	0.00	0.00	0.00	0.00
ii	1.0 g/l	25.72	40.71	46.98	50.85	0.47	0.72	0.30	1.07
iii	1.5 g/l	25.90	40.53	46.88	51.12	1.17	0.27	0.09	1.61
iv	2.0 g/l	25.80	41.14	47.50	51.53	0.78	1.78	1.41	2.42
v	**2.5 g/l***	**26.10**	**41.40**	**47.80**	**51.70**	**1.95**	**2.42**	**2.05**	**2.76**
vi	3.0 g/l	26.08	41.84	47.83	51.71	1.87	3.51	2.11	2.78
vii	3.5 g/l	26.00	41.83	47.55	51.70	1.56	3.49	1.52	2.76
viii	4.0 g/l	25.99	41.82	47.35	51.69	1.52	3.46	1.09	2.74

According to the results, the compressive strength of the FBCM fluctuates little throughout the course of 7 days, 28 days, 90 days, and 180 days regardless of the CaSO4 concentration. Comparing cubes made with deionized water (the control test sample) to those made with CaSO4 concentrations of 2.5 g/l, compressive strength increases by 1.95% for cubes aged for 7 days, 2.42% for cubes aged for 28 days, 2.05% for cubes aged for 90 days, and 2.76% for cubes aged for 180 days. According to Roziere.E., the creation of ettringite and gypsum causes volume growth or expansion, which damages and cracks concrete and reduces its strength. The anhydrous fly ash residue in the mixture and its combination with CaSO4 may be the cause of the reported increase in compressive strength by altering the hydration process, which results in higher compressive strengths.

6. CONCLUSION

Then, a strategy for implementation was selected. In light of this, laboratory experimentation was prepared. Using Vicat's equipment, a total of 654 samples were prepared and tested for initial setting time and ultimate setting time. Using a compressive strength testing equipment, 2616 mortar cubes (7.05x7.05 cm) with a cross-sectional area of 49.7 cm2 were tested for compressive strength after being exposed for 7, 28, 90, and 180 days. RCPT equipment was used to produce and evaluate a total of 654 samples for chloride ion permeability.

Both tabular and graphical formats were used to display the findings of the experimental trials. With reference to the criteria established by IS:456-2000, the results' significance was evaluated. The impact of various chemical compounds at various concentrations in the water used for mixing on the fly ash blended cement's (FBC) initial and final setting durations, as well as the growth of the mortar's short- and long-term compressive strengths. Twelve typical samples, including a control sample, were chosen for powdered X-ray diffraction (XRD) examinations, and the patterns were discovered. These powdered X-ray diffraction patterns were used to formulate the likely chemical reactions that occur when cement is hydrated with chemical compounds in mixing water.

6.1 FUTURE SCOPE

1. Comparable studies on other blended cement pellets or concrete that contain admixtures like metakaolin, silica fume, rice husk, fibers, wheat straw ash, GGBS, wood ash, etc. can be conducted in order to evaluate and assess the impact of different chemical compounds on the development of strength with a focus on durability.
2. For a quantitative analysis and more precise investigation of the creation of several important chemicals that influence the properties of cement and mortar or concrete, advanced X-ray diffraction studies can be used.

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