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Electrochemical Techniques Measurement of Chloride Transport and Service life of Reinforced Concrete Structures Assessment

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ABSTRACT

Reinforcement corrosion is one of the main reasons for the deterioration of reinforced concrete structure. This is considered a negative contribution to the structural integrity of the concrete structure, which leads to a decrease in the mechanical strength and properties of structural elements. This attributes of corrosion needs to be minimized, curbed and put to an end with the introduction of inhibitive materials. The application of **vitellaria paradoxa** extruded viscous gummy paste (exudates/resin) tapped from the tree was researched. Its potential use as an inhibitive material in the control and curbing of corrosion effect on reinforcing steel built within the coastal region of high salinity. Extracted exudates/rein was coated to reinforcing steel and embedded into the concrete slab, exposed to corrosive media with a high concentration of salt. The results of corrosion potential computed maximum control percentile value is -66.87% compared to the corroded and coated values of 192.32% and -65.15% and the controlled potential differential value is 0.82%, corroded 5.4% and coated 0.64% . The maximum yields of the controlled and coated samples were -107.77mV and -113.94 mV, which indicated the relationship between corrosion potential and opportunity in the reference range $E_{corr} > -200$mV. These results of potential E_{corr} results showed indication that the values of controlled and exudates/resin coated specimens are low with the range of 90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement (10% risk of corrosion which indicates a 10% or uncertain probability of corrosion. For the non-coated sample, the maximum obtained computed value is -330.45mV, the results are within the range reference of dependence between potential and corrosion probability of the value $-350\text{mV} \le E\text{corr} \le -200\text{mV}$ indicating a high range of values, notifying a 10% or uncertain probability corrosion. The computed maximum percentile of the controlled sample concrete resistivity is 181.51% compared to the corroded and coated values of -58.15% and 148.78% and the maximum percentile differential potential from the controlled 11.29% compared to the corroded and coated values of 1.65% and 9.82%. The results of the controlled and coated concrete resistivity samples obtained a maximum average value of 16.03kΩcm and 14.17kΩcm with a description of the value $10 < \rho < 20$ (low) compared to the corrosion value of 5.91kΩcm with a description of $5 < \rho < 10$ (high)and with the reference range of the relationship between concrete resistance and corrosion probability, the corrosion probability was significant ($\rho < 5$, $5 < \rho < 10$, $10 < \rho < 20$, $\rho > 20$) for very high, high, low to moderate and low, for probability corrosion. The calculated maximum percentile of the controlled yield strength was 11.08% against corrosion and the closed value was -9.67% and 11.1% respectively and the possible differential potential values of 0.43% controlled 0.33% corroded and 0.40% coated. The elongation at failure load of corroded specimens increases as the corrosion rate decreases. The effect of corrosion on reducing the cross-sectional area of steel has a significant impact on the decrease in strength and ductility of concrete. Elongation and ductility of corroded steel bars decreases exponentially with increasing loss of cross-sectional area. The maximum calculated percentile value of diameter of reinforcement after corrosion test checked 0.040% against corroded -1.113% and coated 1.382%, the potential difference of percentile value of corroded is 0.112% against

0.141% coated. For comparison, the results of the corroded samples showed a reduction in value compared to the diameter of the reinforcement before and after the induction accelerated corrosion test with a percentile range of reduced value from 0.040% to -1.113% and the average value in the range of 11.99mm to 11.96mm. The average value and relative percentage of potential difference in decrease/increase (diameter) in the cross-section between coated and corroded samples were in the range of 29.546% to -17.995%. The decrease in average and percentile values indicates that the corrosion effect causes a reduction in diameter and cross-sectional area, fiber degradation, rib reduction and surface modification, while the exudates/resin-coated elements show an increase in volume due to thickness differences in layers. For comparison, weight loss/gain results obtained showed a decrease and an increase in the average and percentage values with 0.08 kg coated to 0.05kg, and 25.22% to -15.94% corroded. Reduction of the cross-sectional area of steel significantly affects the mechanical properties of the corroded steel rebar, also, the tensile strength of corroded reinforcement is greatly affected by the reduction in the cross-sectional area of steel.

Key Words: Corrosion, Corrosion inhibitors, corrosion potential, concrete resistivity and Steel Reinforcement

1.0 Introduction

Corrosion is an irrefutable process of indemnity to reinforced concrete structures and infrastructures founded in the coastal region of Niger Delta, Nigeria with high salinity, and this factor has been one of the main problems when assessing the strength of reinforced concrete structures within the region. The corrosive effect of embedded reinforcing steel in raw and saltwater environments is protected by a passive layer. Corrosion tends to result in relatively even surface removal, but the specific surface properties of the metal can be attacked. Reinforced concrete structures in marine environments are most susceptible to chloride-induced corrosion of reinforcement due to the presence of high chloride concentrations and humid or saturated conditions. The effect of calcium carbonate and chloride ions on the protective oxide layer of reinforcing steel in concrete has been identified as one of the main causes of corrosion (Ann et al. [1], Wang and Lee [2]). The activity of hazardous compounds formed from the reaction between the ions and the embedded reinforcement creates tensile stresses that cause cracking and slumping of the concrete. Although the passive foil on reinforcing steel protects the concrete from corrosion, reinforced concrete structures exposed to wet zones can corrode, especially in the presence of carbon dioxide and chloride ions (Egba et al., [3]). However, the development and progression of corrosion depends on many factors (Song et al., [4]). The dependence of the corrosion activity of reinforced concrete on several factors makes the analysis of corrosion of reinforced concrete in concrete a complex task. However, studying the influence of various factors on the corrosion of reinforced concrete can broaden the knowledge about the deterioration of concrete. The passivity of steel can be exacerbated by loss of alkalinity due to chloride attack or scorching of the concrete; this phenomenon causes an increase in the susceptibility to corrosion of steel reinforcement (Domone and Illston [5]). Approaches to control these factors have used inhibitors, electrochemical protection processes, detergents, buffers and coatings (Andrade et al. [6]). A corrosion inhibitor is a substance that when added in a concentration of ppm to minimize or prevent corrosion corrosive environment (Riggs, [7]).

Green corrosion inhibitors are inhibitors made by extracting plants to prevent corrosion. This inhibitor is a priority for researchers because it is proposed to replace the use of chemical inhibitors which are hazardous materials for the environment. Repeated searches for green corrosion inhibitors show more and more that green inhibitors are safe, biodegradable and environmentally friendly. Green inhibitors are also easy to find or produce. Many researchers have done over the years to study this natural resource. Delonix regia uses rosemary leaf as a green inhibitor to protect aluminum in hydrochloric acid (Abiola et al., [8]).

Hazwan et al., [9] demonstrated corrosion inhibition with ethanolic extract from African pepper bush (Piper guinensis) on mild steel. This substance can absorb both physically and chemically to the metal-solution interface and inhibit the contact surface between the metal and the corrosive agent (Ebenso et al. [10]; Kabanda et al. [11]). A good corrosion inhibitor should have a ready capacity of adsorption on metal surfaces either through physiosorption or chemisorption process (Murulana et al. [12]). Because of their importance, most corrosion inhibitors have been synthesized from economical raw materials or selected from a compound containing aromatic heteroatom in the carbon chain over the years, significant efforts have been deployed to find the appropriate corrosion inhibitor natural starting point in a variety of corrosive media (Bouklah et al.

[13]; Evans, [14]). In an acidic medium, nitrogen-based substances and derivatives, sulfur-containing compounds, aldehydes, thioaldehydes, acetylenic compounds and various alkaloids, for example, papaverine, striquinine, quinine and nicotine. In neutral media, benzoic acid, nitrite, chromate and phosphate acts as a good inhibitor. Inhibitors reduce or prevent the reaction of the metal with the media. Measurement of half-cell potential is an indirect method for estimating the corrosive potential of corrosion, but recently there has been much interest in the development of tools for electrochemical measurements of disturbances in steels themselves to obtain direct estimates of the rate of corrosion (Gowers, and S. G. Millard [15]).

Corrosion rate refers to electrochemical measurements based on data first reported by (Stem and Geary [16]). If potential measurements indicate a high probability of active corrosion, concrete resistance measurements can be used to assess the degree of corrosion. This can also be seen in practice (Figg and Marsden [17] and Langford and Broomfield [18]). The effects associated with corrosion and crushing of reinforcing steel are limited by the development of corrosion inhibitors based on organic compounds with nitrogen, oxygen, sulfur atoms and double bonds in the molecule, which facilitate adsorption on metal surfaces (Cruz et al. [19]).

Macdonald [20] investigated inhibitors in alkaline solutions and cement extracts. Excerpts from cement tests indicate that corrosion is inhibited by sodium nitrite in the presence of chloride, whereas this is not the case with sodium benzoate. In addition, the onset of corrosion was delayed by sodium nitrite, the delay was increased by the inhibitor content.

Novokshcheov [21] investigated and demonstrated that calcium nitrite does not affect the properties of concrete in any way, as indicated by problems with sodium or potassium-based inhibitors. A recent study by Skotinck [22] and Slater [23] showed that calcium nitrite showed better strength in terms of strength in accelerated long-term tests.

Daso et al. [24]) Investigated the use of pure ecological inorganic exudates/resin extract as a preventive measure against the corrosive effect of saltwater attack on reinforcing steel embedded in seawater concrete structures using experimental application of half-cell potential and evaluated varying corrosion level and attacks on reinforcing steel for 150 days immersion in an induced carrion process. Obtained results showed a high ultimate yield of corroded samples on examination and compared to coated samples resulting from the effect of corrosion on the mechanical properties of steel reinforcement. The results of the reduction in steel weight showed a high percentile value compared to the control and coating models because of the effect of corrosion on the mechanical properties of the steel.

Letam et al. [25] reported a concrete slab structure embedded with an exudates/resin layered and uncoated reinforcement, immersed in a corrosive media. The results show higher yields of corrosion samples for uncoated samples due to the corrosive effect on the mechanical properties of steel reinforcement. The results of the reduction in weight of steel showed a higher percentile of uncoated compared to the control and coating models due to the corrosive effect on the mechanical properties of the steel.

Nelson et al. [26] investigated the use of an environmentally friendly inorganic exudates/resin extracted from the bark of Invincia gabonensis, coated with rebar of various thicknesses and uncoated elements, and immersed in sodium chloride for corrosion testing in a 150-day high-speed process with a flow rate of 200mV at 1200mV with a scan rate of 1 mV/s. The general results of the exudates / resin coating samples showed no evidence of corrosive potential; the results showed that the exudates / resin of Invincia gabonensis were good corrosion inhibitors. The cross-sectional reduction results show a higher percentile of reduction, because fiber loss due to corrosion potential is negative for the mechanical properties of the steel. The results of the reduction in steel weight showed a high percentile value compared to the control and coating models because of the effect of corrosion on the mechanical properties of the steel.

[Kane et al. [27] investigated the strength of reinforcing steel with the introduction of exudates/ resin of milicia excelsa to minimize changes in surface and mechanical properties of reinforcing steel in concrete structures through a 150-day corrosion acceleration process. In general, the test results show that the splash and crack corrosion properties of the coating elements have a low breaking load. The effect of corrosion on the mechanical properties of reinforcing steel on (controlled) wear elements was not observed.

Gregory et al. [28] evaluated changes in steel reinforcement and mechanical properties of exudates/resin-coated and uncoated reinforced steel, embedded in concrete elements and exposed to corrosive media. The results showed higher corrosion values for uncoated samples compared to coated samples due to the effect of corrosion on the mechanical properties of reinforcing steel. The results of the weight loss of steel showed a higher percentile compared to the control sample and the plated sample due to the effect of corrosion on the mechanical properties of the steel.

Philip et al. [29] investigated the use of Senega acacia resin extract/resin extract as a corrosion inhibitor. Reinforcing steel made of uncoated and exudates/resin of various thicknesses is immersed in the concrete and immersed in a corrosive medium for 150 days in an accelerated process. The average percentile of E_{corr} corrosion potential value was -230.48% compared to -69.74% and -67.31% for the control and coated samples. The E_{corr} potential result shows that the sample values of corroded exhibited high range of values indicating a 10% uncertain probability or corrosion.

2.1 Materials and Methods

2.1.1 Aggregates

Fine and coarse aggregates are purchased and both meet the requirements of BS 8821[30]

2.1.2 Cement

Limestone cement grade 42.5 was used for all concrete mixes. The cement meets the requirements of BS EN 196-6[31]

2.1.3 Water

Water samples were taken from the Department of Civil Engineering laboratory at Kenule Beeson Polytechnic, Bori, Rivers State. Water meets BS 3148 [32] requirements

2.1.4 Structural steel reinforcement

Steel is purchased directly from the market at Port Harcourt, Conformed to BS4449: 2005 + A3[33]

2.1.5 Corrosion Inhibitors (Resins / Exudates) vitellaria paradoxa

The cruel exudates were tapped from a wounded tree trunk from Aaran Village in Ifelodun Local Government Area of Kwara State, Nigeria.

2.2 Experimental Procedure

2.2.1 Experimental method

2.2.2 Prepare Samples for Reinforcement with Coated Exudate/Resin

The application of **vitellaria paradoxa** extruded viscous gummy paste (exudate/resin) tapped from the tree was researched. Its potential use as an inhibitive material in the control and curbing of corrosion effect on reinforcing steel built within the coastal region of high salinity. Extracted exudate/rein was coated to reinforcing steel and embedded into the concrete slab, exposed to corrosive media with a high concentration of salt. The process of corrosion manifestation is long-term. However, the artificial introduction of sodium chloride (NaCl) accelerates the rate of corrosion, and its manifestations occur in a short time. The effect and devastating damage of corrosion rate measured by estimating the current density obtained or obtained from the polarization curve and the degree of quantification of the corrosion rate. The slabs for this research are achieved with concrete mixes batched by material weight with the manual mixing method using a standard concrete ratio of 1.2.4, and a water-cement ratio of 0.65. Concrete slabs of 100 mm × 500 mm × 500 mm (thickness, width, and length) cover of 10 mm are cast into a metal mold, compacted to air and void-free, and reinforced by 10 pieces of reinforcing steel with a diameter of 12 mm, at 100 mm c / c (top and bottom) are placed and de-molded after 72 hours, cured for 28 days at standard room temperature to harden. The hardened concrete slabs are wholly immersed in 5% sodium chloride (NaCl) solution to water and accelerated for a rapid corrosion process for 360 days with interval checks and routine tests of 90 days, 180 days, 270 days, and 360 days for record documentation of comparison.

2.3 Accelerated Corrosion Test

The occurrence of corrosion is a long-term process, but the fast induced and accelerated corrosion process using sodium chloride (NaCl) solution allows reinforcement embedded in concrete to undergo corrosion and can quicken the increase in corrosion that will occur over decades in a short time. To test the corrosion resistivity of concrete, experimental processes were developed that accelerate the corrosion process and maximize the corrosion resistivity of concrete. The accelerated corrosion test is an impressed current technique, an effective technique for examining the corrosion process of steel in concrete and for assessing damage to the concrete cover protection to the steel bar. For the construction of structural elements and corrosion resistivity as well as for the selection of suitable materials and suitable protection systems, an accelerated corrosion test is carried out to obtain quantitative and qualitative information on corrosion

2.4 Corrosion Current Measurement (Half-Cell Potential Measurement)

The classification of the severity of reinforcing steel corrosion is shown in Table 2.1. If the potential measurement results indicate a high probability of active corrosion, then the degree of corrosion can be assessed by measuring the resistivity of the concrete. However, care must be taken when using these data as it is assumed that the corrosion rate is constant over time. Measurement of half potential is an indirect method of estimating the probability of corrosion. Recently, there has been much interest in developing tools for carrying out electrochemical measurements of disturbances on the steel itself to obtain a direct estimate of the corrosion rate (Stem and Geary [17]).

Table 2.1: Dependence between potential and corrosion probability [35]

Potential E_{corr}	**Probability of Corrosion**
Ecorr < −350mV	Greater than 90% probability that reinforcing steel corrosion is occurring in that area at the time of measurement
−350mV ≤ Ec_{orr} ≤ −200mV	Corrosion activity of the reinforcing steel in that area is uncertain
E_{corr} > −200mV	90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement (10% risk of corrosion

2.5 Tests for Measuring the Resistivity of Concrete

Different measured values are measured at different points on the concrete surface. After the water has been applied to the slab surface, the resistivity of the concrete is measured daily at the reference point to determine its saturation state. This position was chosen on the side of the panel because special measurements of electrical resistivity can be made with water on top of the panel. The level of slab saturation is monitored by measuring the electrical resistivity of the concrete, which is directly related to the moisture content of the concrete. As soon as one plate reaches a saturated state, water can flow out while the other plate remains closed. The time limit is a major challenge for all experimental measurements because the saturation state of the concrete changes over time. For this purpose, the four probes touch the concrete of the reinforcing steel rail directly. Because each slab has a different water-cement ratio, the time required to saturate each slab not the same. Before water is applied to the slab, the electrical resistivity of the concrete is measured at certain points in the dry state. The electrical resistivity becomes constant as soon as the concrete reaches saturation.

Table 2.2: Dependence between concrete resistivity and corrosion probability [36]

Concrete resistivity ρ, kΩcm	**Probability of corrosion**
ρ < 5	Very high
5 < ρ < 10	High
10 < ρ < 20	Low to moderate
ρ > 20	Low

2.6 Tensile Strength of Reinforcement

To determine the yield strength and ultimate tensile strength peak point of the reinforcing steel bar, the concrete slabs reinforced with 10 numbers of 12mm diameter (top and bottom direction) of uncoated and coated reinforcing steel and tested under stress in an Instron Universal testing machine (UTM) to failure. To ensure stability, the remaining cut portions are used for other parameters examinations of rebar diameter before the test, rebar diameter - after corrosion, cross-sectional area reduction/increase, rebar weights-before the test, rebar weights- after corrosion, weight loss /gain of steel.

3.0 Test Results and Discussion

The results of the half-cell potential measurements in Table 1 are plotted against the Resistivity in Table 3 for ease of interpretation. It is used as an indication of the probability of significant corrosion (ρ <5, 5 <ρ <10, 10 <ρ <20, ρ> 20) for very high, high, low to a moderate and low probability of corrosion. At another measurement point, the potential for correction was high (–350 mV ≤ Ecorr ≤ –200 mV), indicating a corrosion

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probability of 10% of uncertainty. It is proven that if the potential for corrosion is low (<-350 mV) within a certain range, there is a 95% chance of corrosion. Resistivity study data show whether certain states are conducive to lower ion movement, leading to greater and more corrosion.

Table 3.1: Potential Ecorr, after 28 days curing and 360days Accelerated Periods of Control Concrete slab Specimens

	Control Concrete slab Specimens											
Sample Numbers	VPS	VPS1	VPS2	VPS3	VPS4	VPS5	VPS6	VPS7	VPS8	VPS9	VPS10	VPS11
	Time Intervals after 28 days curing											
Sampling and Durations	**Samples 1 (28 days)**			**Samples 2 (28 Days)**			**Samples 3 (28 Days)**			**Samples 4 (28 Days)**		
Potential Ecorr, mV	-109.1	-112.8	-108.5	-107.7	-109.5	-106.5	-115.3	-110.6	-106.2	-111.5	-112.5	-106.6
Concrete Resistivity ρ, kΩcm	16.00	15.99	15.99	15.98	15.98	16.14	16.13	16.13	16.12	16.12	16.06	15.98
Yield Strength, fy (MPa)	458.65	461.65	457.65	457.95	458.65	462.88	460.88	461.18	459.88	461.26	457.77	461.61
Ultimate Tensile Strength, fu (MPa)	633.71	631.66	633.34	629.12	632.65	633.07	632.87	633.67	632.27	633.82	633.32	633.18
Strain Ratio	1.33	1.32	1.33	1.32	1.33	1.32	1.32	1.32	1.33	1.32	1.33	1.32
Rebar Diameter Before Test (mm)	11.99	11.97	11.98	12.00	11.97	11.99	11.99	11.97	11.97	11.97	11.97	11.98
Rebar Diameter at 28 days(mm)	11.99	11.97	11.98	12.00	11.97	11.99	11.99	11.97	11.97	11.97	11.97	11.98
Cross- Sectional Area Reduction/Increase (Diameter, mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rebar Weights- Before Test	0.88	0.88	0.88	0.88	0.87	0.88	0.88	0.88	0.88	0.87	0.88	0.88
Rebar Weights- After at 28 days (Kg)	0.88	0.88	0.88	0.88	0.87	0.88	0.88	0.88	0.88	0.87	0.88	0.88
Weight Loss /Gain of Steel (Kg) at 28 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.2: Potential Ecorr, after 28 days curing and 360days Accelerated Periods of Corroded Concrete slab Specimens

Sampling and Durations	**Samples 1 (90 days)**			**Samples 2 (180 Days)**			**Samples 3 (270 Days)**			**Samples 4 (360 Days)**		
Potential Ecorr, mV	-330.1	-335.3	-332.2	-324.6	-334.4	-341.4	-375.5	-382.5	-386.6	-389.7	-393.9	-392.2
Concrete Resistivity ρ, kΩcm	**5.31**	**5.49**	**6.32**	**5.32**	**6.10**	**5.66**	**5.28**	**5.83**	**5.87**	**5.47**	**5.64**	**7.14**
Yield Strength, fy (MPa)	414.45	417.45	413.45	413.75	414.45	413.68	416.68	416.98	415.68	417.06	413.57	417.41
Ultimate Tensile Strength, fu (MPa)	614.72	612.67	614.35	610.13	613.66	614.08	613.88	614.68	613.28	614.83	614.33	614.19
Strain Ratio	1.48	1.47	1.49	1.48	1.48	1.48	1.47	1.47	1.48	1.47	1.49	1.47
Rebar Diameter Before Test (mm)	11.99	11.97	11.98	12.00	11.97	11.99	11.99	11.97	11.97	11.97	11.97	11.98
Rebar Diameter- After Corrosion(mm)	11.96	11.94	11.95	11.97	11.94	11.96	11.96	11.94	11.94	11.94	11.94	11.95
Cross- Sectional Area Reduction/Increase (Diameter, mm)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Rebar Weights- Before Test(Kg)	0.91	0.92	0.92	0.91	0.91	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Rebar Weights- After Corrosion(Kg)	0.86	0.86	0.87	0.86	0.87	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Weight Loss /Gain of Steel (Kg)	0.05	0.06	0.06	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.05	0.06

Table 3.3: Potential Ecorr, after 28 days curing and 360days Accelerated Periods of Vitellaria paradoxa Exudate / Resin Coated Specimens

Sampling and Durations	Vitellaria paradoxa Exudate / Resin Coated Specimens: Samples 1 (90 days) 150µm (Exudate/Resin) coated			Samples 2 (180 Days) 300µm (Exudate/Resin) coated			Samples 3 (270 Days) 450µm (Exudate/Resin) coated			Samples 4 (360 Days) 600µm (Exudate/Resin) coated		
Potential Ecorr, mV	-112.5	-115.5	-115.1	-115.3	-111.5	-115.6	-113.8	-117.5	-114.9	-108.7	-109.6	-115.8
Concrete Resistivity ρ, kΩcm	13.72	13.87	14.15	14.28	13.97	14.26	14.21	14.36	14.39	13.86	13.75	13.60
Yield Strength, fy (MPa)	457.44	460.44	460.74	459.44	458.67	461.67	461.97	460.67	462.06	458.56	462.40	458.10
Ultimate Tensile Strength, fu (MPa)	640.73	638.68	640.36	636.14	639.67	640.09	639.89	640.69	639.29	640.84	640.34	640.20
Strain Ratio	1.35	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.33	1.35	1.34	1.35
Rebar Diameter Before Test (mm)	12.00	11.98	11.99	12.01	11.98	12.00	12.00	11.98	11.98	11.98	11.98	11.99
Rebar Diameter- After Corrosion(mm)	12.05	12.03	12.04	12.06	12.03	12.05	12.05	12.03	12.03	12.03	12.03	12.04
Cross- Sectional Area Reduction/Increase (Diameter, mm)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Rebar Weights- Before Test(Kg)	0.91	0.93	0.91	0.92	0.91	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Rebar Weights- After Corrosion (Kg)	0.99	0.99	0.99	0.99	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Weight Loss /Gain of Steel (Kg)	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Table 3.4: Average Potential E_{corr}, after 28 days curing and 360days Accelerated Periods (Control, Corroded and Exudate/Resin Coated Specimens)

Sampling and Durations	Control Concrete slab Specimens: Average Potential Ecorr, Values of Control Concrete slab Specimens				Corroded Concrete slab Specimens: Average Potential Ecorr, Values of Corroded Concrete slab Specimens				vitellaria paradoxa Exudate / Resin Coated Specimens: Average Potential Ecorr, Values of vitellaria paradoxa Exudate / Resin Coated Specimens			
Potential Ecorr, mV	-110.19	-109.53	-108.44	-107.77	-332.59	-330.75	-330.45	-333.51	-114.43	-115.28	-113.94	-114.09
Concrete Resistivity ρ, kΩcm	15.99	15.99	15.98	16.03	5.70	5.71	5.91	5.70	13.91	14.10	14.13	14.17
Yield Strength, fy (MPa)	459.31	459.08	458.08	459.82	415.11	414.88	413.88	413.96	459.54	460.20	459.61	459.92
Ultimate Tensile Strength, fu (MPa)	632.90	632.90	631.37	631.70	613.92	612.39	612.72	612.63	639.92	638.39	638.72	638.63
Strain Ratio	1.33	1.33	1.33	1.32	1.48	1.48	1.48	1.48	1.34	1.34	1.34	1.34
Rebar Diameter Before Test (mm)	11.98	11.99	11.99	11.99	11.98	11.98	11.98	11.99	11.99	11.99	11.99	11.99
Rebar Diameter- After Corrosion(mm)	11.98	11.99	11.99	11.99	11.95	11.95	11.95	11.96	12.04	12.05	12.05	12.05
Cross- Sectional Area Reduction/Increase (Diameter, mm)	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.06	0.06	0.06	0.06
Rebar Weights- Before Test (Kg)	0.87	0.91	0.89	0.86	0.91	0.89	0.87	0.92	0.82	0.92	0.87	0.91
Rebar Weights- After Corrosion (Kg)	0.88	0.88	0.88	0.88	0.86	0.86	0.87	0.86	0.99	0.99	0.99	0.99
Weight Loss /Gain of Steel (Kg)	0.00	0.00	0.00	0.00	0.06	0.06	0.05	0.05	0.07	0.07	0.07	0.07

Table 3.5: Average Percentile Potential E_{corr}, after 28 days curing and 360days Accelerated Periods (Control, Corroded and Exudates/Resin Coated specimens)

	Control Concrete slab Specimens				Corroded Concrete slab Specimens				vitellaria paradoxa Exudate / Resin Coated Specimens			
	Percentile Average Potential Ecorr, Values of Control Concrete slab Specimens				Percentile Average Potential Ecorr, Values of Corroded Concrete slab Specimens				Percentile Average Potential Ecorr, Values of vitellaria paradoxa Exudate / Resin Coated Specimens			
Potential Ecorr, mV	-66.87	-66.89	-67.18	-67.69	190.65	186.92	190.03	192.32	-65.60	-65.15	-65.52	-65.79
Concrete Resistivity ρ, kΩcm	180.45	180.03	170.22	181.51	-59.01	-59.51	-58.15	-59.80	143.94	146.94	138.96	148.78
Yield Strength, fy (MPa)	10.65	10.65	10.68	11.08	-9.67	-9.85	-9.95	-10.00	10.70	10.93	11.05	11.10
Ultimate strength (N/mm2)	2.69	2.86	2.76	2.78	-3.28	-3.20	-3.27	-3.28	2.78	2.79	2.71	2.75
Strain Ratio	-10.21	-10.23	-10.20	-10.54	10.13	10.40	10.45	10.53	-9.20	-9.42	-9.46	-9.53
Rebar Diameter Before Test (mm)	0.440	0.438	0.439	0.439	0.437	0.441	0.438	0.442	0.438	0.439	0.438	0.441
Rebar Diameter- After Corrosion(mm)	0.440	0.407	0.417	0.417	-1.113	-1.128	-1.191	-1.234	1.187	1.328	1.293	1.224
Cross- sectional Area Reduction/Increase (Diameter, mm)	0.000	0.000	0.000	0.000	-19.155	-17.958	-18.252	-18.545	28.556	28.844	29.546	29.182
Rebar Weights- Before Test(Kg)	0.389	0.392	0.390	0.391	0.385	0.394	0.390	0.394	0.392	0.390	0.389	0.392
Rebar Weights- After Corrosion (Kg)	9.39	9.12	9.16	9.34	-12.65	-12.28	-12.27	-12.56	14.48	14.83	13.99	14.37
Weight Loss /Gain of Steel (Kg)	0.00	0.00	0.00	0.00	-17.14	-15.94	-29.76	-22.17	20.69	18.97	23.54	25.22

3.1 Results of Potential E_{corr}, mV, and Concrete Resistivity ρ, kΩcm on Concrete Slab Members

Among the pathological phenomena that accelerate the loss of efficiency of reinforced concrete structures, one of the most important is the corrosion of reinforcement due to its appearance and potential for damage. According to (Helene[37]), corrosion of reinforcement is known as a destructive interaction with the environment, which leads to a chemical or electrochemical destruction reaction, regardless of whether it is related to the decomposition process (physically and mechanically) or not. The electrical resistance of concrete has been studied extensively as shown in the literature and most of the measurements obtained are not comparable. This is due to differential potentials in experimental procedures and electrochemical cells (Alonso et al. [38]). The relationship between resistance and corrosion rate is still sparse in the literature. Many researches have been conducted on the relationship between resistance and corrosion rate, which is caused by chloride rather than carbonation. Most of the resistance studies have been carried out using accelerated corrosion methods (partial immersion and impressed current) in which the sample is conditioned in a specific medium. The results may differ from those obtained from natural exposure to the concrete sample. The relationship between the durability of concrete samples exposed to the natural environment and the durability of conditioned concrete samples is not yet known and, if any, the results cannot be summarized due to the variability of the exposure conditions and the heterogeneity of the concrete (Andrade and Alonso, [39]). Therefore, the study of persistence is an important aspect of the study of corrosion of internal reinforced concrete structures exposed to corrosive media.

The obtained data of corrosion potential (E_{corr}, mV) and concrete resistivity (kΩcm) results are presented in Tables 3.1-3.3 and summarized into the average and percentile values in Tables 3.4 and 3.5, plotted graphically in Figures 3.1-3.8b, are the results of controlled samples, non-coated (corroded) and coated for 36 concrete slabs, made up of 3 sets of 12 controlled samples, which are the determining reference range, 12 samples non0coated (corroded) and 12 samples with exudates/resin coated. The average, percentile, minimum, maximum, and differential values of the half-cell corrosion potential measurements computed from the controlled samples were -110.19mV and -107.77mV and with percentile values of (-67.69% and -66.87%) and of potential differential potentials (2.42 mV and 0.82%), the corroded samples were -333.51mV and -330.45mV and percentile computed values of (186.92% and 192.32%) and with differential potential in values of 3.06mV and 5.4%, and the coated samples were -115.28mV and -113.94 mV with percentile computed values of (-65.79% and -65.15%) and the potential differential is 1.34mV and 0.64% respectively. The computed maximum control percentile value is -66.87% compared to the corroded and coated values of 192.32% and -65.15% and the controlled potential differential potential value is 0.82%, corroded 5.4% and coated 0.64% . The maximum yields of the controlled and coated samples were -107.77mV and -113.94 mV, which indicated the relationship between corrosion potential and opportunity in the reference range $E_{\text{corr}} > -200\text{mV}$. These results of potential E_{corr} results showed indication that the values of controlled and exudates/ resin coated specimens are low with the range of 90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement (10% risk of corrosion which indicates a 10% or uncertain probability of corrosion. For the non-coated sample, the maximum obtained computed value is -330.45mV, the results are within the range reference of dependence between potential and corrosion probability of the value $-350\text{mV} \leq E\text{corr} \leq -200\text{mV}$ indicating a high range of values, notifying a 10% or uncertain probability corrosion. The comparative results from the referencing range (controlled), showed that corroded samples exhibited corrosion presence resulting from the induced corrosion acceleration against coated samples that exhibited absence of corrosion. The exudates/resins exhibited inhibitory characteristics against corrosion attacks on reinforcing steel embedded in the concrete slab, exposed to corrosive media by the formation of the resistive coating.

The average value, the minimum and maximum percentiles of concrete resistivity with controlled sample potential differential potential are 15.98kΩcm and 16.03kΩcm and percentiles of (170.22% and 181.51%) and the differential potential value is 0.05kΩcm and 11.29%. Corroded samples were 5.7kΩcm and 5.91kΩcm and percentile computed values of (-59.8% and -58.15%) and the differential potential values were 0.21kΩcm and 1.65%, coated samples were 13.91kΩcm and 14.17kΩcm (138.96% and 148.78%) and the differential potential values of 0.26mV and 9.82%, respectively. The computed maximum percentile of the controlled sample concrete resistivity is 181.51% compared to the corroded and coated values of -58.15% and 148.78% and the maximum percentile differential potential from the controlled 11.29% compared to the corroded and coated values of 1.65% and 9.82%. The results of the controlled and coated concrete resistance samples obtained a maximum average value of 16.03kΩcm and 14.17kΩcm with a description of the value $10 < \rho < 20$ (low) compared to the corrosion value of 5.91kΩcm with a description of $5 < \rho < 10$ (high)and with the reference range of the relationship between concrete resistance and corrosion probability, the corrosion probability was significant ($\rho < 5$, $5 < \rho < 10$, $10 < \rho < 20$, $\rho > 20$) for very high, high, low to moderate and low, for probability corrosion. From the comparison of coated and corroded samples, the maximum value obtained in both samples clearly shows the value of the coated sample with a range of $10 < \rho < 20$, which classifies the range of values from low to moderate, with a significant indication of the possibility of corrosion. The maximum value of the corroded sample is in the range of $5 < \rho < 10$ which indicates high, signs indicating the presence of corrosion probability, as in the works of (Kanee et al., [27]; Gregory et al., [28]; Philip et al., [29]; Nelson et al., [26]; Daso et al., [24]; Letam et al., [25]). From the results obtained it can be compared that the effect of corrosion attack was observed in uncoated samples, while samples with exudates/resin with anti-corrosion properties with highly resistant and water-resistant membranes that prevent corrosion of the reinforcing steel embedded in concrete slabs, and exposed induced accelerated corrosion media.

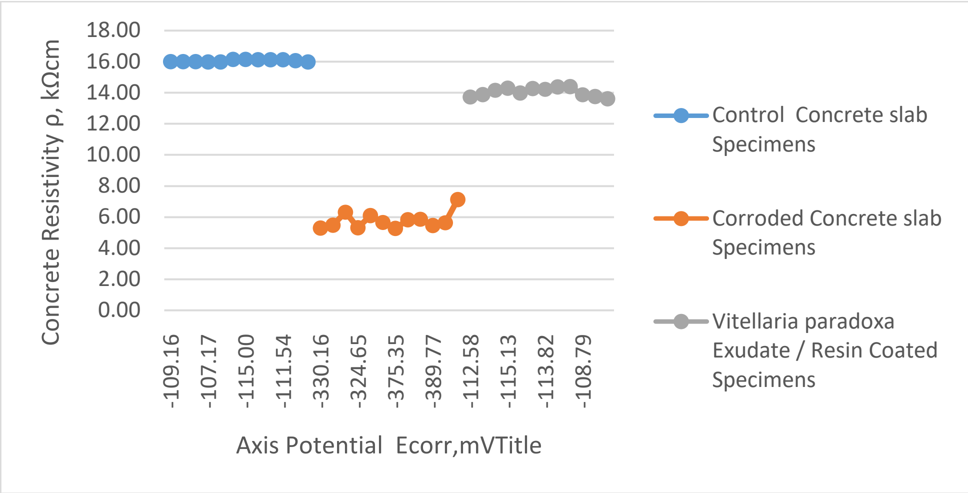

Figure 3.1 : Concrete Resistivity ρ, kΩcm versus Potential Ecorr,mV Relationship

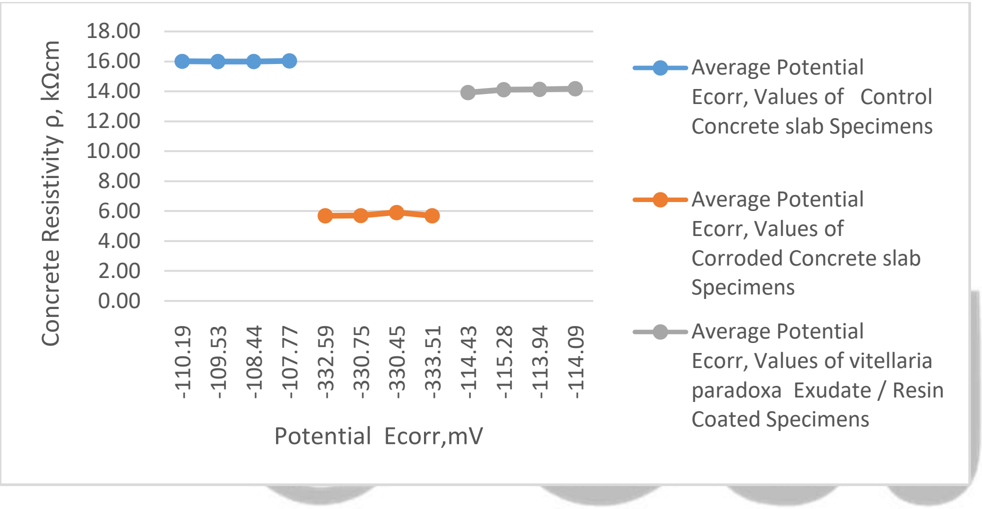

Figure 3.1 : Concrete Resistivity ρ, kΩcm versus Potential Ecorr,mV Relationship

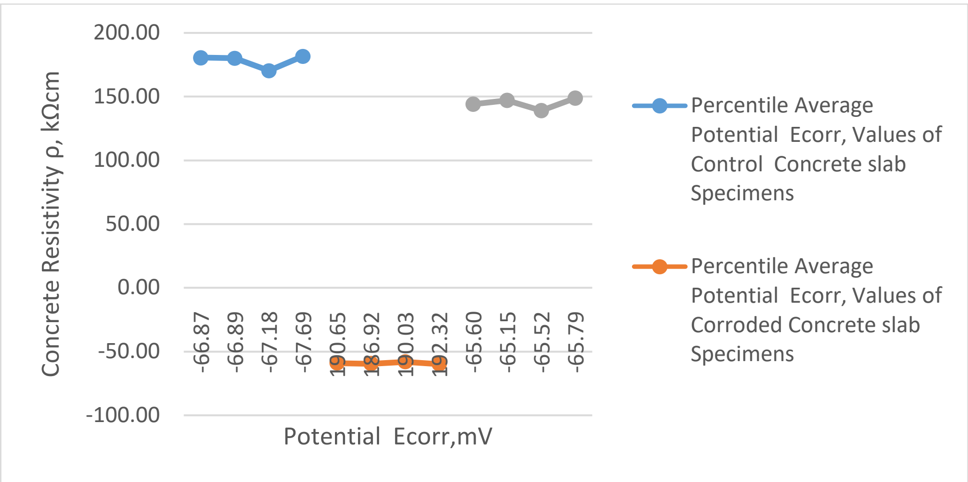

Figure 3.1B : Average Percentile Concrete Resistivity versus Potential Relationship

3.2 Results of Mechanical Properties of Yield Strength, Ultimate Strength and Strain Ratio of Embedded Reinforcing Steel in Concrete Slab

The elongation and ductility of corroded reinforcement is significantly reduced over its yield point and maximum strength. Elongation and ductility decrease exponentially with increasing corrosion losses (Tang et al. [28]). Even, although the elongation, maximum strength and plastic area corroded parameters of small diameter and/or ordinary rods were reduced more than those of large diameter and/or ribbed rods, these differences were insignificant and could be neglected (Du et al. [41]). The reduction in steel area is linearly related to the actual tensile strength. It is clear that the tensile strength of corroded reinforcement is more affected by the reduction in cross-sectional area. Tensile behavior of corroded beams is very important to assess the load bearing capacity of corroded reinforced concrete structures. Reduction in the effective diameter of steel bars has a significant impact on the tensile strength of reinforced concrete structures. This changes the tensile strength of the bar, calculated from the actual cross section significantly (Apostolopoulos [42]). The results show an inverse relationship between the corrosion rate and the true tensile strength of the controlled, corroded and coated samples. The degree of corrosion according to (Loreto et al. [43]) is inversely related to rail capacity; ie increasing the corrosion rate decreases the tensile strength, which is consistent with this study. The results of the average, percentile and the differential potential between the minimum and maximum yield strength limits, fy (MPa) of the controlled sample were 458.08MPa and 459.82MPa and with percentile values of (10.65% and 11.08%) and the differential potential values were 1.74 MPa and 0.43%, the corroded samples were 413.88 MPa and 415.11 MPa and with percentile values of (-10% and -9.67%) and the differential potential values were 1.23 MPa and 0.33%, the coated sample values were 459.54 MPa and 460.2 MPa and with percentile values of (10.7% and 11.1%) and the differential potential value is 0.66 MPa and 0.4%. The calculated maximum percentile of the controlled yield strength was 11.08% against corrosion and the closed value was -9.67% and 11.1% respectively and the possible differential potential values of 0.43% controlled 0.33% corroded and 0.40% coated. The average, percentile, and the differential potential between the minimum and maximum tensile strength, fu (MPa) of the controlled sample were 631.37MPa and 632.9MPa percentage (2.69% and 2.86%) and the differential potential value was 1.53 MPa and 0, 17%, corroded 612.39 MPa and 613.92 MPa and with percentile values of (-3.28MPa and -3.2%) and a differential potential of 1.53MPa and 0.08%, the coated is 638.39MPa and 639.92MPa and with percentile values of (2.71% and 2.79%) and the differential potential value is 1.53MPa and 0.08%.

The minimum and maximum average, the percentile and the differential potential in strain ratio values of the controlled sample are 1.32 and 1.33 (-10.54% and -10.2%) with a differential potential value of 0.01 and 0.34%, the corroded sample is 1.48 and 1.48 (10.13% and 10.53%) and the differential potential values of 0.00 and 0.4%, the coated samples were 1.34 and 1.34 (-9.53% and -9.2 %) and the differential potential value of 0.00 and 0.33%., and the coated, 10.53% and -9.2% and different peaks controlled by 0.34%, corroded by 0.33% and coated by 0.33%, as in the works of (Kanee et al., [27]; Gregory et al., [28]; Philip et al., [29]; Nelson et al., [26]; Daso et al., [24]; Letam et al., [25]). From the computed results, which are summarized in Tables 3.4 and 3.5 and shown graphically in Figures 3.1-3.8b, the yield strength, tensile strength and deformation ratio of the average, percentile and differential potential values of the control, uncoated (corroded) and samples layered concrete slabs showed that coated samples had higher breaking loads compared to corroded specimens with reduced breaking loads and low load bearing capacity and with average values and percentiles to the reference range, while uncoated (corroded) samples recorded lower loads carrying capacity and reduced value compared to the reference range. The results in comparison show that the low load carrying capacity is caused by the effect of corrosion attack on the exposed (corroded) elements, which affects the reinforcing steel fibers, ribs and passive formation and surface modification. The preserved value of the coated samples in the two average values is due to the potential for resistance when corrosion penetrates the reinforcing steel with the formation of a protective membrane; these attributes indicate the effectiveness and efficiency of exudates/resin as an inhibitor against the effects of corrosion of reinforced concrete structures in high salinity coastal marine areas. Tensile stress and failure strength decrease with increasing degree of corrosion, based on the average loss of cross-sectional area. As corrosion increases, the yield strength and ultimate strength of steel reinforcement decrease more rapidly than the average cross-sectional area. The elongation at failure load of corroded specimens increases as the corrosion rate decreases. The effect of corrosion on reducing the cross-sectional area of steel has a significant impact on the decrease in strength and ductility of concrete. Elongation and ductility of corroded steel bars decreases exponentially with increasing loss of cross-sectional area.

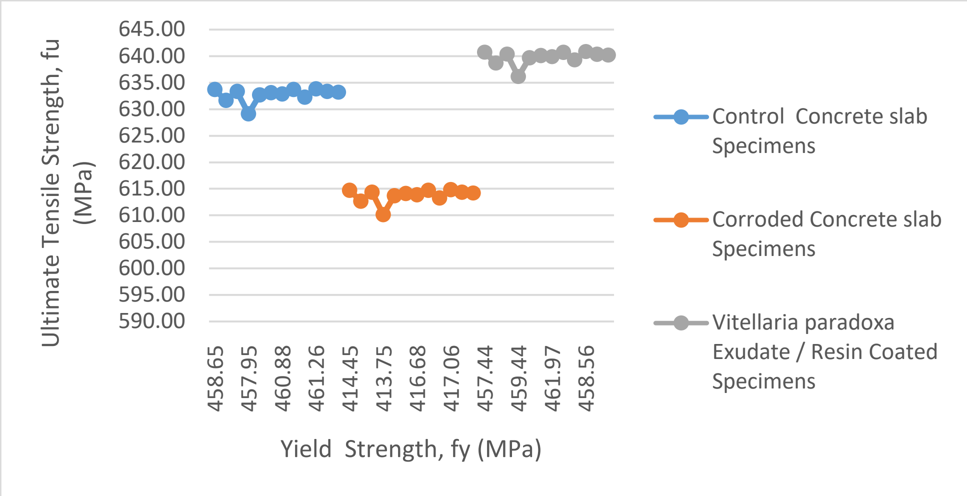

Figure 3.2 : Yield Strength versus Ultimate strength

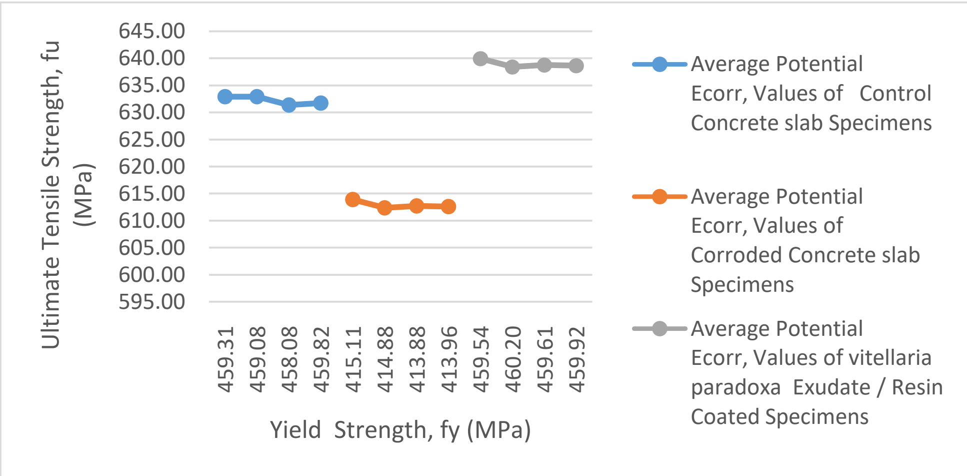

Figure 3.2A: Average Yield Strength versus Ultimate Tensile Strength

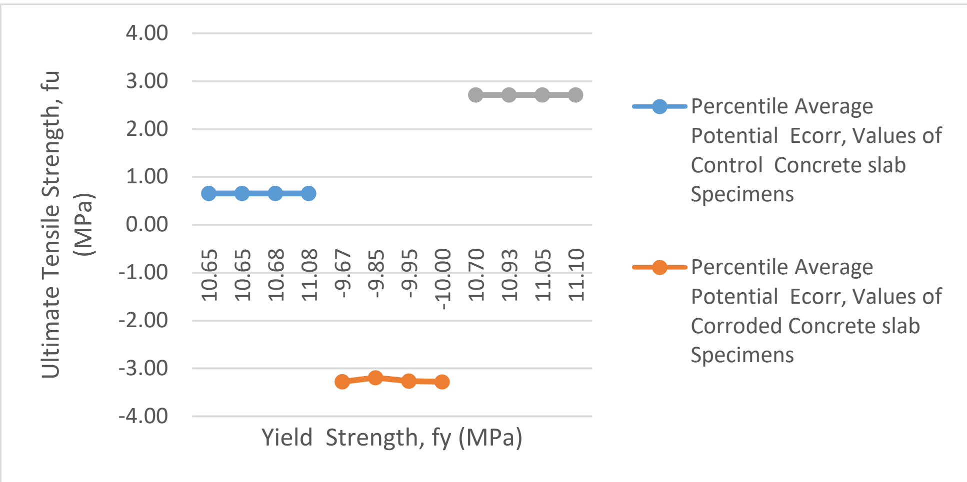

Figure 3.2B: Average Percentile Yield Strength versus Ultimate Tensile Strength

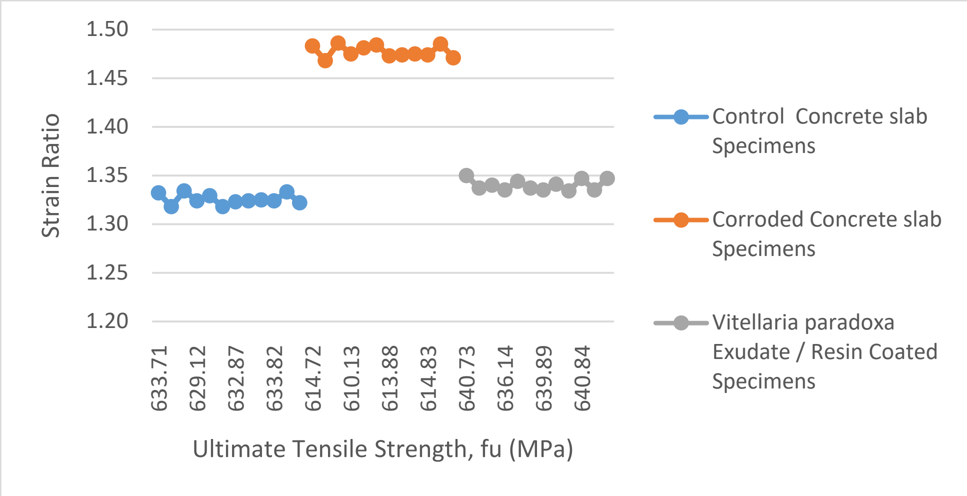

Figure 3.3: Ultimate Tensile Strength versus Strain Ratio

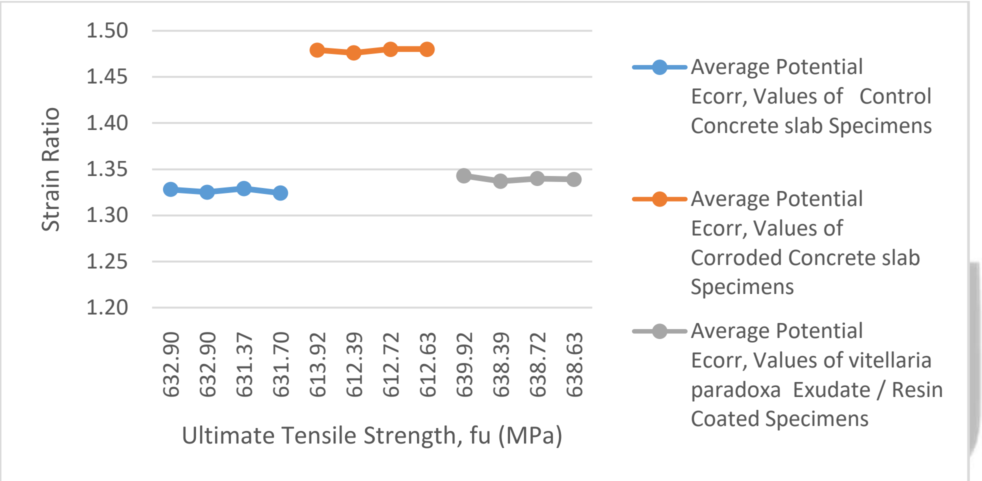

Figure 3.3A: Average Ultimate Tensile Strength versus Strain Ratio

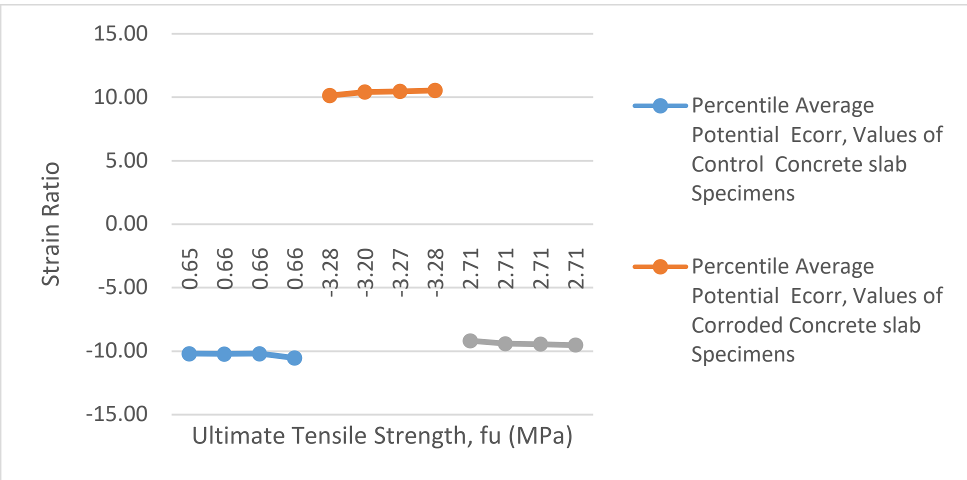

Figure 3.3B: Average percentile Ultimate Tensile Strength versus Strain Ratio

3.3 Results of Mechanical Properties of Rebar Diameter, Cross -Sectional Area and Weight Loss / Increase of Embedded Reinforcing Steel in Concrete Slab

The mechanical properties of corroded reinforced concrete structures depend on the cross section, the size of the reinforcement area and the corrosion rate. The active cross-section of the steel decreases in proportion to the corrosion rate, as the mechanical properties change. The reduction in cross-sectional area due to corrosion causes the reinforcement to deflect before reaching its load-bearing capacity. Residual strength of corroded reinforcement decreases more rapidly with reduced cross-sectional area. It also significantly reduces the residual strength of corroded reinforcement, as measured by resistance. Residual load-bearing capacity of corroded reinforcement not only decreases with increasing degree of corrosion, but also varies with decreasing diameter and type of reinforcement. The maximum corrosion rate that causes structural failure is not more than 16% (Stewart and Ali [44].

Anchor diameter before testing (mm) the average and minimum and maximum percentile values were controlled from 11.97mm and 11.99mm (0.035% and 0.040%) with a difference of 0.01 mm and 0.002% of the corroded specimen 11.98mm and 11.99mm and percentile values of (0.037% and 0.042%) and the difference in values were 0.01mm and 0.005%, and the coated sample values were 11.99mm and 1.99mm with percentile computed values of (0.038% and 0.041%) and values of 0.00mm and 0.003% were computed differentially. The unit weight of the rebar before the corrosion test showed a small potential difference in relation to the product and shape by the firm and by-products used in the production process.

The average, percentile and difference between the minimum and maximum diameter of reinforcement after corrosion test (mm) obtained for the controlled samples were 11.97mm and 11.99mm and computed percentile values of (0.035% and 0.040%) with a difference of 0.01mm and 0.002% respectively. If the 100% reference value is maintained, the corrosion values of the samples are 11.95mm and 11.96mm (-1.234% and -1.113%) and the difference is 0.01 mm and 0.121%, the coated sample values are 12.05mm and 12.05mm (1.328% and 1.328%) and a difference of 0.01 mm and 0.141%. The maximum calculated percentile value of diameter of reinforcement after corrosion test checked 0.040% against corroded -1.113% and coated 1.382%, the potential difference of percentile value of corroded is 0.112% against 0.141% coated. The results obtained in Tables 3.4 and 3.5, which are summarized from Tables 3.1, 3.2 and 3.3 and shown graphically in Figures 3.3-3.6b, shows the effect of corrosion attack on reinforcing steel embedded in concrete slabs, which are subjected to induced corrosion-accelerating activities. For comparison, the results of the corroded samples showed a reduction in value compared to the diameter of the reinforcement before and after the induction accelerated corrosion test with a percentile range of reduced value from 0.040% to -1.113% and the average value in the range of 11.99mm to 11.96mm.

The decrease/increase (diameter) in the cross-section of the minimum and maximum average and percentile values was controlled 100%, with no decrease or increase in the description after 360 days of immersion in fresh water. Corroded sample values are 0.03mm and 0.03 mm (-19.155% and -17.995%) and the difference is 0.00% and 1.197% for corroded, coated sample values 0.06 mm and 0.06 mm (28.556% and 29.546%), and the difference between 0.00 mm and 0.00%. The average value and relative percentage of potential difference in decrease/increase (diameter) in the cross-section between coated and corroded samples were in the range of 29.546% to -17.995%. The decrease in average and percentile values indicates that the corrosion effect causes a reduction in diameter and cross-sectional area, fiber degradation, rib reduction and surface modification, while the exudates/resin-coated elements show an increase in volume due to thickness differences in layers as in the works of (Kanee et al., [27]; Gregory et al., [28]; Philip et al., [29]; Nelson et al., [26]; Daso et al., [24]; Letam et al., [25]). It can be concluded that the exudates/resin has inhibitory properties against corrosive effects on reinforcing steel embedded in the concrete slab sample, which is induced in a high salinity environment. Anchor weights - before testing (Kg), the average and minimum, maximum and differential percentiles of the controlled sample were 0.86kg and 0.91 kg (6.337% and 6.453%) and the difference was 0.05% and 1.16%, the corroded samples weighed 0.87kg and 0.92kg (6.334% and 6.416%) and the difference was 0.05% and 0.082%, the coated samples weighed 0.82kg and 0.92 kg (6.158% and 6.452%) with a difference of 0.00% and 0.386%.

The average and percentage of reinforcement weight after corrosion (Kg) and the aggregate difference values of the minimum and maximum values of the controlled sample were 0.86kg and 0.91kg (6.337% and 6.453%) and the difference was 0.05% and 1.16%, the corroded samples were 0.86kg and 0.87kg (-12.65% and -12.27%) and the difference was 0.01% and 0.38%, the coated sample values were 0.99kg and 0.99kg (13.99% and 14.83%) and the difference between 0.001% and 0.84%. The average and the minimum and maximum weight loss/gain percentage of steel (Kg) and the percentage potential difference in comparison are represented by values maintained at 100% as a result of aggregation in fresh water tanks with no trace of corrosion potential in relation to the corroded sample value 0.05kg and 0.06 kg (-29.76 % and -15.94%) and coverage of 0.07kg and 0.07 kg (18.97% and 25.22%). The calculation results obtained from Tables 3.1-3.3 and summarized in 3.4-3.5 and shown graphically in Figure 3.7-3.8b show the effect of corrosion on uncoated (corroded) and coated steel and check the weight of the pieces of reinforcement before and after the corrosion test. For comparison, weight loss/gain results obtained showed a decrease and an increase in the average and percentage values with 0.08 kg coated to 0.05kg, and 25.22% to -15.94% corroded, as in the works of (Kanee et al., [27]; Gregory et al., [28]; Philip et al., [29]; Nelson et al., [26]; Daso et al., [24]; Letam et al., [25]). The aggregate results show that the corrosion effect causes a reduction in weight/weight reduction in the corroded samples compared to coatings with a percentage exposure and an average increase, resulting in a small increase in the volume of the coating thickness. This study shows the effectiveness and efficiency of exudates/resin as an inhibitor against the effects of corrosion on reinforcement embedded in samples of concrete slabs exposed to induced corrosion. Reduction of the cross-sectional area of steel significantly affects the mechanical properties of the corroded steel rebar. The tensile strength of corroded reinforcement is greatly affected by the reduction in the cross-sectional area of steel.

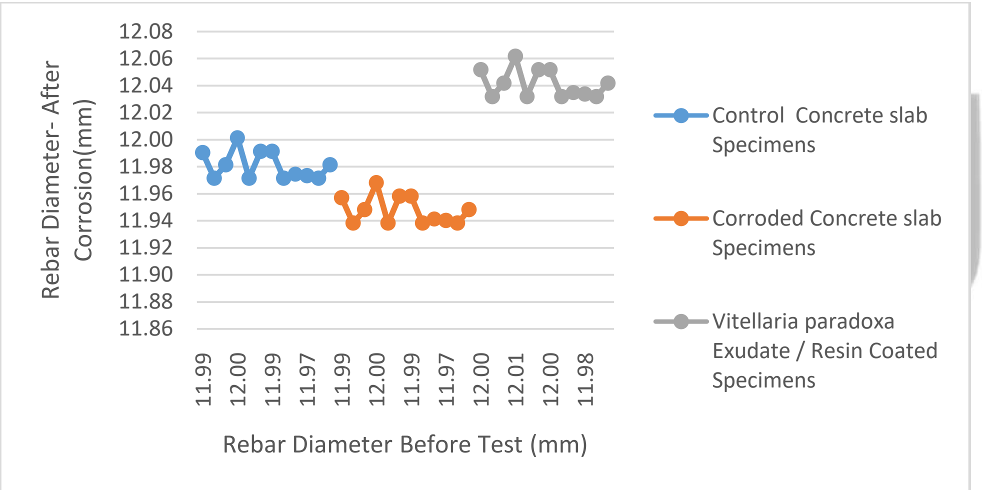

Figure 3.4: Rebar Diameter Before Test(mm) versus Rebar Diameter- After Corrosion(mm)

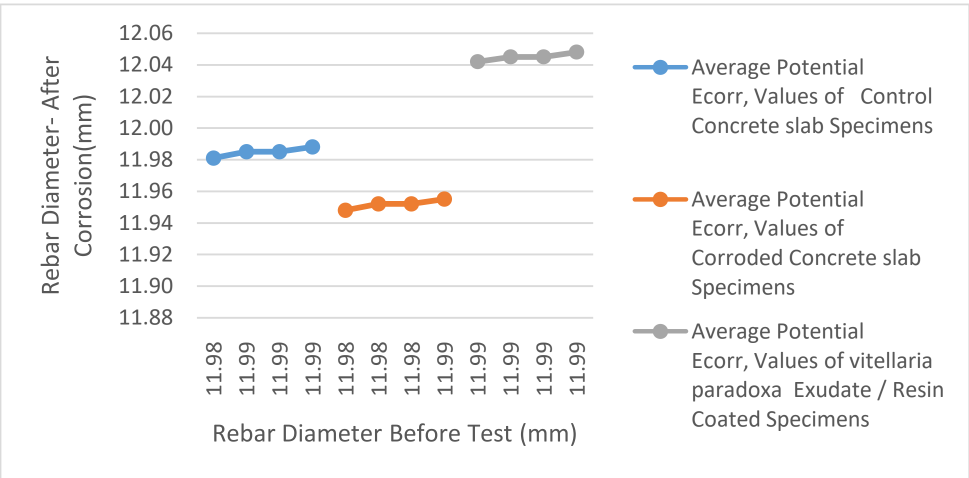

Figure 3.4A: Average Rebar Diameter Before Test(mm) versus

Rebar Diameter- After Corrosion(mm)

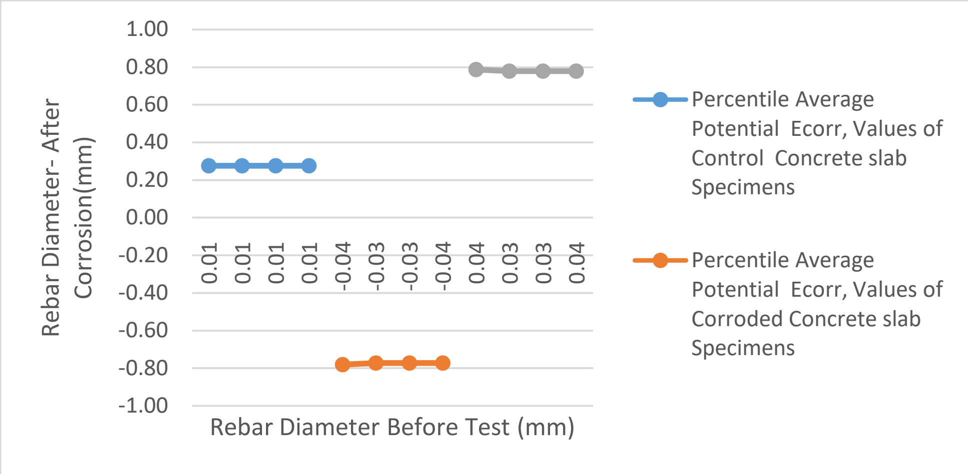

Figure 3.4B: Average Percentile Rebar Diameter Before Test(mm) versus Rebar Diameter- After Corrosion(mm

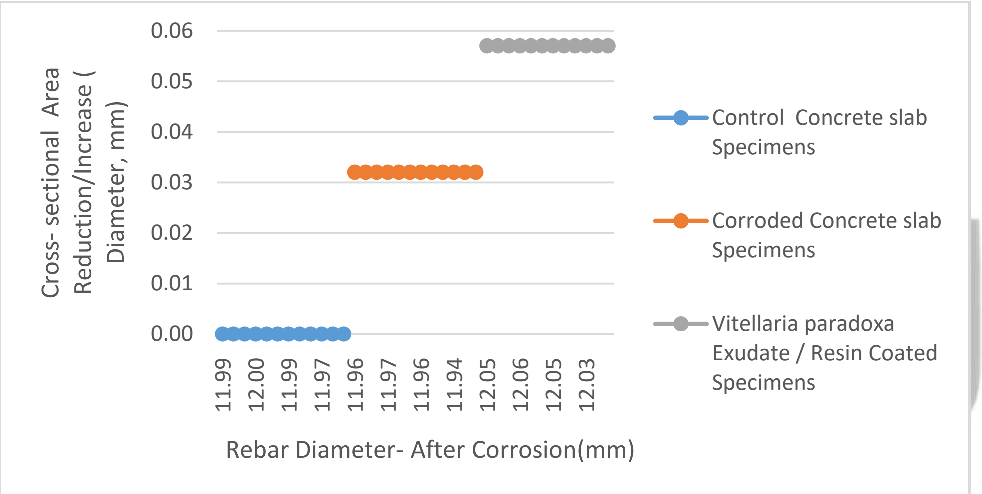

Figure 3.5: Rebar Diameter- After Corrosion (mm) versus Cross- section Area Reduction/Increase (Diameter, mm)

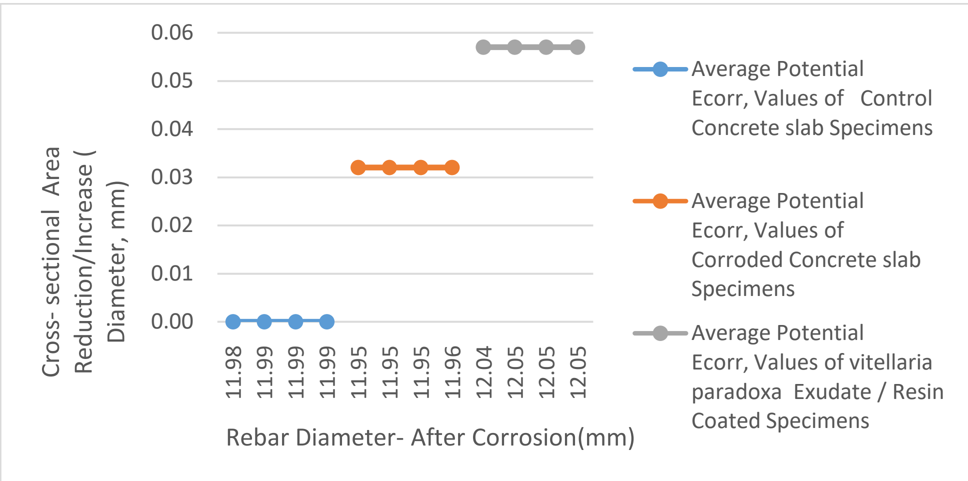

Figure 3.5A: Average Rebar Diameter- After Corrosion (mm) versus Cross- section Area Reduction/Increase (Diameter, mm)

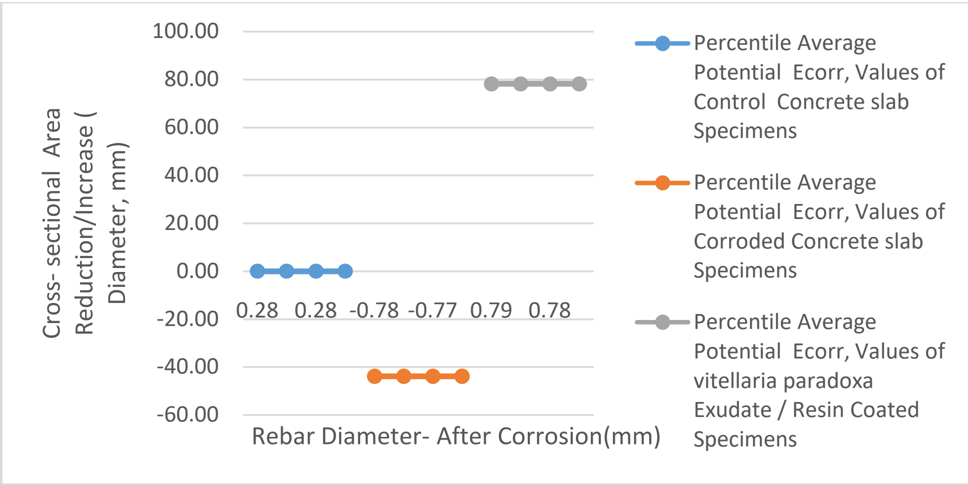

Figure 3.5B: Average Percentile Rebar Diameter- After Corrosion (mm) versus Cross- section Area Reduction/Increase (Diameter, mm)

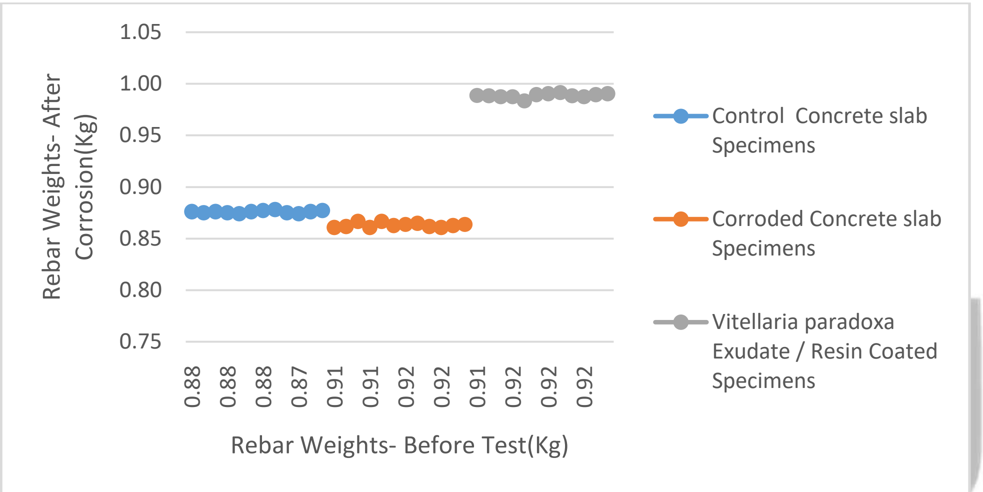

Figure 3.6: Rebar Diameter - After Corrosion (mm) versus Cross- section Area Reduction/Increase (Diameter, mm)

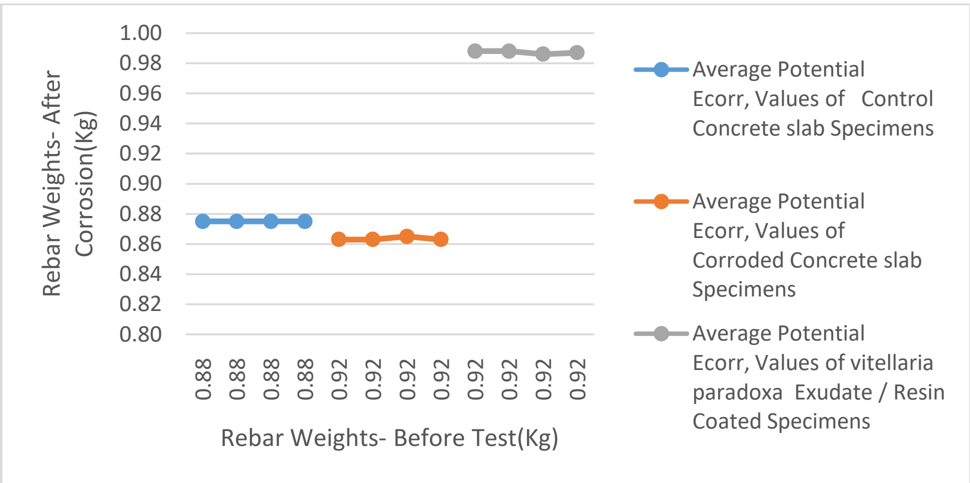

Figure 3.6A: Average Rebar Diameter - After Corrosion (mm) versus Cross- section Area Reduction/Increase (Diameter, mm)

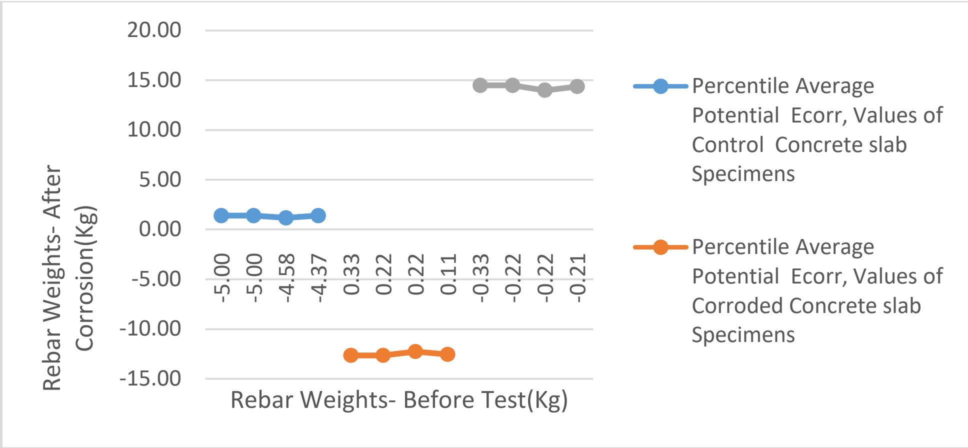

Figure 3.6B: Average Percentile Rebar Diameter - After Corrosion (mm) versus Cross- section Area Reduction/Increase (Diameter, mm)

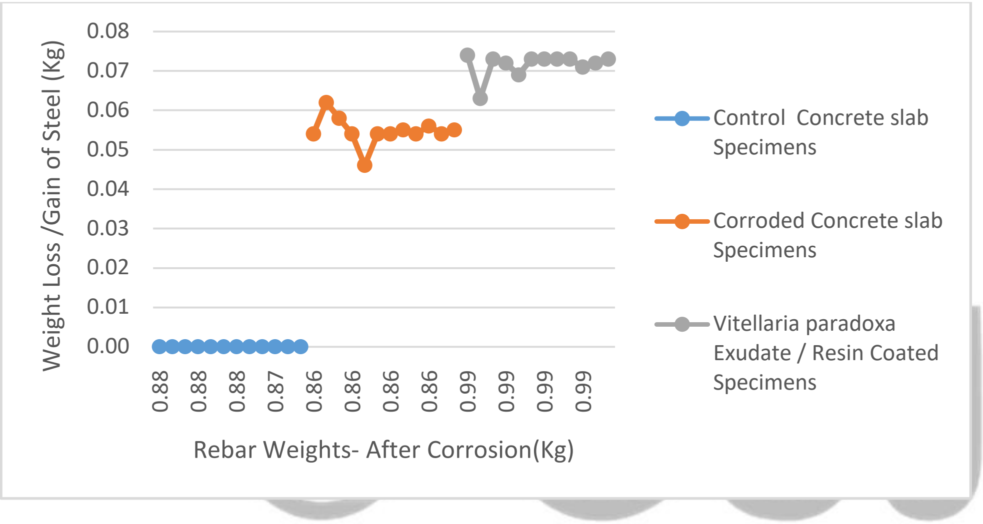

Figure 3.7: Rebar Weights- After Corrosion (Kg) versus Weight Loss /Gain of Steel (Kg)

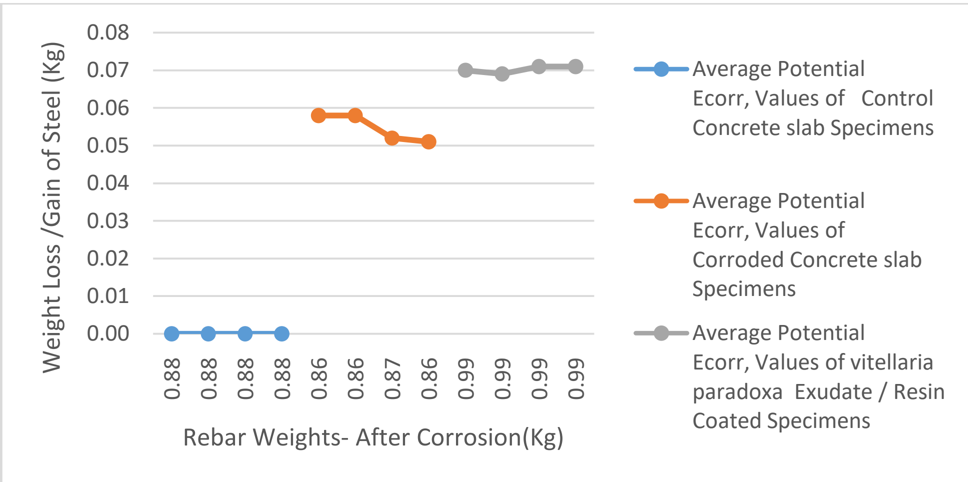

Figure 3.7A: Average Rebar Weights- After Corrosion (Kg) versus Weight Loss /Gain of Steel (Kg)

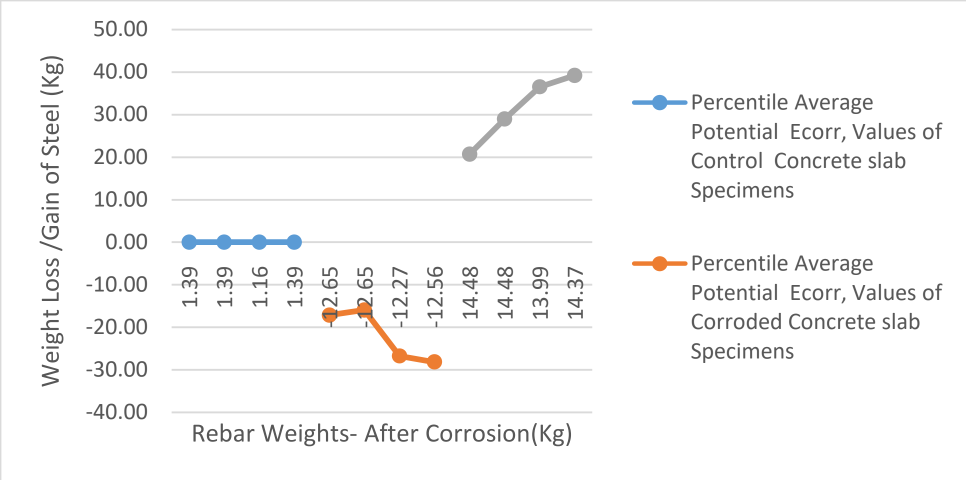

Figure 3.7B: Average Percentile Rebar Weights- After Corrosion (Kg) versus Weight Loss /Gain of Steel (Kg)

4.0 Conclusion

The experimental results show the following conclusions:

1. From the comparison results obtained, it can be seen that the effect of corrosion attack was observed in uncoated samples, while samples with exudates/resin coating had anti-corrosion properties with highly resistant and water-resistant membranes that prevented corrosion of reinforcement.

2. The comparison results show that the low load bearing capacity is caused by the effect of corrosion on the uncoated (corroded) elements, which interferes with reinforcing steel fibers, ribs and passive surface design and modification.

3. The observed mean values for the coated samples are related to the probability of corrosion resistance penetrating the reinforcing steel to form a protective membrane; These signs indicate the effectiveness and effectiveness of the exudates/resin as an inhibitor against the corrosive action of reinforced concrete structures exposed to heavy sea areas with high salinity.

4. Aggregate results show that the corrosion effect causes a decrease in weight of the corroded sample compared to the percentile exposure coated sample and an increase in mean, resulting in a small volume increase in coating thickness.

5. The study showed the efficacy and effectiveness of exudates/resin as an inhibitor against the effects of corrosion on reinforcing steel embedded in samples of concrete slabs exposed to induced corrosion.

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