Mechanical and Statistical Study of Seawater Mixed Concrete

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Abstract - *The need for fresh water in daily life has increased, but the potential sources of water are decreasing, thus we must consider alternate methods of obtaining water for construction projects. Many physical, chemical, and electrochemical degradation processes happen simultaneously on reinforced concrete structures exposed to coastal environments. It is crucial that these structures have a lengthy service life and be able to survive the ravages of time and the damaging effects of the harsh environmental conditions with little need for maintenance given the enormous cost involved in initial construction, repair, and rehabilitation. Studying the impact of bond strength and corrosion of rebars in concrete is crucial to extend the service life of these buildings. This study will use concrete of various grades to examine the impact on the sorptivity of concrete, bond strength, and corrosion resistance of the rebar in concrete.*

***Key Words*: Seawater Concrete, Corrosion inhibitors, Compression, Bond Strength, Sorptivity.**

1. INTRODUCTION

One of the most often utilised building materials is concrete. Concrete is frequently used because of its strength, ease of shaping into desired forms, durability, and other qualities. The building sector has seen enormous transformation as a result of improvements in concrete, such as reinforcing and pre-stressing processes. A significant area of civil engineering, concrete technology is always being researched and advanced. Man can now construct sturdy structures wherever he wants. For the construction of high-rise buildings, storage vessels, underground structures, maritime structures, structures exposed to harsh atmospheric conditions, etc., reinforced concrete structures with greater strength and durability are employed.

Steel reinforcement corrosion during service causes issues with durability for reinforced concrete structures. Highly porous, fragile, and frequently found surrounding reinforcing steel, corrosion products have a number of interrelated impacts. These impacts significantly shorten the service life and load-bearing capacity of reinforced concrete elements. Numerous parameters, including cement type, concrete permeability, concrete cover, concrete pH value, concrete carbonation, the presence of corrosion inhibitors, etc., have an impact on corrosion activity. Today, corrosion inhibitors, chemical admixtures, and mineral admixtures are used to strengthen the link between concrete and rebars and to increase the corrosion resistance of reinforced concrete structures. Due to its widespread occurrence in a variety of construction types and the significant expense of repairing these structures, the corrosion of reinforcing steel in concrete has drawn more attention in recent years. In fact, corrosion of the steel reinforcing concrete is a developing global issue. When reinforced concrete structures are exposed to hostile environments, reinforcement corrosion is the most frequent damage process that occurs.

Steel reinforced concrete's structural performance depends on how well the steel rebar adheres to the concrete. Pure water supplies are being used up more quickly than they can be replenished, which has a negative economic impact on the construction industry. Due to the scarcity of drinking water, the construction sector now uses seawater. The use of seawater could pose major risks such concrete spalling and cracking, corrosion of rebars, decreased bond strength, and others.

It is important to examine the issue of reinforcing corrosion and strength when using seawater to mix cement in concrete. Various dissolved salts, such as calcium sulphate, magnesium sulphate, sodium chloride, and magnesium chloride, are present in seawater. All chlorides have the tendency to hasten cement setting and increase the initial strength of concrete. On the other hand, the sulphates have a tendency to delay cement setting and reduce the early strength of concrete. It is discovered that the combined result of these two conflicting processes is a strength loss of concrete of between 8 and 20%. It has been discovered that, as long as the concrete is dense and the reinforcement is well covered, seawater does not cause the reinforcement to corrode.

1.1 Objectives

- To carry out a mechanical and statistical analysis of seawater-mixed concrete.
- Based on the many studies that have already been conducted, conduct a comparative analysis of the usage of different corrosion inhibitors in concrete.

- To study how corrosion inhibitors affect concrete and rebar.
- To investigate the rebar-concrete bond's resistance to salinity and the sorptivity of concrete.
- To investigate if the application of corrosion inhibitors causes a relative rise or fall in bond strength and corrosion resistance.
- To locate the most effective and reasonably priced corrosion inhibitor on the market.
- To determine the connection between bond strength and corrosion resistance.

1.2 Scope of Study

This project focuses on employing corrosion inhibitors to improve the bond strength and corrosion resistance of concrete made with seawater. In this study, the bond strength and corrosion resistance of seawater-mixed concrete mixes M20, M25, and M30 with anticorrosive-coated reinforcements and reinforcements without such coatings are compared. For the investigation, the readily accessible corrosion inhibitors on the market must be taken into account. In this work, it will be examined whether there has been a percentage gain or decrease in the bond strength, sorptivity, and corrosion resistance of seawater mixed concrete.

2. EXPERIMENTAL STUDY

2.1 Materials and Mixes

Throughout the experiment, ordinary Portland cement of grade 53 that complies with IS 12269 and has a specific gravity of 3.15 was utilised as the cement. Fine aggregate is made of sand. As coarse aggregates, 20mm and 12.5mm size aggregates were employed. Potable water with a pH of 6.5 and saltwater with a pH of 7.85 were the two types of water used in this investigation. According to the code IS: 3025 (Part-32, 24, 18) -2009, the amount of chloride, sulphate, and inorganic impurities in saltwater exceeds the maximum allowable limit. Steel reinforcement with a 16mm diameter and a 1.58kg/m density was used for the pullout specimens. In this investigation, two different kinds of corrosion inhibitors are also utilised.

M20, M25, and M30 mix considerations were made for this investigation. According to the suggestions and calculations indicated in IS: 456:2000 and IS: 10262-2009, the mix designs for M20, M25, and M30 were completed. Various qualities needed for the mix design were tested on the materials. Concrete in the M20, M25, and M30 grades is mixed with potable water as well as seawater to create specimens for various testing and are tested to compare the effect of potable water and seawater on various properties of concrete.

2.2 Tests for Various Properties

i. Slump Test: The slump test is one of the fresh property tests that is frequently done at sites. Slump test is carried out in each mix in order to find out the workability of concrete.

ii. Compression Test: The most frequent test on hardened concrete is the compression test, in part because it is simple to execute and in part because the majority of the desired characteristics of concrete are qualitatively connected to its compressive strength. The cubes used to manufacture the specimens for compressive strength testing are 150x150x150mm. For each blend, six specimens were cast. 36 cubes in total were cast. For each concrete grade, three specimens were required for the seventh day test and three for the twenty-eighth day test. For seawater-mixed concrete, tests for compressive strength were performed on days seven and twenty-eight.

iii. Pull-out Test: The pull-out test is used to evaluate the bond strength between steel and concrete. The pull-out test specimens were cast as 150x150x150mm cubes, each of which contained a 95cm-long, 16mm-diameter bar. The bar is fastened in the cube so that it should receive a 20mm bottom cover. Because introducing corrosion could cause the bar to corrode quickly, the bottom projections of cubes were avoided. There are three different types of bars used to cast pull-out specimens. Bars without a corrosion inhibitor coating, bars with an inhibitor I solution coat, and bars with an inhibitor II solution coat. For each mix, a total of six specimens were cast in seawater. The specimens were kept for 28 days curing. After 28 days of curing, the specimens underwent rapid corrosion. Through a system of galvanic cells, the specimens received the corrosion. Pull-out tests using a 1000kN universal testing machine were used to measure the steel-concrete bond strength following the curing and accelerated corrosion periods.

iv. Sorptivity Test: The test was conducted in order to gauge how much water was absorbed through capillaries. The samples were heated to 100°C for 24 hours, removed, and allowed to cool for 24 hours. The slices were then placed on a mesh weld such that water could freely access the bottom surface. The water didn't get any higher than five millimetres above the specimen's base. After wiping off any extra water, the specimen's weight was recorded at intervals of 0, 5, 10, 20, 30, 60, 120, 180, 240, and 300 minutes.

3. RESULTS AND DISCUSSIONS

The tests that were performed on the samples yielded the following results.

3.1 Slump Test

The slump value of seawater concrete is on higher side compared to the potable water mixed concrete. This shows that the sea water mixed concrete has more workability.

3.2 Compressive Strength

For the 7th and 28th days, the compressive strength of seawater mixed and potable water mixed concrete was determined. On the seventh day, all grades of seawater mixtures and regular water mixtures reach a strength of more than 75%. Results of M20, M25, and M30 concrete grades' seventh-day compressive strength tests conducted using potable water reveal that these concrete grades achieved their typical compressive strength at 28 days within 7 days. Each concrete grade has a seventh-day strength that is greater than the typical compressive strength at 28 days. The findings of the seventh-day compressive strength test indicate that concrete made with potable water has more strength than concrete made with seawater.

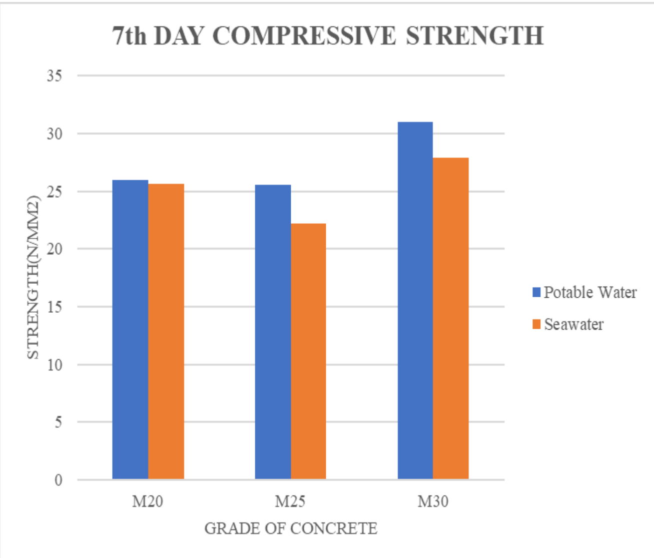

Chart -1: 7th day compressive strength

Results from tests on M20, M25, and M30 grades of concrete using potable water at day 28 indicate that they reached their desired mean strength at that time. Each concrete grade has a 28-day strength that is more than the intended mean strength. The 28th day compressive findings of concrete grades M20, M25, and M30 in seawater reveal that they also acquired their typical compressive strength, however some grades were unable to reach the desired mean strength. The 28th day compressive strength test reveals that concrete made with potable water has more strength than concrete made with seawater.

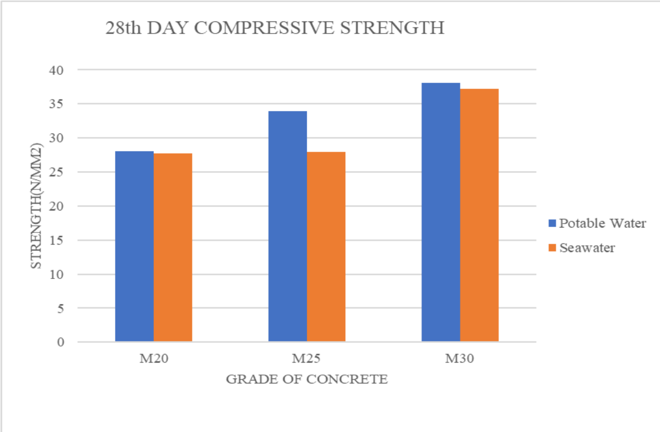

Chart -2: 28th day compressive strength

3.3 Pull out Test

The pullout test is conducted for all grades of seawater and potable water mix, and it is observed from the maximum loads at which the specimen fails that the specimen with corrosion inhibitor-I coated bars exhibit greater bond strength compared to specimens with corrosion inhibitor-II coated bars and uncoated bars. The outcomes are shown below.

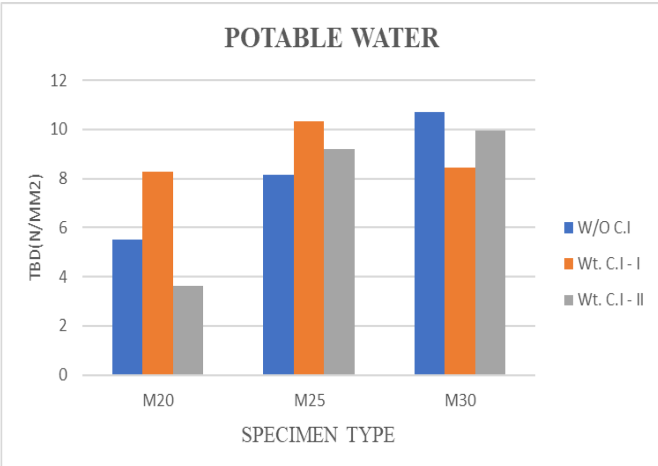

Chart -3: Bond stress for coated and uncoated bars with potable water mix

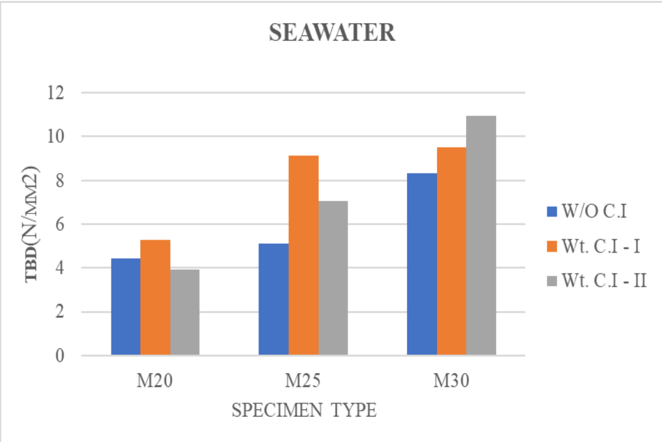

Chart -4: Bond Stress for Coated and Uncoated Bars with Sea Water Mix

3.4 Sorptivity

The sorptivity test illustrates the obstruction to water flow caused by capillary suction on concrete specimen surfaces. The pore structure of the concrete and curing time both generally have an impact on this attribute. It is found that the sorptivity of seawater mixed concrete is higher than the potable water mixed concrete. And the sorptivity of M20 grade shows the maximum value.

4. CONCLUSIONS

The bond strength of concrete grades M20, M25, and M30 utilising potable water and seawater was tested using a variety of research papers. Bars without corrosion inhibitor, bars covered with corrosion inhibitor-I, and bars coated with corrosion inhibitor-II were the three examples taken into consideration for the study, and the specimens were subjected to accelerated corrosion. From these experimental studies, the following conclusions can be drawn:

- Concrete mixed with potable water has a seventh-day compressive strength that is 0.3 to 16 percent higher than concrete mixed with seawater.
- Concrete mixed with potable water has a 28-day compressive strength that is 1 to 20% higher than concrete mixed with seawater.
- The pullout results indicate that for M20 and M25 grade concrete, the specimen with bars coated with corrosion inhibitor - I exhibits the maximum bond stress for both potable water and seawater mix concrete, and that for M30 grade specimen with bars coated with corrosion inhibitor - II exhibits slightly higher bond stress than corrosion inhibitor - I.
- As the grade of concrete increases, the bond stress rises for all types of specimens with potable water and seawater mix except for the specimen.
- Sorptivity of M20 grade is maximum and it is greater in seawater concrete than potable water concrete.

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