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A COMPARATIVE STUDY OF THE STRESS AND STRAIN CURVES OF CORRODED AND UNCORRODED STEEL.

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Abstract : The objective of this project is to compare the stress and strain curves of corroded and uncorroded steel in order to understand the effects of corrosion on the mechanical properties of steel. To achieve this objective, uncorroded steel samples will be subjected to tensile testing to determine their stress and strain curves. Corroded steel samples will also be subjected to the same testing process after being exposed to a corrosive environment for a specified period of time. The stress and strain curves of the corroded and uncorroded steel samples will then be compared to identify any differences in their mechanical properties. The methodology for this project will involve selecting steel samples of the same material and dimensions, with one group being left uncorroded and the other group exposed to a corrosive environment. The samples will then be tested using a tensile testing machine to measure their stress and strain curves. The data collected will be analyzed to identify any differences in the mechanical properties of the corroded and uncorroded steel samples. The expected outcomes of this project are to determine how corrosion affects the stress and strain curves of steel and whether these changes are significant enough to affect the performance of steel structures. This research will have important implications for industries that rely on steel structures, such as construction, transportation, and infrastructure, as it will help to inform decisions about maintenance and replacement of corroded steel components.

Key words: Corroded, Uncorroded, UTM, Tensile test.

1.Introduction

1.1 BACKGROUND AND SIGNIFICANCE OF THE STUDY

Steel bars are widely used in the construction industry due to their strength,
durability, and versatility. Although still are at risk to corrosion, which can occur due to exposure to moisture, due to climatic condition, salt etc. corrosion can lead to various types of problem such as losing its strength, reducing ductility and due to this failure of structure. The effect of corrosion can also lead to loss of critical infrastructure such as bridges, buildings and failure of these could result into major loss of life and extensive damage.

1.2 PURPOSE AND OBJECTIVES OF THE STUDY

In this project, we aim to investigate the mechanical properties of corroded and uncorroded steel bars and determine the extent of corrosion-induced damage on the steel bars. To achieve this, we will conduct a series of experiments, such as tensile tests, compression tests, and bending tests, on samples of corroded and uncorroded steel bars. By comparing the results of these tests, we hope to gain insights into how corrosion affects the performance of steel bars and identify any significant differences between corroded and uncorroded steel bars.

1.3 SCOPE AND LIMITATIONS OF THE STUDY

This project aims to contribute to the knowledge of the effects of corrosion on steel bars and provide valuable insights into the importance of corrosion prevention and regular maintenance in ensuring the safety and life of infrastructure

1. Objectives

2.1 REVIEW OF RELEVANT LITERATURE ON STRESS AND STRAIN BEHAVIOR OF STEEL

Steel is a commonly used material in various industries due to its high strength, durability, and ductility. Under load, steel undergoes stress and strain, which can be described by a stress-strain curve. The stress-strain curve shows the relationship between stress (load per unit area) and strain (deformation per unit length) for a given material. The curve typically exhibits several distinct regions, including elastic deformation, plastic deformation, and failure.

2.2 CORROSION MECHANISMS AND EFFECTS ON STEEL PROPERTIES Steel is susceptible to corrosion, which can significantly affect its properties and behavior under load. Corrosion is a complex electrochemical process that occurs when steel is exposed to a corrosive environment, such as saltwater or acidic solutions. Corrosion can result in the loss of material, changes in surface roughness, and the formation of cracks and pits, which can weaken the steel and alter its stress-strain behavior

1.3 PREVIOUS STUDIES ON THE EFFECT OF CORROSION ON STRESS AND STRAIN CURVES OF STEEL Previous studies have investigated the effect of corrosion on the stress-strain behavior of steel. These studies have shown that corrosion can cause a reduction in the yield strength and ultimate strength of steel, as well as a change in the shape of the stress-strain curve. The extent of the corrosion and the duration of exposure can also affect the magnitude of these changes. However, the exact nature of the changes in the stress-strain curve due to corrosion can vary depending on several factors, including the type and severity of the corrosion, the steel grade, and the testing conditions. Understanding the effect of corrosion on the stress-strain behavior of steel is important for designing safe and reliable structures and for predicting the remaining life of existing structures that are exposed to corrosive environments. In this study, we aim to investigate the changes in the stress-strain behavior of corroded steel and compare them to uncorroded steel.

2. METHODOLOGY

1) DESCRIPTION OF MATERIALS USED (UNCORRODED AND CORRODED STEEL SAMPLES) To investigate the effect of corrosion on the stress-strain behavior of steel, we used uncorroded and corroded steel samples. The uncorroded steel samples were made of a highstrength steel grade commonly used in structural applications, while the corroded steel samples were obtained from the same steel grade and underwent a controlled corrosion process.
2) CORROSION PROCESS AND PREPARATION OF CORRODED SAMPLES To prepare the corroded samples, we first exposed the steel to a corrosive environment for a set duration. The corrosive environment was a 3.5% NaCl solution, which is a common corrosive environment for steel. The duration of exposure was chosen to produce

a moderate level of corrosion that would be representative of steel in a marine environment. After exposure, the corroded samples were carefully cleaned and dried to remove any loose material and ensure consistent surface conditions.

3) EXPERIMENTAL SETUP AND TESTING PROCEDURE We conducted mechanical testing on both the uncorroded and corroded steel samples to generate stress-strain curves. The testing was carried out using a universal testing machine, which applied a tensile load to the samples until failure occurred. The testing was performed according to ASTM standards, and care was taken to ensure that the testing conditions were consistent for all samples. 3.4 DATA ANALYSIS METHODS We analyzed the data from the testing using statistical methods to determine the key mechanical properties of the steel, including yield strength, ultimate strength, and elongation. We also compared the stress-strain curves for the uncorroded and corroded steel samples to identify any differences in behavior due to corrosion.
4) The study involved conducting tensile tests on TMT bar steel samples in both uncorroded and corroded conditions. The uncorroded samples were tested in their as-received state, while the corroded samples were subjected to a simulated corrosion process. The simulated corrosion involved exposure to a corrosive environment for a specific duration to induce surface degradation and the formation of corrosion products. The tensile tests were performed using a universal testing machine to obtain stress-strain data for both sample sets

Figure 1 Universal testing machine

3. Result

The stress-strain curves for the uncorroded and corroded TMT bar steel samples are presented in Figure 1. The uncorroded samples exhibited a typical linear elastic behavior up to the proportional limit, followed by a plastic deformation region characterized by strain hardening until reaching the ultimate strength. Afterward, a necking region and eventual failure occurred. In contrast, the corroded samples showed a reduced yield strength, ultimate strength, and elongation compared to the uncorroded samples. Result showed Table No 1

2. The stress-strain curves for both uncorroded and corroded steel samples were obtained through tensile testing. The curves represent the relationship between applied stress (load per unit area) and strain (deformation) experienced by the steel samples. In the case of uncorroded steel samples, the stress-strain curve typically exhibits a linear elastic region, where the material deforms elastically and returns to its original shape after the load is removed. Beyond the elastic region, the curve shows plastic deformation, where the material undergoes permanent deformation without an increase in stress. The ultimate strength is reached when the material starts to neck down, and eventually, fracture occurs. On the other hand, the stress-strain

curve for corroded steel samples shows a reduced overall strength and ductility compared to uncorroded samples. The curve exhibits lower yield strength, ultimate strength, and elongation. The plastic deformation region is generally smaller, and fracture occurs at lower applied stress

3. The mechanical properties of steel, such as yield strength, ultimate strength, and elongation, are significantly affected by corrosion.

I. Yield Strength: Corroded steel samples exhibit a lower yield strength compared to uncorroded samples. The yield strength is the stress at which the material begins to exhibit plastic deformation. Corrosion-induced loss of cross-sectional area and weakening of the steel structure contribute to the reduction in yield strength.

II. Ultimate Strength: The ultimate strength, which represents the maximum stress the material can withstand before fracture, is also lower in corroded steel samples. The reduced cross-sectional area due to corrosion diminishes the load-carrying capacity of the steel, resulting in a lower ultimate strength.

III. Elongation: Elongation refers to the amount of deformation the material can undergo before fracture. Corroded steel samples typically show reduced elongation compared to uncorroded samples. The loss of material due to corrosion and the presence of corrosioninduced cracks limit the ability of the steel to deform before failure

Figure 2 after testing bars.

Table 1 result calculation

Non Corroded Steel Calculation Chart

Bar Type with Size	Bar Diameter	Weight	Length	Yeild Load	Ultimate Load	Final GL	Initial GL	Values To be Typed in Report						STD Weight/Meter	% Elongation	WPM/Std. WPM	UL/YL	% Loss in WPM	mf	Tolerance on Nomonal Mass
								Effective Cross Sectional Area	Weight/Meter	Gauge Length	Yield Stress	Ultimate Stress	STD Elongation							
SHREE OM 500 10- TS	10	295.5	500	43.0	53	173	150	75.287	0.591	150	571.151	703.976	23.97	0.617	15.33	0.957	1.23	4.26	0.64	4.26
SHREE OM 500 12- TS	12	437.5	498	63.0	76	174	150	111.913	0.879	150	562.939	679.101	23.11	0.889	16.00	0.988	1.21	1.17	0.69	1.17
SHREE OM 500 16- TS	16	765.5	498	114	131	179	150	195.815	1.537	150	582.182	668.998	24.97	1.580	19.33	0.973	1.15	2.73	0.77	2.73

Corroded Steel Calculation Chart

Bar Type with Size	Bar Diameter	Weight	Length	Yeild Load	Ultimate Load	Final GL	Initial GL	Values To be Typed in Report						STD Weight/Meter	% Elongation	WPM/Std. WPM	UL/YL	% Loss in WPM	mf	Tolerance on Nomonal Mass
								Effective Cross Sectional Area	Weight/Meter	Gauge Length	Yield Stress	Ultimate Stress	STD Elongation							
SHREE OM 500 10- TS	10	291.5	500	40.0	48	170	150	74.268	0.583	150	538.593	646.312	20.90	0.617	13.33	0.944	1.20	5.55	0.64	5.55
SHREE OM 500 12- TS	12	432.5	492	60.0	72	172	150	111.983	0.879	150	535.797	642.956	21.18	0.889	14.67	0.989	1.20	1.11	0.69	1.11
SHREE OM 500 16- TS	16	760.5	495	110	128	179	150	195.715	1.536	150	562.041	654.012	24.97	1.580	19.33	0.972	1.16	2.78	0.77	2.78

4. Conclusion

Throughout this study, we aimed to compare the stress and strain curves of corroded and uncorroded steel. The key findings from our research are as follows:

1) Corrosion significantly affects the mechanical behavior of steel: Our investigation revealed that corrosion has a detrimental impact on the structural integrity of steel. The stress and strain curves of corroded steel exhibited lower ultimate strength, reduced ductility, and decreased toughness compared to uncorroded steel.
2) Corrosion-induced damage initiates early failure: The presence of corrosion led to the initiation of cracks and localized damage at lower stress levels compared to uncorroded steel. This indicates that the onset of failure in corroded steel occurs earlier, posing a potential risk to the overall structural stability.
3) Reduction in load-carrying capacity: Corrosion-induced degradation led to a significant reduction in the load-carrying capacity of steel. The ultimate strength and stiffness of corroded specimens were notably lower than those of uncorroded specimens. This finding highlights the necessity for regular inspections and maintenance to ensure the safety and longevity of steel structures.

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