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"IMPACT OF SULPHATE ATTACK ON MECHANICAL PROPERTIES AND DURABILITY OF CONCRETE"

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***Abstract-**: The present thesis investigates performance of concrete during sulphate attack, its effect on the durability & mechanical properties. Sulphate attack is a typical form of deterioration observed in concrete structures exposed to environments containing high concentrations of sulphate ions, such as soil, groundwater, and industrial waste. This research aims to contribute to the understanding of how sulphate attack affects the performance and longevity of concrete.*

***Keywords* - Sulphate attack, concrete deterioration, mechanical properties, durability, accelerated testing, mitigation strategies.**

1. INTRODUCTION

Sulphate attacks is a sophisticated type of corrosion that has caused damage to concrete structures all throughout the world. Sulphate attack is exceptionally complicated because the sulphate source might be internal or external (delayed ettringite generation), and the discomfort can be chemical owing to product hydration changes or physical due to phase shifts in the penetrating sulphate solution.. The only emphasis of this project's final report is on external sulphate attacks, which can take both chemical and physical forms.

EXPOSURE OF CONCRETE TO SULPHATE

Sulphate attacks is a sophisticated type of corrosion that has caused damage to concrete structures all throughout the world. Sulphate attack is exceptionally complicated because the sulphate source might be internal or external (delayed ettringite generation), and the discomfort can be chemical owing to product hydration changes or physical due to phase shifts in the penetrating sulphate solution.. The only emphasis of this project's final report is on external sulphate attacks, which can take both chemical and physical forms.

Fig 1: Effect of sulphate attack

CONCRETE EXPOSED TO GYPSUM-EXPOSED SOILS HAS SULPHATE RESISTANCE.

It has been hypothesized that there is reduced risk of sulphate-induced anxiety since Gypsum is far less soluble than other widely used sulphate forms, including sodium sulphate and magnesium sulphate. Because most laboratory research have utilised more aggressive sulphate solutions, especially sodium sulphate, there is a general lack of information regarding the potential harm that gypsum may do to concrete, which furthers the confusion around this solubility-related issue.

IDENTIFYING THE LEVEL OF EXPOSURE

Estimating the amount of exposure that a particular concrete construction will experience is the first step in the overall strategy for preventing sulphate attack that the American Concrete Institute (ACI) and other organizations propose. This entails taking a sample of the subject site's soil or groundwater and evaluating it for the presence of sulphates. A suitable preventative remedy would then be chosen based on the determined sulphate concentration, for instance, concrete mixtures with lower ratios of water to cementitious components and/or additional cementing materials (SCMs). Since one merely needs to determine the sulphate concentration using the proper analytical procedures, measuring sulphates in groundwater is a simple and uncontroversial matter. However, the inherent problem with the solubility of various sulphate forms becomes essential when attempting to determine the amount of sulphates present in a soil sample. The issue is that because sulphate must be removed from the subject soil by dilution with water, the outcomes for a given extraction ratio (or water/soil ratio) depend on how soluble the sulphate in the soil is.

CONCRETE'S RESISTANCE TO PHYSICAL SULPHATE ATTACK.

Recent years have seen the recognition of a relatively unique type of sulphate-induced distress in which sulphates enter concrete and cause degradation without chemically modifying the hydration products present in concrete (Folliard and Sandberg, 1994). Phase shifts inside the penetrating sulphate solution cause crystallization pressures that can physically deteriorate concrete, causing this anguish, also called a physical sulphate attack. Under this initiative, research was started to find out which salts can result in this kind of suffering and how this degradation can be stopped.

2. OBJECTIVE

The key objective of present study is to investigate the effect of sulphate attack on the mechanical properties and durability of concrete. The study focuses on three primary tests:

i. Crushing strength test conducted at7, 14, 28, and 56 days. the research aims to evaluate the changes in mechanical strength,
ii. Water absorption test of normal concrete sample and sulphate affected concrete.
iii. Sorptivity of concrete under the influence of sulphate attack. by analyzing these parameters, the thesis aims to provide a comprehensive understanding of the deterioration mechanism caused by sulphate attack and its impact on the long-term performance and durability of concrete structures.

3. TEST PERFORMED ON MATERIALS

MATERIALS TEST

Cement Test-

- Consistency Test
- Fineness Test

Fine Aggregate Test-

- Bulking Of Sand
- Specific Gravity Of Sand
- Sieve Analysis

Coarse Aggregate Test-

- Specific Gravity Test
- Water Absorption
- Elongation and Flakiness
- Crushing Value
- Grading Of Coarse Aggregate

TEST PERFORMED ON CONCRETE

Fresh Concrete-

- Slump Cone Test
- Vee Bee Test
- Compaction Factor Test

Hardened Concrete-

- Compressive Strength
- Sorptivity Test

TEST PERFORMED ON CEMENT

- Consistency Test (IS:4031-Part 1)
- Fineness Test (IS:4031-Part 4)

TABLE 1: BULKING OF SAND

S.No.	Sample	Value
1.	Mass of empty container	0.067kg
2.	Mass of container & dry aggregate	0.586kg
3.	Average of bulking of sand	15.01%

TABLE 2: SPECIFIC GRAVITY OF SAND

S.No.	Sample	Values
1	Mass of oven dried sample	496gm
2	Mass of saturated surface	500gm
3	Mass of flask+water+sample	1826gm
4	Mass of flask +water	1514gm
5	Specific Gravity	2.64

TABLE 3: ELONGATION AND FLAKINESS VALUES

Total weigh	Pass	Retain	Flakiness	Elongation
2.661 kg		20	0.43	2.507
1.742kg	20	2516	0.167	0.323
0.754kg	16	12.5	0.197	0.414
0.475kg	12.5	10	0.081	0.272

TABLE 4: CEMENT CONSISTENCY

Water by Volume	Penetration
30 %	2 mm
34 %	13 mm
36 %	18 mm
39 %	34 mm

TABLE5: CRUSHING VALUE TEST OF AGGREGATE

S.No.	Sample	Values
1.	Weight of jar	600gm
2.	Weight of sample	2776gm
3.	Tampering time,3 layers,25 times	16 min
4.	Sample weight after passing a 2.36 mm sieve	34.58%<40%

TABLE 6: TEST DATA FOR MATERIALS

S.No.	Sample	Values
1.	Cement's Specific Gravity	3.15
2.	Compressive Strength at 7 days of cement	28.6
3.	Coarse Aggregate's Specific Gravity	2.62
4.	Fine Aggregate's Specific Gravity	2.64
5.	Water absorption in Coarse Aggregates	0.50%
6.	Water absorption in Fine Aggregates	1.0%
7.	Moisture on the Surface of Coarse Aggregates	nil
8.	Moisture on the Surface of Fine Aggregates	2.0%
9.	Concrete's Target Mean Strength	28

4. TEST RESULTS

4.1. Compressive Strength of Concrete

TABLE 7: CRUSHING STRENGTH OF CONCRETE CURED WITH NORMAL WATER.

Dimensions of the Cube : 100x100x100mm

No of days	Load (kN)	Strength (MPa)	Average Strength (MPa)
7 day	112 106 108	11.2 10.6 10.8	10.8
14 day	280 280 274	28 28 27.4	27.8
28 day	320 340 345	32 34 34.5	33.5
56 day	410 430 440	41 43 44	42.6

TABLE 8: CRUSHING STRENGTH OF CONCRETE CURED WITH SULPHATE WATER.

Dimensions of the Cube:100x100x100mm

No of days	Load (kN)	Strength (MPa)	Average strength (MPa)
7 day	115 110 110	11.5 11 11	11.17
14 day	290 290 300	29 29 30	29.34
28 day	310 290 317	31 29 31.7	30.57
56 day	410 395 380	41 39.5 38	39.5

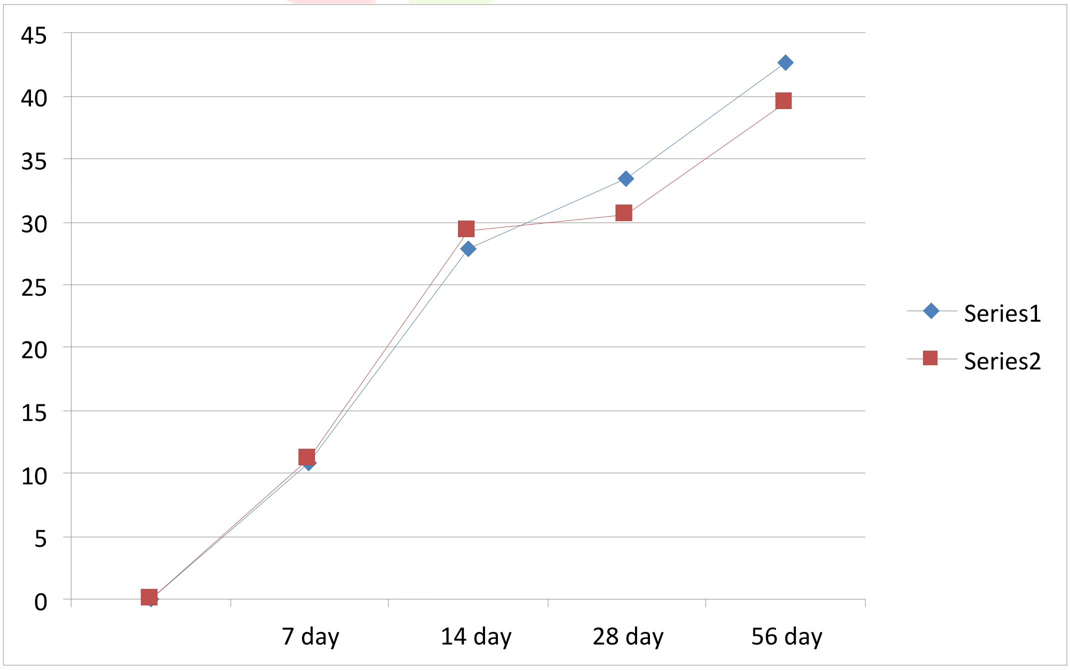

Fig. 3: Graph showing difference between strength of concrete on normal water cured condition and sulphate water cured condition.

4.2: Sorptivity test

TABLE 9: SORPTIVITY OF CONCRETE SPECIMEN CURED UNDER NORMAL WATER

No of days	Initial reading (grams) W1	Final reading (grams)W2	Water absorption (F-I/I X100)	Sorptivity in 10^{-5}mm per min$^{.05}$
7 day	2443	2458	.614	5.69
14 day	2556	2594	1.48	14.4
28 day	2561	2594	1.29	12.5
56 day	2440	2441	.040	3.8

TABLE 10: SORPTIVITY OF CONCRETE SPECIMEN CURED UNDER SULPHATE WATER.

No of days	Initial reading (grams) W1	Final reading (grams)W2	Water absorption (F-I/I X100)	Sorptivity in 10^{-5}mm per min$^{.05}$
7 day	2553	2576	.9	8.73
14 day	2579	2596	.65	6.45
28 day	2568	2589	.81	7.96
56 day	2486	2492	.24	2.27

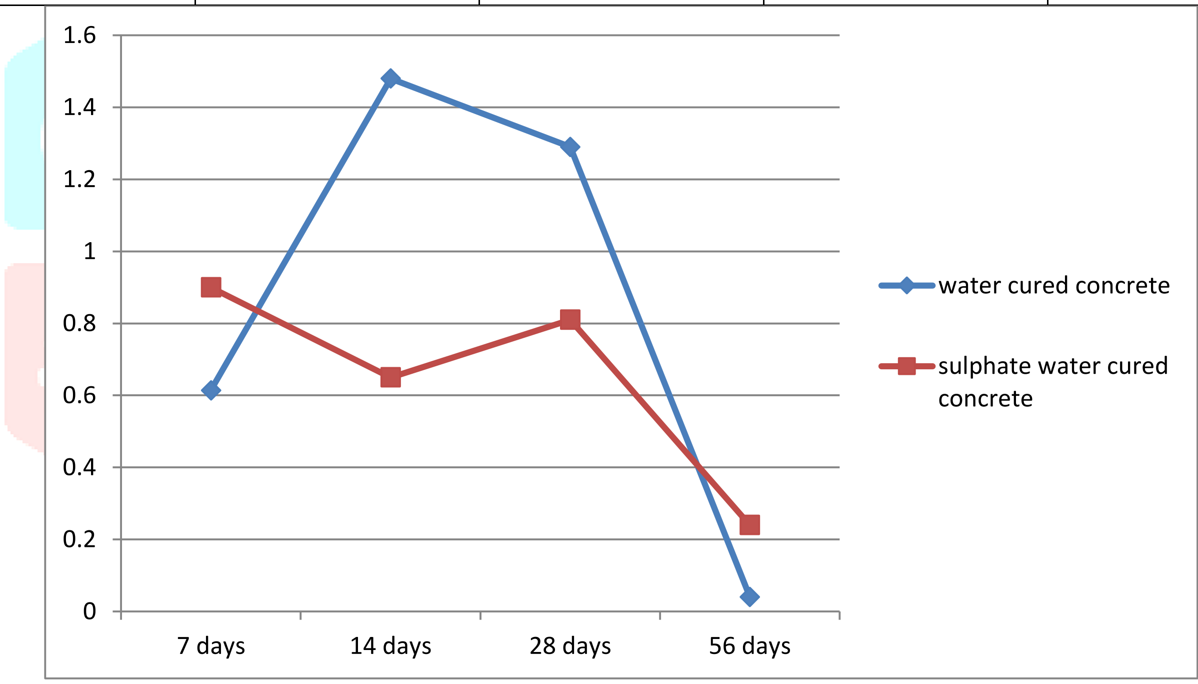

Fig. 4: Graph showing difference between percentage of water absorption of concrete cured on normal water condition and concrete cured on sulphate water condition.

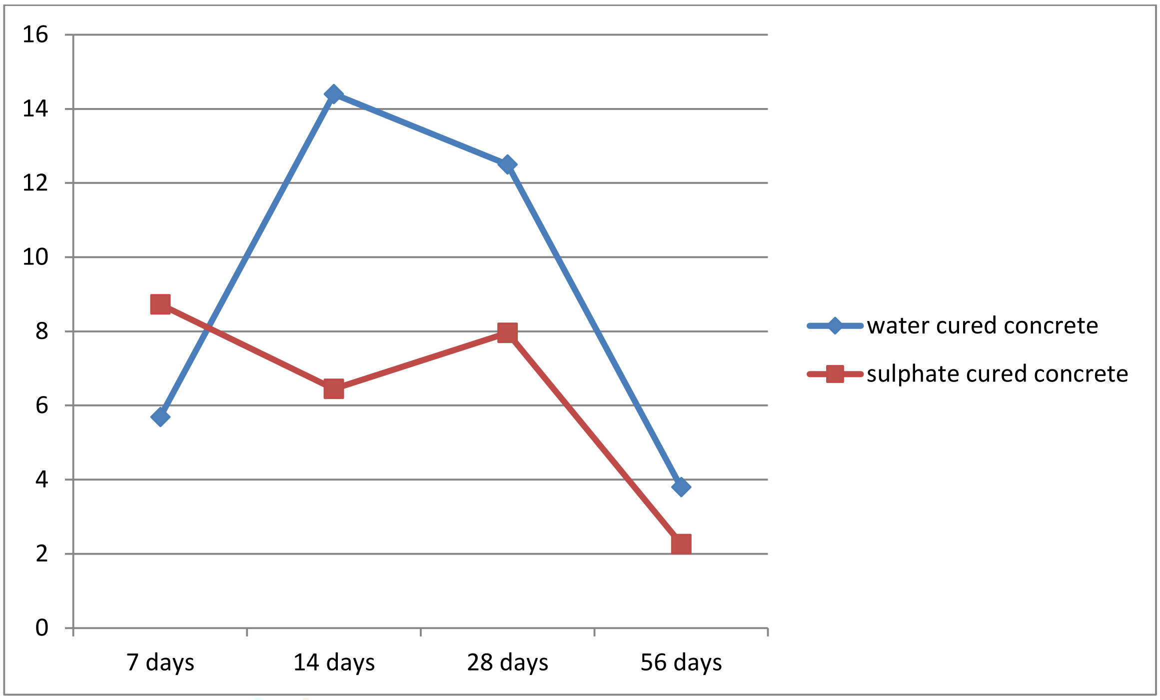

Fig. 5: Graph showing difference between sorptivity of concrete cured on normal water condition and concrete cured on sulphate water condition

5. CONCLUSION

Compressive strength:

- On the basis of sulphate attack on concrete we concluded that , initially the concrete cured under sulphate condition gains more strength than the concrete cured through normal water but later on with the passage of time the sulphate attack on concrete reduces the strength of concrete and make it unsuitable to use by deteriorating it .
- Further studies have been made to take the necessary preventive action to protect the concrete from being attack by sulphate.

Sorptivity test:

- Sorptivity test is basically a measure to know the water absorption capacity of the concrete under different medium. Thus, from our study we came to know that concrete cured under the sulphate medium absorbs much more water as compared to the concrete cured under natural water medium.

As a result we came to know about the causes of sulphate water on concrete & its effects, how it can deteriorate the structure. Thus, necessary actions must be taken before using water for curing and mixing purpose.

6. REFRENCES

1) Nadir, H. M., and A. Ahmed. "The Mechanisms of Sulphate Attack in Concrete–A Review." Modern Approaches on Material Science5.2 (2022): 658-670.
2) Cheng, Hanbin, et al. "Compressive strength assessment of sulphate-attacked concrete by using sulphate ions distributions." Construction and Building Materials 293 (2021): 123550.
3) Sun, Dandan, et al. "Reliability assessment of concrete under external sulphate attack." Case Studies in Construction Materials15 (2021): e00690.
4) Merida, Ahcene, and Fattoum Kharchi. "Pozzolana concrete durability on sulphate attack." Procedia Engineering 114 (2015): 832-837.
5) Alam, B. A. S. H. I. R., et al. "Sulphate attack in high-performance concrete-a review." International Journal of Advanced Structures and Geotechnical Engineering1.1 (2012): 15-18.
6) Ikumi, Tai, Sergio HP Cavalaro, and Ignacio Segura. "The role of porosity in external sulphate attack." Cement and Concrete Composites 97 (2019): 1-12.
7) Ikumi, Tai, et al. "Simplified analytical assessment of damaged induced by the external sulphate attack in concrete piles." High Tech Concrete: Where Technology and Engineering Meet: Proceedings of the 2017 fib Symposium, held in Maastricht, The Netherlands, June 12-14, 2017. Springer International Publishing, 2018.
8) Prasad, J., D. K. Jain, and A. K. Ahuja. "Factors influencing the sulphate resistance of cement concrete and mortar." (2006): 259-268.
9) Trivedi, Ashutosh Shanker, Sudhir Singh Bhadauria, and Sarvesh Kumar Jain. "Experimental study of sulphate attack on steel embedded in reinforced concrete." Journal of The Institution of Engineers (India): Series A 100 (2019): 387-394.

10) ASTM C511, (2009),Standard specification for mixing,American society for testing and materials.
11) ASTM C192 (2012), "Standard practice for making and curing concrete test specimens in the laboratory."American society for testing and materials.
12) American ceramic society by James Clifton Year-1999.
13) American Concrete Institute Farmington Hills, USA.
14) Adam Neville, 2004.
15) ASTM (2013c) Standard test method for Measurement of Rate of Absorption of Water by Hydraulic cement concrete.
16) Concrete Technology book by M S Shetty.
17) Haynes, H,andBassuoni, M.T.,(2011) "Physical salt attack on concrete", Concrete International, Vol. 33.,No.11,pp..38-42
18) Haynes, H, O'Neil, (1996), "Concrete deterioration from physical attack by salts.
19) Mehta, P. K, (2000),"Sulphate attack on concrete: separating myths from reality." Concrete international…vol..22..,no..8..pp..57-61.
20) Malhotra, V. M, Carette(1987), "Durability of concrete containing supplementary in marine environment."SP-100-63 pp.1227-1258.
21) Santhanam, M. Cohen, (2001)."Sulphate attack research-whither now?, Cement and concrete research, vol. 31,no 6 pp 845-51.
22) Scherer,G.W.(2004), stress from crystallization of salts, cement and concrete research.

IS Codes-

1) IS: 383- 1970. Specification for Coarse and Fine Aggregates from Natural Sources for Concrete.
2) IS: 2386 (Part I) – 1963. Methods of Test for Aggregates for Concrete (Part I Particle Size and Shape).
3) IS: 516 – 1959. Methods of Tests for Strength of Concrete.