Determination of Deterioration of Concrete due to Sulphate Attack

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Abstract

This project investigated the impact of sulfate attack on concrete cubes, with a specific focus on pore formation and mass loss. Sulfate attack is a chemical process that can lead to the deterioration of concrete structures, potentially compromising their structural integrity. Two primary forms of sulfate attack, external and internal, were explored, each resulting from different sources of sulfate exposure. The study utilized a combination of penetration tests and weight loss measurements to assess the extent of deterioration in concrete cubes exposed to sulfate attack. The results revealed noticeable pore formation within the concrete matrix, primarily in the form of ettringite and gypsum crystals, characteristic products of sulfate attack. Mass loss measurements also indicated a significant reduction in the mass of the concrete specimens, which is attributed to the leaching of calcium ions from the cement paste, leading to a loss of binding material. The consequences of pore formation and mass loss were discussed in the context of concrete strength and durability.

1 INTRODUCTION

Sulfate attack is a corrosion process in which sulphate ions attack the components of cement paste. Water-soluble sulphate Consist of salts such as alkali-earth (calcium, magnesium, sodium) sulphate, which are chemically reactive with solid constituents, causing sulphate attack. The process of deterioration of concrete structure begins when sulphates present in the environment enter. the concrete Sulfate attack on concrete can take several forms depending on the chemical type of sulphate and the environmental exposure of the concrete. Sulphate attack can result in expansion, cracking, loss of strength and deterioration. When sulphate ions interact with the components of concrete, SA occurs on the concrete. This reaction can result in the formation of expanded compounds, which can cause corrosion. One of the most common degradation mechanisms is sulphate attack. This type of chemical damage can weaken the structure by causing cracks, breaks and disintegration.

2 MATERIAL AND METHODS

2.1 Cement

Ordinary Portland Cement

2.2 Aggregate

This can be divided into: (a) Fine aggregate. Local natural sand was used in preparing the concrete mixes, (b) Coarse aggregates

2.3 Grade of Concrete

M30 & M40 (Taken according to the exposure conditions)

3 EXPERIMENTAL WORKS

3.1 CASTING AND CURING SPECIMENS

Two concrete mixes were cast in 1m3 cubes. The experimental work included the casting of eighteen cubes for compressive strength and sulfate penetration tests. After casting the cubes was immersed in tap water for 7 days. After curing, the specimens were kept in the concentrated solution for 7 days as well.

Table 1. Grade of Concrete and Period of Curing

Grade of Concrete	Curing in Tap Water (Days)	Immersion in Concentrated Solution (Days)	Concentration of Magnesium Sulphate (Mg/L)
M30 (Cube1)	7	7	8
M30 (Cube2)	7	7	8
M30 (Cube3)	7	7	8
M30 (Cube4)	7	7	9
M30 (Cube5)	7	7	9
M30 (Cube6)	7	7	9
M30 (Cube7)	7	7	10
M30 (Cube8)	7	7	10
M30 (Cube9)	7	7	10
M40 (Cube1)	7	7	8
M40 (Cube2)	7	7	8
M40 (Cube3)	7	7	8
M40 (Cube4)	7	7	9
M40 (Cube5)	7	7	9
M40 (Cube6)	7	7	9
M40 (Cube7)	7	7	10
M40 (Cube8)	7	7	10
M40 (Cube9)	7	7	10

Table 2. Weight Loss test results

Grade of concrete	Curing in tap water (Day)	Curing or immersion in concentration in sulphate solution (Day)	Concentration of magnesium sulphate (g)	Initial Wt of cube before curing in sulphate solution (kg)	Final Wt of cube after curing in sulphate solution (kg)	Avg Wt of cube before curing in sulphate solution (kg)	Avg wt of cube after curing in sulphate solution (kg)
M30(Cube1)	7	28	8	7.430	7.383	7.371	7.273
M30(Cube2)	7	28	8	7.283	7.110		
M30(Cube3)	7	28	8	7.400	7.326		
M30(Cube4)	7	28	9	7.800	7.736	7.696	7.618
M30(Cube5)	7	28	9	7.600	7.510		
M30(Cube6)	7	28	9	7.688	7.610		
M30(Cube7)	7	28	10	7.741	7.712	7.695	7.634
M30(Cube8)	7	28	10	7.623	7.510		
M30(Cube9)	7	28	10	7.721	7.681		
M40(Cube1)	7	28	8	7.730	7.603	7.759	7.639

M40(Cube2)	7	28	8	7.723	7.503		
M40(Cube3)	7	28	8	7.826	7.812		
M40(Cube4)	7	28	9	7.530	7.481	7.438	7.311
M40(Cube5)	7	28	9	7.548	7.426		
M40(Cube6)	7	28	9	7.236	7.023		
M40(Cube7)	7	28	10	7.406	7.303	7.393	7.254
M40(Cube8)	7	28	10	7.410	7.182		
M40(Cube9)	7	28	10	7.363	7.287		

3.2 Compressive Strength Test

The compressive strength test was determined through compressive test. Three cubes were tested for each mix.

3.3. Sulfate Resistance Test

Sulfate resistance is found by immersing specimens in different concentrations of Magnesium Sulfate solutions. The concentration rate, age of curing and age of immersion is mentioned in Table.1.

RESULTS

The findings of this study provide valuable insights into the impact of sulfate attack on concrete structures. Sulfate attack is a complex chemical process that can lead to significant deterioration, posing a risk to the durability and structural integrity of concrete. The study investigated both external and internal sulfate attacks, each stemming from different sources of sulfate exposure, and examined their effects on concrete cubes. The results of penetration tests and weight loss measurements revealed the presence of noticeable pore formation within the concrete matrix, primarily in the form of ettringite and gypsum crystals, which are characteristic products of sulfate attack. This pore formation weakens the concrete structure, leading to internal pressure, microcracking, and reduced structural integrity. As a result, the compressive and flexural strength of the concrete cubes were adversely affected. The observed mass loss in the concrete cubes exposed to sulfate attack is a significant concern, as it is attributed to the leaching of calcium ions from the cement paste, resulting in a loss of binding material. This mass loss indicates concrete deterioration and raises questions about the long-term durability of concrete structures in sulfate-rich environments.

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