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Technical Report:
Using Absorbent Materials to Support Sacrificial Anodes in Splash Zones

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ABSTRACT
Sacrificial anodes are unable to perform optimally in the splash zone due to the absence of a stable electrolyte layer on the metal surface, which hinders their ability to prevent corrosion. This study evaluated the water absorption capabilities of several materials—including sponge, wool thread, chamois cloth , and sanitary pad material—to determine the most suitable material for forming a stable electrolyte layer in the splash zone, and compared their performance with the fully submerged zone. The results showed that unprotected steel in the splash zone exhibited the highest corrosion rate, at 0.403 mm/year, while the sanitary pad material demonstrated the closest corrosion rate to unprotected steel in the submerged zone (0.0390 mm/year), with a value of 0.0521 mm/year. The small difference of 0.0131 mm/year suggests that the sanitary pad material can nearly replicate submerged conditions in terms of corrosion protection, making it a promising candidate for enhancing sacrificial anode performance in splash zone application

KEYWORDS
Splash Zone
Electrolyte Layer
Corrosion Rate
Sanitary Pad Material

INTRODUCTION

Corrosion is one of the main issues affecting steel structures in marine environments, particularly in the splash zone, which is known as the most aggressive area due to wet-dry cycles, high chloride ion content, and oxygen availability. Various protective methods have been developed to address this issue, including surface coatings with materials like glass flake polyester (GFP) and Thermal Spray Aluminium (TSA), as well as wrapping systems that mimic submerged zone conditions. One promising alternative is the use of sacrificial anodes; however, their effectiveness in the splash zone is limited due to the absence of a stable electrolyte. Previous studies have shown that materials with good water absorption and retention properties can help form a seawater film, allowing sacrificial anodes to function properly. This study evaluates the

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water absorption capacity of several materials and tests their performance under laboratory conditions simulating the marine splash zone environment

LITERATURE REVIEW

Corrosion is one of the main problems affecting steel structures in marine environments, especially in the splash zone, which is known as the most aggressive region toward metals. This is caused by the constant wet-dry cycles, the high chloride ion content from seawater, and the availability of oxygen that accelerates oxidation reactions [1]. Over the long term, corrosion in the splash zone can lead to significant structural damage and reduce the service life of offshore steel components.

Previous studies have shown that surface coating with protective materials such as glass flake polyester (GFP) can provide long-term protection, even up to 25–30 years, with minimal maintenance [2]. On the other hand, metal-based coating methods, such as Thermal Spray Aluminium (TSA), have also proven effective by providing dual protection: serving as a physical barrier and as a sacrificial layer that slows down the corrosion rate [3].

Another alternative that has been developed is the wrapping system, which functions to retain moisture and limit direct oxygen exposure to the metal surface. This system, as developed by NIST, mimics the more stable and less corrosive submerged zone environmental conditions [4].

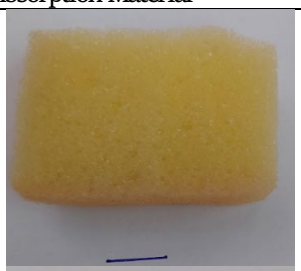
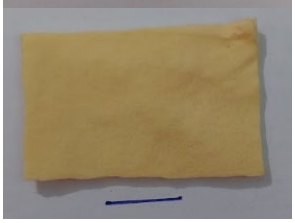
If sacrificial anodes can work properly in the marine splash zone, they would represent an important alternative for solving anti-corrosion problems. The reason sacrificial anodes do not work properly in the splash zone is that there are no stable electrolytes around the metalwork to enable the anode to function. If a stable seawater film can be formed on the surface of splash zone metal structures, sacrificial anodes would be able to protect the structure. By selecting a material with good water absorption and retention properties for splashed seawater, it can be wrapped around the structure to enable the sacrificial anode to function. Linen has better water absorbing capacity compared with cotton, dacron and chemical fiber and it can be used as the material helping electrolyte layer forming on the steel structure in splash zone. The protection efficiency by sacrificial anode in marine splash zone is high.[6]

In this paper, the water absorption capacity of various materials—including sponge, wool thread, chamois cloth (Kanebo), and sanitary pad material—was evaluated. Additionally, corrosion in the splash zone was studied by wrapping selected seawater-protective materials around the specimens using laboratory testing. The samples were subjected to repeated short-term wetting and drying cycles simulating splash zone conditions, where the specimens are intermittently wetted by wave splashes and dried by air exposure in rapid succession, along with a cyclic wet-and-dry method.

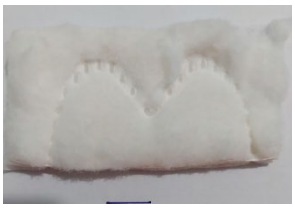
RESEARCH METHOD

This study was conducted using an experimental approach by testing the corrosion rate of carbon steel with the following chemical composition (WT%): C: 0.05–0.15; Mn: 0.3–0.60; Si: 0.1–0.35; S: max 0.05; P: 0.04; Fe: balance. The surface of the carbon steel samples was rinsed with acetone. The water absorption capacity of various materials—including sponge, wool thread, chamois cloth, and sanitary pad material—was evaluated as shown at Table 1. A 3.5% saltwater solution was used as the electrolyte. The samples were mounted on the experimental setup (Figure 1). The up-and-down movement of the samples relative to the saltwater surface was designed to simulate splash zone conditions, characterized by alternating wet and dry cycles. This vertical motion was powered by a modified wiper motor, operating at a speed of 40 rotations per minute. For comparison, several samples were kept fully submerged throughout the experiment. The entire test was conducted over a 14-day period. The procedure for corrosion testing and corrosion rate calculation (weight loss method) follows the ASTM G31 standard [7].

Table 1. Absorption Material and Sample Code

Absorption Material		Sample Code
Sponge		Splash Zone, Sponge (SZ, SP)
Wool Thread		Splash Zone, Wool Thread (SZ, WT)
Chamois Cloth		Splash Zone, Chamois Cloth (SZ, CH)

Sanitary Pad Material



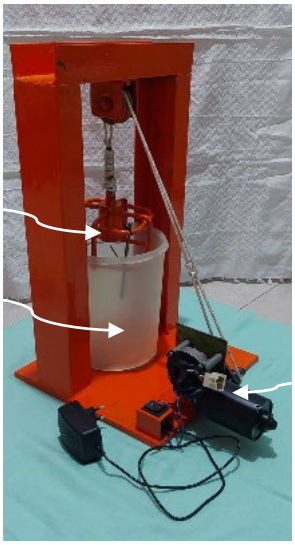
Splash zone, Sanitary Pad Material (SZ, SPM)

Unprotected steel

Submerged, Unprotected Steel (SMZ, US)

Sample Holder

Saltwater Container (3.5% NaCl)



Wiper Motor

Figure 1. Experimental Setup

DISCUSSION

The research data are presented in Table 2 and Figure 2. This study observed the corrosion rate of carbon steel samples at two different locations: the submerged zone (SMZ) and the splash zone (SZ). The main focus was on how protective materials affect weight loss and the corrosion rate of the steel.

In the submerged zone, unprotected steel experienced a weight loss of 0.075 grams, with a low corrosion rate of 0.0390 mm per year (mmy). This indicates that even without protection, the submerged environment tends to be more stable and less aggressive than the splash zone in causing corrosion (Figure 2).

In contrast, conditions in the splash zone are much more aggressive. Unprotected steel in this area showed the highest weight loss of 0.343 grams, with the highest corrosion rate: 0.4029 mmy. This suggests that the combination of saltwater and air exposure significantly accelerates corrosion.

Table 2. Measured Sample Weight Loss and Corrosion Rate Calculationo

Sample code	Height (mm)	Initial Diameter (avg) (mm)	Final Diameter (avg) (mm)	Reduction in Diameter (mm)	Weight Loss (g)	Corrosion Rate (mmy)
SMZ, US	67	5.174	5.171	0.003	0.075	0.0390
SZ, CH	69.5	5.174	5.16	0.014	0.12	0.1822
SZ, SP	70.5	5.129	5.101	0.028	0.215	0.3640
Sz, WT	72	5.163	5.147	0.016	0.133	0.2082
LZ, US	68	5.19	5.159	0.031	0.343	0.4029
SZ, SPM	69	5.171	5.167	0.004	0.107	0.0521

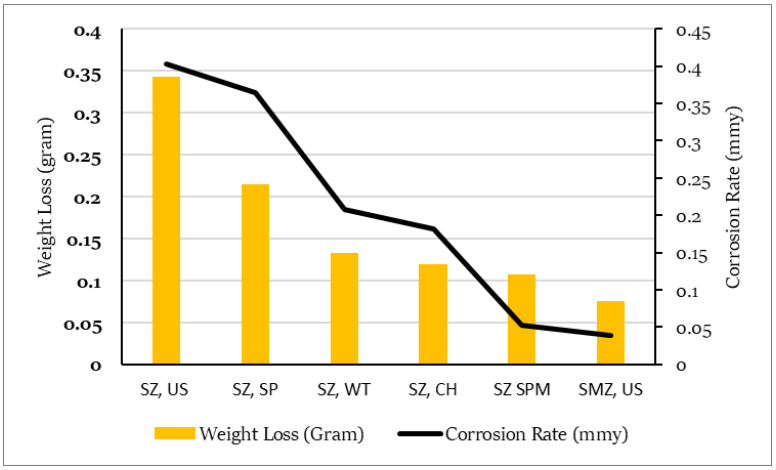


Figure 2. Title of figure

Various protective materials were tested for their effectiveness in inhibiting corrosion in the splash zone. The results are as follows: Sanitary pad material provided the best protection, with a weight loss of only 0.107 grams and a very low corrosion rate of 0.0521 mmy. Chamois cloth was fairly effective, with a weight loss of 0.12 grams and a corrosion rate of 0.1822 mmy. Wool thread performed slightly worse, with 0.133 grams of weight loss and a corrosion rate of 0.2082 mmy. Sponge showed low effectiveness, with a weight loss of 0.215 grams and a corrosion rate of 0.3640 mmy.

Corrosion Rate Based on Type of Protective Material and Exposure Location

Based on the test data, the highest corrosion rate was found in the unprotected specimen placed in the splash zone, reaching 0.4029 mmy. This indicates that the splash zone environment is highly aggressive toward metals, especially without protective layers. Conversely, the lowest corrosion rate in the splash zone was observed in the specimen covered with sanitary pad material, at only 0.0521 mmy. This shows that sanitary pad material is the most effective in reducing corrosion compared to other tested materials. The effectiveness ranking of the protective materials, from most to least

effective, is as follows: Sanitary pad material; Chamois cloth; Wool thread; Sponge. The Surface condition of the samples show in Table 3.

The effectiveness of sanitary pads in reducing corrosion is due to their ability to absorb. Superabsorbent polymer (SAP) demonstrates the highest absorption capacity compared to the other three materials, with the ability to absorb 50–100 times its own weight [8]. Chamois cloth (PVA) absorbs 8–10 times its weight, while polyurethane sponge has a moderate absorption capacity of 3–6 times its weight [9]. Based on data obtained from online market sources, wool thread absorbs only 0.3–1 time its own weight.

The high corrosion rate in the splash zone is caused by the highly aggressive nature of the NaCl solution. Steel in this zone corrodes rapidly due to several key factors. First, the repeated wet-dry cycle exposes the steel surface to continuous splashing of the NaCl solution, followed by drying due to wind and sunlight. This cycle leads to chloride ion deposits from the salt and the formation of highly corrosive brine as water evaporates. Second, the high availability of oxygen in this zone—unlike in fully submerged parts of the structure—accelerates oxidation processes, further increasing the corrosion rate

Table 3. Surface Condition of The Sample

Sample Code	Surface Condition Of The Sample
S Z, US	
S Z, SP	
S Z, WT	
S Z, MC	
S Z, SPM	

SM Z, US

Moisture Control as A Corrosion Mitigation Strategy

The protective material with a corrosion rate closest to unprotected steel in the submerged zone (0.0390 mmy) is the sanitary pad material, with a corrosion rate of 0.0521 mmy. The difference is only 0.0131 mmy, indicating that this material is almost as effective as full submersion in preventing corrosion, even when used in the much more aggressive splash zone.

The use of protective materials capable of absorbing NaCl solution, such as sanitary pad material, aims to create environmental conditions in the splash zone that resemble those in the submerged zone, where corrosion rates are generally lower. By absorbing salt solution and maintaining relatively stable moisture around the steel surface, this material helps reduce extreme wet-dry cycles, lowers the concentration of chloride ions depositing directly on the metal surface, and limits direct contact between the steel and open air.

This combination of mechanisms effectively reduces the rate of oxidation caused by high oxygen availability in the splash zone. Sanitary pad material functions as a medium that forms a stable electrolyte layer on the metal surface, thereby creating conditions similar to those found in a submerged environment.

CONCLUSION

The test results confirmed that the splash zone is the most critical area for corrosion in marine structures. Without protective materials, steel in this zone is highly susceptible to damage. However, the strategy of using absorbent materials—such as sanitary pad material—proved effective, functioning as a medium to form a stable electrolyte layer on the metal surface and replicating conditions similar to a fully submerged environment

MANAGERIAL IMPLICATION

This study highlights critical insights for managers overseeing the maintenance and protection of marine steel structures. The splash zone has been confirmed as the most vulnerable area to corrosion due to its exposure to alternating wet and dry conditions, high salinity, and oxygen. Without proper protection, steel components in this zone are prone to rapid deterioration.

A key managerial takeaway is the effectiveness of using absorbent materials—such as sanitary pad material—as a corrosion protection strategy. These materials serve as a medium to retain seawater on the steel surface, enabling the formation of a stable electrolyte layer. This layer allows sacrificial anodes, which normally fail in the splash zone due to the absence of consistent moisture, to function properly and provide active corrosion protection.

Moreover, combining the absorbent layer with an outer HDPE (High-Density Polyethylene) jacket creates a double protection system. This setup not only supports the anode's function but also acts as a physical barrier against environmental exposure, enhancing long-term protection.

For asset integrity and operations managers, this approach presents a cost-effective and practical alternative to more complex and expensive corrosion control methods. The materials involved are readily available, easy to apply, and require minimal maintenance, making them suitable for both new installations and retrofit applications.

Managers are encouraged to consider pilot implementation of this system, especially in high-risk areas of offshore structures. Incorporating this method into existing corrosion management plans can extend the lifespan of structures, reduce maintenance frequency, and ultimately lower operational costs.

LIMITATION AND FUTURE RESEARCH

Limitation: This study was conducted solely under laboratory conditions; therefore, the findings may not be fully generalizable to real-world field environments.

Recommendation: It is recommended that future studies explore the integration of sanitary pad usage with sacrificial anode application.

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