STRESS CORROSION CRACKING IN PRESTRESSED CONCRETE: A STUDY OF SCC IN PRESTRESSED CONCRETE APPLICATIONS

Rodrigo Pierott, Sergio Luis Garcia, Diogo Kropf, Vivian Tam, Assed Haddad

ABSTRACT

This paper delves into the prevalent issue of pathological problems in concrete structures, with a specific focus on corrosion in steel reinforcement. It details an experimental investigation into the effects of chloride environments on prestressed concrete structures. Central to this study is the analysis of stress corrosion cracking (SCC) in 5 mm prestressing strands. The findings reveal that SCC predominantly manifests as pitting corrosion, which in turn initiates micro cracking on the wire surface. Intriguingly, the stress applied to the wires appears not to alter the composition of the corrosion products. This research offers comprehensive insights into the behavior of high-carbon steel wires under SCC conditions. A critical discovery is the significant influence of stress level on SCC progression, which markedly diminishes the ultimate strength of the corroded wires. This is particularly evident in the 48% reduction in ductility of wires at 95% of the tensile strength (fptk), a consequence of the formation of localized microcracks. These findings underscore the need for a deeper understanding of SCC in prestressed concrete structures, which is vital for enhancing their durability and longevity.

Keywords: **c**hloride attacks, stress corrosion cracking, steel wire degradation, civil infrastructure durability, prestressed concrete.

INTRODUCTION

Prestressed concrete, a cornerstone in modern construction, benefits from the pre-application of stress to enhance its strength and durability under service loads. This engineering marvel utilizes high-performance concrete coupled with high-strength steel, enabling structures to withstand significant stress levels before external loads are applied [1]. Despite its widespread adoption for its superior performance, prestressed concrete is not immune to the insidious threat of stress corrosion cracking (SCC). SCC represents a critical failure mode, where the synergistic effects of mechanical stress and corrosive environments precipitate the formation of microcracks on steel surfaces [2,3,4]. These microcracks can expand rapidly under continued stress, leading to sudden and often unpredictable failures in structural elements, significantly reducing their yield strength and, ultimately, their service life.

The phenomenon of SCC is particularly alarming due to its ability to compromise the integrity of structures without prior deformation or visible signs of distress, making early detection and intervention challenging [5]. SCC is influenced by a trinity of factors: the material's inherent susceptibility, the level of applied stress, and the presence of a corrosive environment [6,7,8]. This complexity is further compounded by the diverse nature of these elements, including variations in stress types (residual or externally applied) [9], material properties, and environmental conditions such as temperature, aeration, and the presence of specific corrosive agents. For instance, the susceptibility of different alloys to SCC can vary dramatically in the presence of certain chemicals, highlighting the intricate interplay between material science and environmental chemistry in the context of SCC [5].

The pressing need to understand and mitigate SCC in prestressed concrete is underscored by its prevalence in critical infrastructure, including nuclear power plants, where the long-term performance and safety of such structures are of paramount importance [10]. Despite the durability of prestressed concrete, the advent of chloride-induced steel corrosion emerges as a dominant factor undermining the structural integrity of these constructions [11]. Recent studies have illuminated the detrimental impact of corrosion on the residual strength of prestressed tendons, indicating significant reductions in ultimate strength and ductility, which in turn affect the failure modes of the structures [12-27].

Amidst this backdrop, our study endeavors to bridge a crucial knowledge gap by examining the behavior of prestressing strands, particularly those with diameters less than 8 mm, a domain less explored in contemporary research. Given the heightened risk of cross-sectional loss and subsequent deterioration in smaller diameter strands, our investigation seeks to shed light on the nuanced impacts of different prestressing levels on SCC, employing an experimental approach that encompasses a comprehensive analysis of material behavior under simulated environmental conditions [28]. Through this research, we aim to contribute to the broader understanding of SCC mechanisms, offering insights that could inform more resilient design and maintenance strategies for prestressed concrete structures.

BACKGROUND

The phenomenon of stress corrosion cracking (SCC) has emerged as a significant concern for the longevity and reliability of prestressed concrete structures. SCC involves the initiation and propagation of cracks in a material subjected to tensile stress in a corrosive environment, leading to premature failure of structural components. In prestressed concrete, this manifests as a critical threat, particularly due to the high levels of stress applied to the steel reinforcement to achieve desired prestress levels.

Recent advancements in monitoring technologies have allowed for a more nuanced understanding of corrosion-induced degradation within these structures. (Jiang et al., 2017) developed a piezoceramic-based sensing approach to monitor the progression of corrosion within prestressed concrete beams, highlighting the potential for early detection of corrosion-induced damage before visual signs become apparent.

The susceptibility of prestressed steel to SCC is further complicated by the presence of local concrete cracks. (Sun et al., 2014) investigated the impact of such cracks on the stress corrosion sensitivity of prestressed steel, uncovering that local concrete defects significantly increase the material's vulnerability to SCC.

Despite the recognition of these risks, the behavior of corrosion cracks in pretensioned prestressed concrete members remains less explored. (Agus et al., 2013) provided insights into the mechanisms of corrosion crack in such members, emphasizing the need for further research in this area.

Understanding the bond loss between the prestressed steel and concrete due to corrosion is crucial for assessing structural integrity. (Ortega et al., 2018) reviewed the mechanical effects of reinforcement corrosion on the bond strength in prestressed concrete beams, shedding light on the factors that reduce service life and load-bearing capacity.

Furthermore, the propagation of corrosion in prestressing steel strands embedded in concrete exposed to chlorides has been identified as a significant risk factor for structural failure. (Li et al., 2011) conducted a long-term experimental program to examine this phenomenon, finding that stress levels and the type of steel significantly affect corrosion rates, with pitting corrosion being the predominant form of damage in such environments.

Understanding the impact of corrosion on the structural performance of prestressed concrete beams, especially under transverse loads, is crucial for assessing their long-term reliability. (Recupero & Spinella, 2019) undertook experimental tests on corroded prestressed concrete beams to evaluate how tendon corrosion influences their response behavior. Their work highlights the detrimental effects of corrosion on the load-bearing capacity of beams, thus emphasizing the importance of timely corrosion detection and intervention strategies.

Moreover, the initiation of SCC in prestressing steel within hardened cement mortar, particularly under chloride exposure, remains a complex issue warranting further investigation. (Joseline et al., 2021) shed light on this matter by exploring the passive to active transition indicative of SCC onset. Their study underscores the critical role of environmental conditions, such as chloride concentration, in facilitating this transition, thereby contributing to our understanding of SCC initiation mechanisms and the pivotal factors that influence them.

By situating our study within this context, we aim to address the gaps identified in the current understanding of SCC in prestressed concrete, particularly focusing on the behavior of smaller diameter prestressing strands under various corrosive conditions. Our research seeks to contribute to the development of more durable and resilient prestressed concrete structures capable of withstanding the challenges posed by corrosive environments.

EXPERIMENTAL RESEARCH

Selection and Characterization of Materials

This study focuses on cold-drawn carbon steel wire, a material extensively used in prestressed concrete applications. Its selection was guided by its compliance with NBR 7482:2008 standards, ensuring that our findings are directly applicable to the construction industry. The chemical and mechanical properties of the specimen were meticulously analyzed to understand their influence on the steel's performance, especially its susceptibility to stress corrosion cracking (SCC).

Table 1 - Chemical composition of the specimen (Weight Percent, wt.%).

Elements	Carbon	Manganese	Silicon	Phosphor	Sulfur
(%)	0.79	0.65	0.21	0.013	0.010

The chemical composition, as detailed in Table 1, highlights a high carbon content which is known to significantly affect the steel's mechanical properties, including its strength and ductility. The controlled amounts of manganese, silicon, phosphorus, and sulfur contribute to the wire's overall performance in harsh environments.

Table 2 Mechanical Properties of the Specimen.

Maximum load	Elongation	Creep load	Modulus of elasticity	Ultimate Tensile Strength	Average Hardness
37.5 kN	4.6%	32.20kN	202.5 GPa	1860 MPa	509 HV10

Table 2 presents the mechanical properties of the steel wire, including its ultimate tensile strength and modulus of elasticity, which are critical in determining its behavior under stress.

The wire's high hardness level further underscores its potential for high performance in prestressed concrete applications, albeit with considerations for its brittleness.

Microstructural Analysis

The wire's microstructure was extensively examined to provide deeper insights into its characteristics that might influence its susceptibility to SCC. The analysis revealed a predominantly pearlitic structure with fine lamellar spacing, indicative of the wire's high strength and hardness. The presence of pearlite, along with trace amounts of cementite, suggests that the wire, while high in strength, may also exhibit a level of brittleness — a factor that could influence its behavior in corrosive environments typically encountered in prestressed concrete applications.

The detailed examination of the wire's microstructure is crucial for understanding how its inherent properties affect its durability and performance, particularly its resistance to stress corrosion cracking. The high carbon content, responsible for the wire's strength, also necessitates careful consideration of its application in environments where corrosion could precipitate brittle failure.

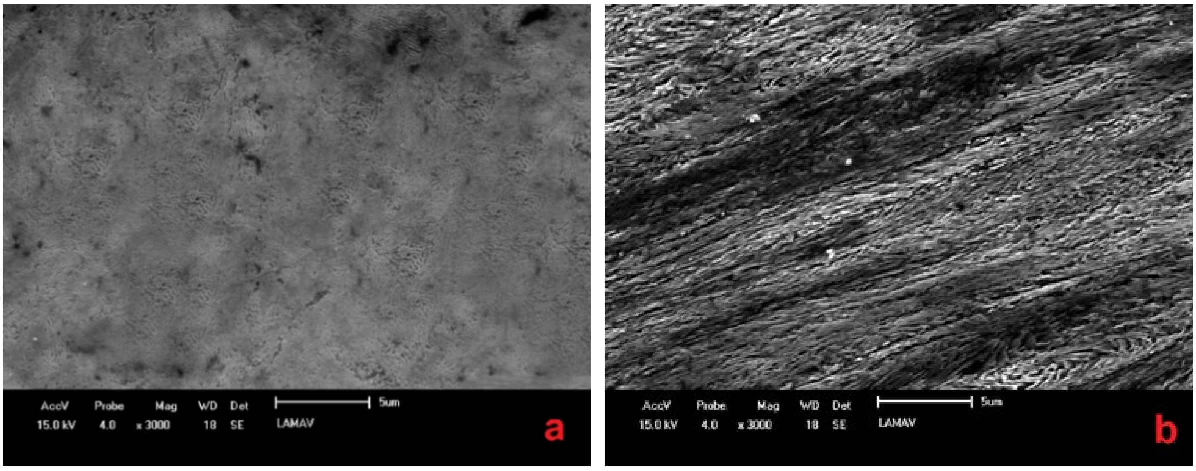


Figure 2.1 - Microstructure of the wire, a: Transverse view, and b: Longitudinal view

The microstructure of the cold-drawn carbon steel wire was meticulously analyzed to uncover characteristics that potentially influence its susceptibility to stress corrosion cracking (SCC). Understanding the microstructural features is paramount, as they directly impact the mechanical behavior and corrosion resistance of the material.

Figure 2.1: Microstructure of the Wire

2.1a (Transverse View): This view showcases the lamellar pearlite patterns within the wire. The fine structure of pearlite, characterized by alternating layers of ferrite and cementite, endows the wire with its high strength and hardness. This microstructural complexity is a critical determinant of the wire's mechanical properties, influencing how it responds to stress and environmental aggressors.

2.1b (Longitudinal View): The longitudinal view further elucidates the wire’s microstructure, emphasizing the orientation of pearlite and the presence of cementite lines. This arrangement not only contributes to the wire’s notable strength and hardness but also to its brittleness, a factor that could enhance its vulnerability to SCC in corrosive environments.

The analysis of the wire's microstructure reveals a dual nature: while its strength and hardness are desirable for prestressed concrete applications, the brittleness—stemming from its high carbon content and microstructural features—necessitates a cautious approach to its use in environments prone to corrosion.

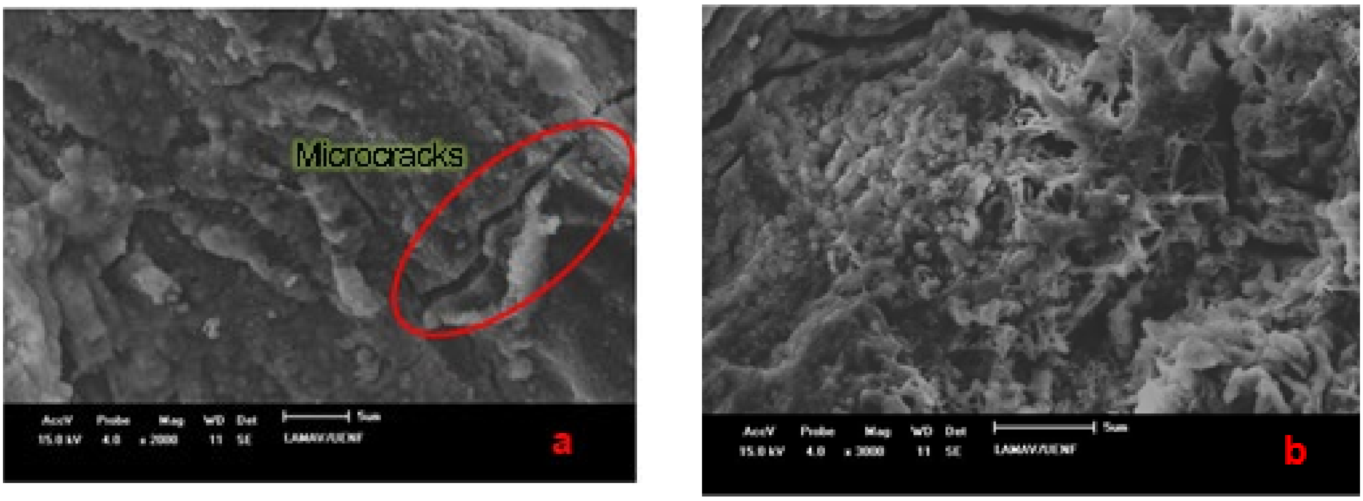


Figure 2.2 - Microscopy details of the 95%f_{ptk} wire: (a) microcracking on the wire surface (2000x magnification); (b) presence of microvoids (3000x magnification).

Figure 2.2 presents microscopy evidence of the microstructural degradation in 95% fptk prestressed steel wires under corrosive stress. Part (a) of the figure, captured at 2000x magnification, reveals the presence of microcracks on the wire surface. These microcracks are critical indicators of the onset of stress corrosion cracking (SCC), a significant concern for the longevity and safety of prestressed concrete structures. The high magnification allows for a clear visualization of the damage, emphasizing the severity of the microcracking phenomenon.

This figure provides visual confirmation of the microcracking and underscores the intricate details of the corrosion process that can lead to structural failure. The presence of microcracks is a testament to the vulnerability of the material when exposed to simultaneous mechanical stress and corrosive environments. The detailed visualization offered by this figure is essential for understanding the micro-mechanisms contributing to SCC and serves as a powerful tool for elucidating the material's behavior under conditions that mimic real-world applications.

The analysis of such microstructural damage is vital for advancing the field's understanding of SCC and for developing more effective corrosion-resistant materials and protective measures. It is through such detailed studies that engineers and researchers can improve the design and durability of prestressed concrete structures, ensuring their performance and reliability over time.

The anchoring system plays an important role in the application of pre-tension to the steel wires, simulating the operational stresses encountered in real-world prestressed concrete scenarios. This system ensures that the wires are subjected to a uniform pre-tension, crucial for the study of stress corrosion cracking under controlled conditions.

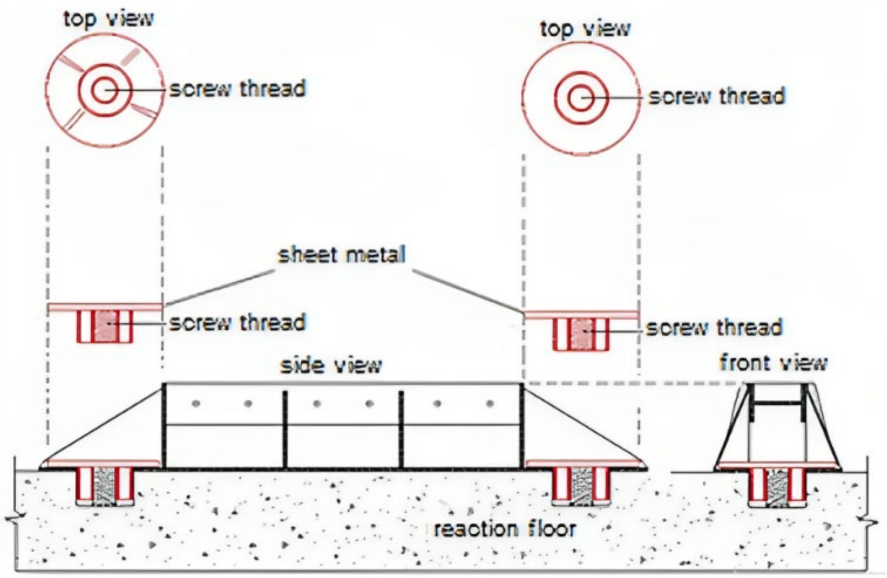


Figure 3 - Schematic of the anchoring system showing the devices used to fix the profile to the reaction slab.

Figure 3 provides a detailed schematic view of the anchoring system, illustrating the components and their arrangement for securing the wire to the reaction slab. The design of this system is instrumental in applying a precise and consistent pre-tension to the steel wire, mimicking the conditions under which prestressed concrete is utilized in construction projects.

Layout of the Prestressing System. Succeeding Figure 4, this layout offers an overview, to understanding of the experimental setup for prestress application.

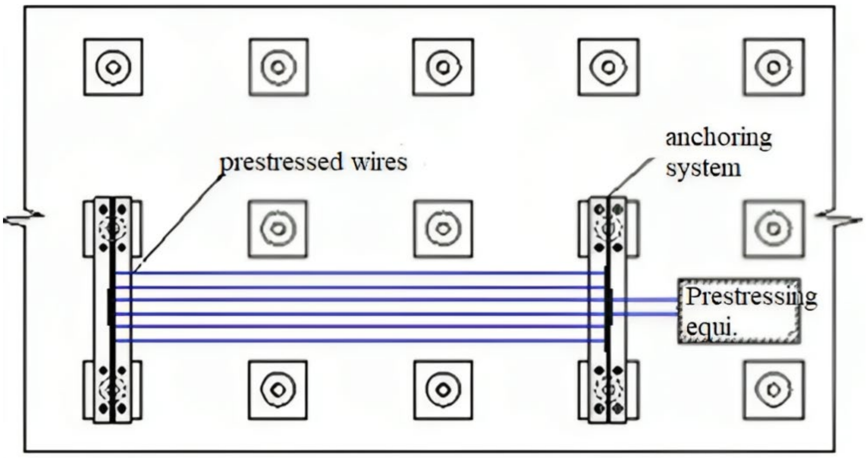


Figure 4 - Layout of the prestressing system.

The development and implementation of a robust anchoring system are essential for accurately replicating the stress conditions that prestressed steel wires undergo in service. By ensuring the uniform application of pre-tension, the anchoring system facilitates a controlled investigation into the effects of mechanical stress on the corrosion behavior of the steel wire.

Following the schematic, this layout offers an expansive view of the entire prestressing setup, including the anchoring system and the mechanism for applying pre-tension. This overview is crucial for understanding the experimental framework within which the SCC analysis is conducted.

The prestressing process is a crucial aspect of our study, designed to closely replicate the stress conditions that are inherent to prestressed concrete structures in real-world scenarios. A sophisticated hydraulic system was employed to apply and precisely control the tension across the steel wires. This methodology ensures that the applied pre-tension closely mimics the operational stresses experienced by prestressed concrete components, thereby enhancing the relevance of our findings to practical applications.

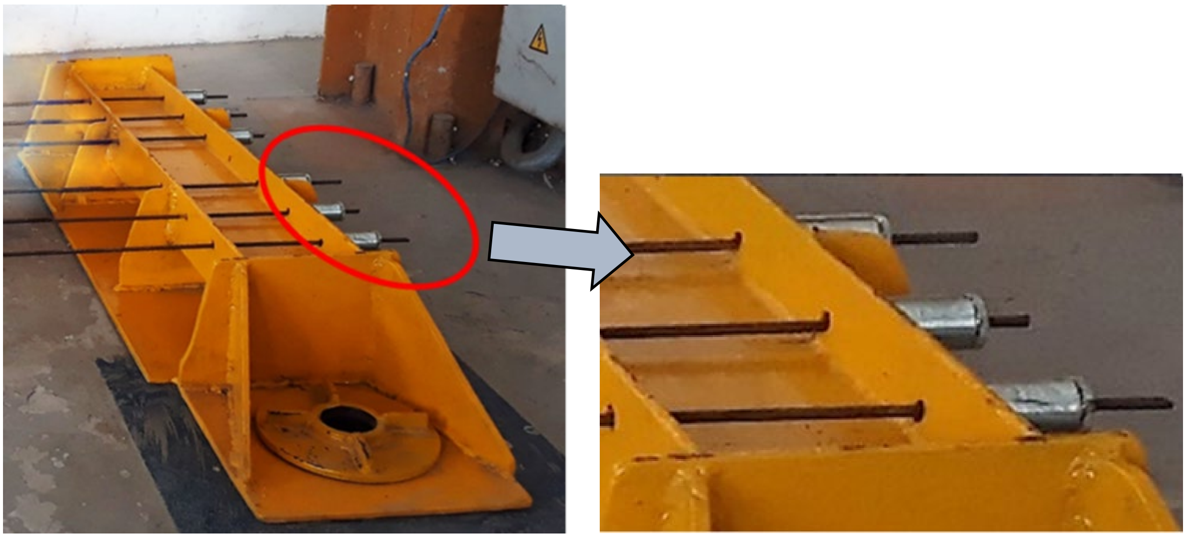


Figure 5 - Anchoring system of the prestressed strands

Figure 5 illustrate the sophisticated arrangement designed to maintain consistent wire tension throughout the experiment. The visual provided in Figure 5 is essential for understanding the mechanical setup that enables the precise application of pre-tension, a critical factor in exploring the relationship between stress levels and their influence on corrosion behavior. The figure showcases the hydraulic system and its components, highlighting the meticulous design that underpins the replication of prestress conditions.

To investigate the synergistic effects of mechanical stress and corrosive environments on SCC, we established a controlled experimental setup. This setup was meticulously designed to simulate the environmental conditions known to precipitate SCC, thereby allowing for a comprehensive analysis of how such conditions affect the susceptibility of steel wires to corrosion when under stress.

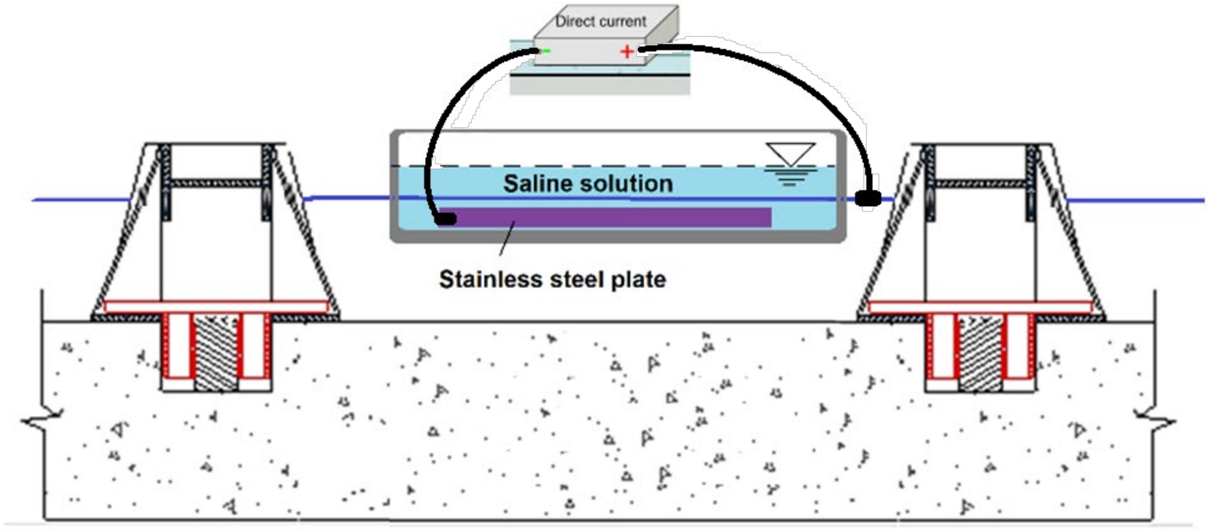


Figure 6 - Experimental setup.

Figure 6 provides a vivid illustration of the laboratory setup tailored for this purpose. This figure serves as a visual guide to the experimental arrangement, elucidating the methods employed to create a corrosive environment that simulates real-world conditions. The setup depicted in Figure 6 includes the corrosion-inducing elements and the system for applying tension, facilitating a controlled study of SCC under conditions that reflect the challenges faced in the field.

To accurately simulate the aggressive conditions that lead to stress corrosion cracking (SCC), a meticulous corrosion acceleration test was conducted. This involved the application of a direct current to the steel wire samples, a method proven to expedite the corrosion process and thereby mimic the accelerated deterioration observed in real-world scenarios.

Figure 7 - Corrosion Acceleration Test.

Figure 7 captures the setup used to apply electrical current to the steel wires. The image demonstrates how multimeters are employed to monitor the current flow, ensuring that the desired conditions for accelerated corrosion are achieved. This visual aid is pivotal in conveying the practical steps taken to induce corrosion, offering readers a clear window into the experimental procedures that underpin our findings.

Understanding the impact of varying stress levels and environmental exposures on corrosion behavior necessitated a systematic classification of steel wire samples. This organization allows for a nuanced analysis of how different pre-tension levels and exposure durations influence the development of corrosion patterns, providing insights into the complex interplay between mechanical stress and corrosive environments.

Table 3 Stress levels

Sample	Diameter (ϕ)	Quantity	Stress (MPa)	Time (hours)

0% f_{ptk}	5.0	3	0.0	3
50% f_{ptk}	5.0	3	930	3
70% f_{ptk}	5.0	3	1302	3
95% f_{ptk}	5.0	3	1767	3
0% f_{ptk} - 6	5.0	3	0.0	6
50% f_{ptk} - 6	5.0	3	930	6
70% f_{ptk} - 6	5.0	3	1302	6
95% f_{ptk} - 6	5.0	3	1767	6

In Table 3, samples are grouped according to their pre-tension levels and assigned exposure times. This classification forms the basis of our experimental design, facilitating a targeted investigation into the specific effects of prestress conditions on corrosion susceptibility. The table serves as an essential reference for interpreting the experimental setup and understanding the rationale behind the grouping strategy.

A comprehensive assessment of corrosion rates was carried out, leveraging both quantitative weight measurements and qualitative microstructural analyses. This dual approach enables a thorough understanding of SCC effects, merging numerical data with microscopic observations to paint a complete picture of the corrosion process.

The evaluation of corrosion rates involved precise measurements of weight loss before and after exposure to corrosive conditions, adhering to established standards for accuracy. Concurrently, advanced microscopy techniques were employed to examine the microstructural changes in the wires, identifying the presence of corrosion products, pit formation, and any indications of crack initiation and propagation. This meticulous analysis sheds light on the material's degradation mechanisms, offering valuable insights into the factors that contribute to the susceptibility of prestressed steel wires to stress corrosion cracking.

Table 6 - Analysis of variance of the weight loss results obtained

Analysis of Variance						
Source of variation	QS	DOF	RMS	F	P-value	Critical F value
Attack Period	34.56	4	8.64	11.62	0.00043	3.25
Pre-applied tension	62.73	3	20.91	28.12	1.03E-05	3.49

where:
QS = the sum of between-sample and within-sample variation
DOF = degree of freedom
RMS = QS/DOF
F = the ratio of between-sample to within-sample variation

Table 6 presents a comprehensive analysis of variance (ANOVA) for the weight loss results, a critical metric in evaluating the severity of corrosion in steel wires subjected to different conditions. This statistical examination meticulously quantifies the impact of two major experimental variables: the attack period and the pre-applied tension on the corrosion process. By delineating the sum of squares (QS), which aggregates both between-sample and within-sample variations, and the degrees of freedom (DOF) associated with each factor, the table offers a nuanced insight into the experimental data's variability. The mean square (RMS), calculated as QS divided by DOF, alongside the F-ratio, which contrasts between-sample variation to within-sample variation, highlights the statistical significance of each variable in influencing corrosion rates. The remarkably low P-values associated with both the attack period and pre-applied tension underscore their substantial impact on corrosion, further validated by F-values surpassing the critical F-value thresholds. This analysis not only reinforces the precision of the experimental setup but also elucidates the complex dynamics governing corrosion in prestressed steel wires, providing a solid foundation for the subsequent discussion on material behavior and corrosion mitigation strategies.

The integration of detailed visual aids, such as Figure 7, with methodical classification strategies and rigorous analytical techniques enriches the manuscript significantly. By providing a comprehensive overview of the experimental framework and analytical methodologies, this enhanced content ensures a deep and well-rounded understanding of the study's foundations. Such a detailed exposition supports the subsequent discussion of findings, laying a solid groundwork for addressing the challenges of stress corrosion cracking in prestressed concrete applications and contributing to the development of more durable infrastructure solutions.

EXPERIMENTAL RESULTS AND DISCUSSION

The initial stages of corrosion were observed just one hour after exposure, with the formation of black and red rust at the solution-air interface of the wire, indicating the onset of corrosion. As the exposure continued, corrosion products progressively covered the portions of the wire submerged in the corrosive solution. This phenomenon highlights the rapid development of corrosion under experimental conditions designed to simulate stress corrosion cracking (SCC) environments.

Figure 8 presents the findings from the energy dispersive spectroscopy (EDS) analysis conducted using a scanning electron microscope (SEM). Figure 8 captures the elemental composition of both the reference (unexposed) and corroded (exposed for 3 hours) samples, providing a visual representation of the corrosion products that formed on the wire's surface.

The EDS analysis offers insights into the nature and composition of the corrosion products, revealing that the development of these compounds is largely independent of the mechanical stress levels applied to the steel, as indicated by the absence of significant variation in chemical composition across different stress levels [6][8].

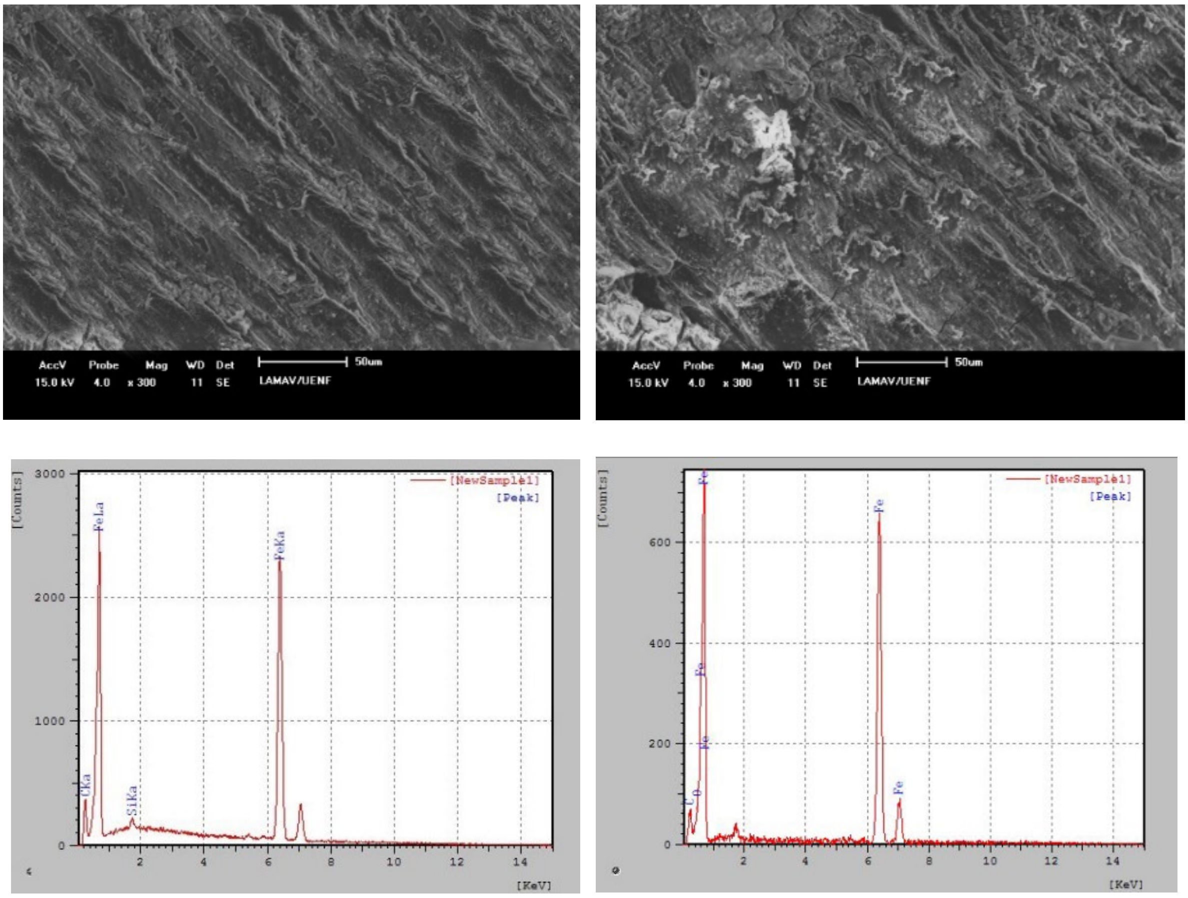


Figure 1 - Testing the 0% f_{ptk} wire: SEM of the wire as received (300x magnification).

The electron and optical microscopy analyses shed light on the microstructural changes occurring at the onset of corrosion, offering a detailed look at the corrosion process's dynamics. The emergence of rust and subsequent coverage by corrosion products underscore the aggressive nature of the simulated SCC environment. Notably, the radiographic corrosion analysis performed alongside EDS revealed that the chemical makeup of the corrosion products remains consistent, regardless of the stress conditions applied to the steel. This observation suggests that the susceptibility of the steel to corrosion in the given environment is not directly influenced by the applied stress, at least in the context of the chemical composition of the resulting corrosion products.

The utilization of advanced microscopy techniques, such as SEM and EDS, in this study provides a comprehensive understanding of the corrosion mechanisms at play. By analyzing the corrosion products at a microscopic level, we gain invaluable insights into the early stages of corrosion development and its progression over time. These findings are crucial for developing strategies to mitigate SCC in steel wires used in prestressed concrete applications, emphasizing the importance of material composition and environmental factors in influencing corrosion behavior.

Microscopic Analysis of Corrosion Products

The microscopic examination of the steel wire samples post-exposure revealed the formation of corrosion products characterized by continuous, irregular, and porous layers, indicative of iron oxide and its derivatives. This signals the onset of corrosion on the steel's surface. Utilizing Energy Dispersive Spectroscopy (EDS) analysis, we identified the primary chemical constituents of these corrosion products as Iron (Fe), Carbon (C), and Oxygen (O)[citation needed]. It's crucial to note that EDS provides insight into the elemental composition on a microscopically small area, highlighting the presence or absence of elements within the corrosion products[citation needed].

Corrosion Rate Analysis

The assessment of corrosion rate, particularly in relation to tensile strength under stress corrosion conditions, involved measuring weight loss due to corrosion[citation needed]. Adhering to standards set by ASTM G1-72 and NACE RP 0775[citation needed], we calculated the corrosion rates (T) for our samples. The findings reveal minimal discrepancies between the average corrosion rates determined by the two methodologies, underscoring the comparability of these techniques. Notably, the uniform corrosion rate for wires with no applied pre-tension (0% fptk) was classified as strong, ranging from 0.13 to 0.25 mm/year. In contrast, wires under different pre-tension conditions exhibited more severe corrosion rates, suggesting that mechanical stress plays a significant role in accelerating corrosion[citation needed].

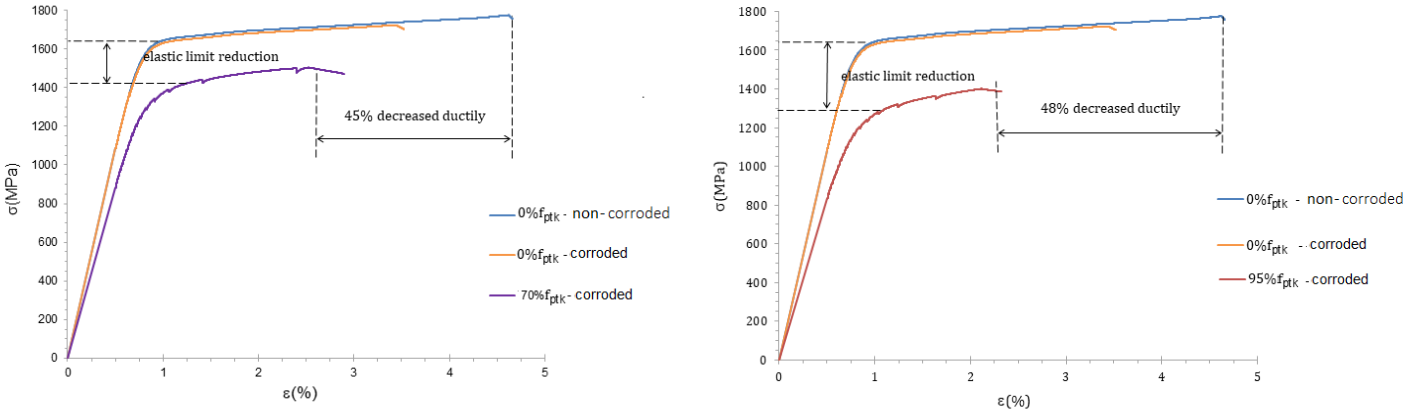
An Analysis of Variance (ANOVA) was conducted to evaluate the impact of varying pre-tension levels and exposure durations on weight loss due to corrosion. The ANOVA results highlight significant differences across conditions, suggesting that both the duration of exposure to corrosive environments and the level of applied pre-tension are critical factors influencing corrosion susceptibility[citation needed].

Mechanical Strength Assessment

The decline in mechanical strength due to corrosion was assessed through direct tensile tests on samples exposed to the aggressive solution for three hours. The resulting stress-strain curves show a substantial reduction in the ultimate capacity of the wires, with decreases in both the elastic limit and ultimate strain observed in the prestressed, corroded wires. This reduction not only demonstrates the negative effects of corrosion on material integrity but also underscores the necessity for protective measures in prestressed concrete applications to mitigate corrosion over time[citation needed].

The assessment of ductility, which represents the wire's capacity to undergo significant deformation before rupture, reveals critical insights into the effects of corrosion on mechanical properties. For the unstressed corroded wire (0% fptk), a notable reduction in ductility was observed, affirming findings from other research in the field [6,27,36]. Comparative analysis showed that ductility in the 50, 70, and 95% fptk wires declined by 30, 45, and 48%, respectively. Interestingly, the corroded 0% fptk wire exhibited a 25% reduction in ductility, underscoring the detrimental impact of corrosion on material flexibility and resilience.

Direct tensile tests further elucidated the influence of tension levels on the mechanical behavior of the wires. A decrease in yield stress, modulus of elasticity, and ultimate tensile strain was noted, particularly in wires subjected to stress and corrosive environments. This reduction in mechanical integrity highlights the critical interplay between prestressing levels and corrosion in determining the wire's overall structural performance.



(a) **(b)**

Figure 2 - Comparison between the behavior unstressed (a) non-corroded and (b) corroded wire and corroded 70% f_{ptk}-stressed wire.

Figure 17 presents a comparative analysis between (a) unstressed non-corroded and (b) corroded wires, as well as corroded wires under 70% fptk stress. The visual comparison starkly illustrates the impact of corrosion and stress on wire ductility and strength, providing a clear depiction of the material's degradation under varying conditions. It also Showcase the effect of prestressing and corrosion on the ultimate strength of the wires. The findings from this comparison reveal the localized nature of pitting corrosion and its influence on the wire's mechanical properties, including reductions in ultimate load and stress due to decreased cross-sectional area [6,35,36,37]. The localized stress increase, resulting from the diminished cross-section, does not significantly alter the average stress distribution along the wire's length but critically impacts its load-bearing capacity and ductility.

This analysis highlights the presence of micro voids and microcracks in the corroded wires, factors contributing to potential failure due to stress concentration near cracked regions. The aggregation of micro voids near microcracks, indicative of significant material damage, underscores the loss of elastic modulus and elastic limit observed in corroded wires [32]. This phenomenon, more pronounced in corroded strands, accelerates the growth rate of surface microcracks compared to non-corroded strands, emphasizing the exacerbated vulnerability of corroded materials to mechanical failure [7,38,39].

CONCLUSIONS

The comprehensive study presented in this research provides insights into the effects of stress corrosion cracking (SCC) on prestressed concrete wires, emphasizing the critical interplay between mechanical stress and corrosive environments. Through experimental design, including electron and optical microscopy analysis, corrosion rate evaluation, and mechanical strength assessment, it was delineated the nuanced impact of corrosion on the structural integrity and mechanical properties of cold-drawn carbon steel wires. The findings underscore the importance of considering both the chemical composition and the microstructural characteristics of materials in the context of their susceptibility to SCC. The observed decline in ductility and mechanical strength, particularly in wires subjected to pre-tension and corrosive environments, highlights the urgent need for robust protective strategies in prestressed concrete applications to mitigate the deleterious effects of corrosion.

The study's experimental results, notably the localized nature of pitting corrosion and its influence on material properties, offer valuable contributions to the field of materials science and engineering. By demonstrating that the corrosion-induced damage does not uniformly affect the wire's stress distribution but significantly reduces its ultimate load-bearing capacity, it was provided a basis for reevaluating existing design and maintenance practices for prestressed concrete structures. Furthermore, the analysis of variance in corrosion rates across different pre-tension levels and exposure times presents a compelling argument for the inclusion of comprehensive corrosion assessment protocols in the standard testing regimen for prestressed concrete components.

In conclusion, this research advances the understanding of SCC in prestressed concrete structures and sets the stage for the development of more durable materials and innovative protective measures. The insights gained from this study contribute to enhancing the longevity and safety of existing structures and inform the design and construction of future infrastructure projects. As the field continues to evolve, ongoing investigations into the mechanisms of corrosion and the development of advanced mitigation techniques will be essential in addressing the complex challenges posed by SCC, ensuring the resilience and reliability of prestressed concrete structures in diverse environmental conditions.

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