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Evaluation of Reinforced Concrete Mechanical Properties of Rebar Load Carrying Capacity Exposed to Corrosive Media

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ABSTRACT

Corrosion of reinforced concrete has led to the sudden collapse of many of the exposed structures in coastal areas with severe weather. The effect of corrosion on mechanical properties of reinforcing steel flexural strength, midspan deflection, yield strength, ultimate strength, strain ratio, cross-section reduction, weight loss has been investigated for non-coated and exudates/resin coated reinforcing steel, embedded in concrete and subjected to induced acceleration corrosion process for 360 days. Obtained flexural strength load test comparatively results maximum values are controlled 26.58% against corroded and coated sample values of -19.97% and 26.59%. The differential averages and percentile ranges are controlled (0.54kN and 1.38%), corroded are (0.67kN and 1.03%), coated are (0.52kN and 1.63%). Comparative results showed that the maximum obtained values to the failure state are controlled -45.13% against corroded 83.77% and coated -45.58%. The average and percentile differential values recorded are controlled (0.26kN and 1.09%), corroded (0.27kN and 3.57%) and coated are (0.27kN and 1.07%). The results showed lower failure deflection loads in controlled and coated samples with decreased values over the corroded sample with higher failure deflection load and increased values compared to the reference range (controlled) and the coated samples. The comparative results obtained during and after the corrosion test maximum value of the rebar diameter was controlled by 0.75% in relation to the corroded -1.02% and the sample with the coating 0.97%. The calculated mean differential and percentile values were checked at (0.01% and 0.14%), the corroded values were (0.02kN and 0.13%) and the covered values were (0.03kN and 0.04%). The results showed the effect of corrosion on the mechanical properties of reinforcing steel with a reduction in diameter, where as the average value and the percentage of corroded samples decreased, while the controlled and coated samples showed a preserved condition, with an increase in the diameter of the coating such as due to different layer thicknesses with exudates/resin. The corroded sample cross-sectional area of the reinforcing steel registers distinguished average and percentage value of 0.02mm and 4.22%) and coated values (0.01 mm and 7.76%). The results obtained showed the effect of corrosion on the mechanical properties of reinforcing steel with a decrease in the diameter of the reinforcement in the corroded sample, while the coated sample showed an increase due to the thickness of the exudates paste layer. The results of the calculation of the maximum comparative value for both yield strength and tensile strength for the controlled sample are 6.68% and 3.11% based on the corroded and coated values of -1.57% and -3.31% are the coated values of 6.68 % and 3.44%. From the data obtained and compared, the yield strength and tensile strength values of the corroded samples account for the mean and percentile values that decrease with low load applications. The low bearing capacity was caused by corrosive effect on the mechanical properties of reinforcing steel through surface modifications affecting the ribs and fibers, whereas the coated samples at higher loads recorded an increase in the mean and percentage values of the reference range. The ratio of the maximum calculated strain (deformation) ratio for the mean and the percentile value for the controlled is -3.07% compared to the corroded and coated values of 3.15% and -2.77%, respectively. The mean differential and percentage values obtained for the control were (0.02 and 0.28%), corrosion values (0.01 and 0.31%) and coated values (0.01 and 0.28%). The results showed that corroded specimens had a higher percentage of deformation due to lower breaking loads and higher yield strengths, while coatings had higher breaking loads with lower yield strengths. The lower stress and yield strength and higher stress are the result of the corrosive effect on the mechanical properties of reinforcing steel, which has affected the interface, surface modification, reduction of fibers and ribs detached. The maximum elongation comparative values for the controlled sample were -25.2% compared to the corroded and coated sample of 36.55% and -25.59%, respectively. The mean differential and percentage values obtained for the

controlled samples were (0.83% and 1.15%), corrosion values (0.82% and 2.15%), and values with coating (0.82% and 1.18 %). In comparison, the corroded samples showed higher stress values and also higher elongation rates, whereas the coated state of the coated samples was lower stress and reduced elongation. The calculated data for the maximum percentage of reinforcement weight before corrosion test for controlled, corroded and coated values were 0.05%, 0.05% and 0.07%. The maximum comparison values recorded after the corrosion test for the controlled samples remained the same, without any trace of corrosive effects, because they were collected in fresh water, the values were -6.46% and 7.35% for corrosion and layered samples. The study has proven that exudates /resin showed inhibitory properties against corrosion attack to reinforcing steel embeeded into concrete and exposed to corrosion media.
Index Terms: Corrosion, Corrosion inhibitors, Flexural Strength, Concrete and Steel Reinforcement

1.0 INTRODUCTION

Corrosion is the surface decomposition of a metal/alloy within a specific environment. Metals basically exhibit higher corrosion resistance than other metals, which several factors, such as the chemical composition and the nature of the electrochemical reaction itself others. The corrosion resistance of a metal can be defined as its ability to withstand. This largely determines the functional life of the component. However, there are several definitions of corrosion, International Pure and Applied Chemical Association (IUPAC) "Corrosion is an irreversible interface. Due to the reaction of materials (metals, ceramics and polymers) and the environment consumption of substances or dissolution of environmental components into substances. Although not necessarily, corrosion often has a detrimental effect on the use of the product. Exclusive physical or mechanical processes such as melting or evaporation, wear or mechanical cracking is not included in the term corrosion. This definition covers virtually all engineering materials and other definitions are provided by ISO 8044-1986[1]. The interaction of metals and its environment within physical and chemical processes changes the properties of metals. A technical system that constitutes the function, environment, or part of a metal". The most widely used definition of corrosion is material degradation. By reaction with the environment (Trethewey and Chamberlain, [2]). The main concepts of definition: decomposition, matter, reaction and environment. In general, corrosion is considered harmful due to the deterioration/destruction that occurs. However, it should be noted that there are many beneficial uses when it comes to corrosion. Deterioration is considered a harmful effect of corrosion, although technologically advanced, it is known that of all the available metals are “gap”. It is used to classify corrosion according to the mechanism. The effect of chloride on structural deterioration of reinforced concrete infrastructure is affected by worsening corrosion especially those exposed to the marine/sea in severe and corrosive conditions. In chloride-containing media, daily and seasonal fluctuations in temperature and humidity are triggered, which lead to expansion-contraction and hydration-dehydration cycles, leading to the emergence and spread of corrosion of reinforcement, leading to cracking, decay and loss of load-bearing capacity of reinforced concrete structures (Baluch et al., [3]. To protect reinforcing steel from corrosion, the mechanism of chloride entry into concrete and the factors that influence it must be understood and limited through the use of inhibitors (Li et al., [4]).

The reduction in corrosion of steel reinforcement in concrete is due to: aggressive agents in the environment which affect the durability of the structure and increase premature deterioration. Some of the causes of damage to reinforced concrete are the attack of chlorides, acids and sulfates, the reaction of alkaline pore solutions with carbon dioxide in the atmosphere (Elsener, [5]). The decomposition of the thin protective oxide layer around the steel reinforcement and the reinforcement is susceptible to corrosion (Steven, [6]). When the corrosion process begins, corrosion products in the form of rust will extend inward, causing cracks, dents and poor load bearing capacity. Preventive measures in construction to increase the service life of concrete reinforcement are carried out by epoxy coating, water resistance, reduced water/cement ratio, and increased coating on reinforcement, commercially available chemicals, cathodic protection, and penetrating sealants. One of the most economical and recently used techniques for controlling or slowing the corrosion of reinforcement in concrete is corrosion inhibitors. Inhibitors can be applied to reinforced concrete structures when the concrete is mixed or can be applied to the surface of existing reinforced concrete structures for repair work (Luca, [7]. Inhibitors can be organic or inorganic depending on their use. Organic inhibitors include plant extracts. The advantages of green inhibitors compared to chemical inhibitors are their availability, are less toxic, biodegradable, do not contain heavy metals, are environmentally friendly and are easily renewable (Mohammad and Abdulrahman, [8]).

Inhibitors are involved not only in reducing the corrosion rate, but also in properties such as: compressive strength of the structure. Inhibitors are chemicals or plant extracts whose concentrations in small amounts slow the rate of corrosion (C0R05) [9].

They form a hydrophobic film on the surface which enhances the adsorption of ions or molecules on the surface barrier. Inhibitors reduce reinforcement corrosion by blocking the cathode or anode reaction and are very simple and inexpensive. The effectiveness of the inhibitor mainly depends on the concentration of the inhibitor, the higher the inhibitory effect of the concentration on corrosion (Annaamalai et al.,[10]). Applications require transport of inhibitors to the reinforcement, if necessary, so that the surface of the reinforcement protects the steel from corrosion or reduces flow corrosion. The use of inhibitors does not require much knowledge; this only depends on adding the right dose or the right proportion of inhibitors (Dhouibi et al., [11]). Many researchers have studied the behavior and effectiveness of organic and inorganic inhibitors in relation to their ability to reduce or slow down the corrosion process.

Minkara and Ringo [12] found that 20% of the exposed reinforcement length did not affect the ultimate flexural strength of the beam specimen, 60% of the exposed length resulted in a 20% reduction in ultimate flexural strength.

Cairns and Zhao [13] observed a 50 percent reduction in ultimate flexural strength for beams with a tensile reinforcement coefficient of 1.5% and an exposed length of more than 90% of reach, while reporting no loss of beam strength with a coefficient of 0.5% to tensile reinforcement and exposed length of more than 90% of the area.

Sharaf and Soudki [14] reported a 35% reduction in ultimate flexural strength for beam samples with unbound reinforcement of more than 90% of the area. Other investigators have carried out experimental studies on CRC carriers with partial corrosion.

El Maaddawy et al. [15] concluded that corrosion causes a reduction in ultimate strength and that this reduction is proportional to the reduction in the cross-sectional area of the steel.

Wang and Chen [16] conducted and provided a study on partially corroded RC beams stating that the length of exposed steel reinforcement does not affect strength of concrete beams, but affects the hardness. In addition, it was found that the reduction in the cross-sectional area of the reinforcement is proportional to the reduction in the ultimate flexural strength of the reinforced concrete elements. This is because the flexural strength is directly proportional to the amount of steel reinforcement and the steel reinforcement has reached the yield point in all the beams examined. It was found that the loss of point joints between the reinforcement and the surrounding concrete did not reduce the ultimate flexural strength. Corrosion reduces the cross-sectional area and strength of steel reinforcement, but also affects bonding between the steel reinforcement and the surrounding concrete. Without joints, the tension in the steel bars is no longer compatible with the stresses around the concrete and the code equation for RC section analysis is omitted.

Gilbert et al. [17] Research to minimize corrosion reduction of steel reinforcement, which destroys concrete structures in saltwater areas by introducing exudates/resin, coated to reinforcing steel of different thicknesses, built into concrete beams, and investigated the effects of corrosion on uncoated and coated elements. The detailed test results show the potential corrosion resistance of the coated elements on the mechanical properties of the reinforcing effects of weight loss, cracking, peeling and weight loss. The test results show evidence of uncoated elements with corrosive properties that reduce the surface thickness of steel bars, loss of cut weight, and presence of cracks. These traits have resulted in variable load failure and high retention with low average use, high anxiety levels, stretching, and deviations from the average range.

TrustGod et al. [18] The study evaluated the effectiveness of using olibanum exudates/resin on reinforcing steel embedded in concrete, pools in a corrosive environment with accelerated corrosion properties. Corroded elements exhibit low flexural loads with high deflections and expansion of the center area. The effect of corrosion on the mechanical properties of reinforcing steel is caused by the poor performance of corrosive elements.

Daso et al. [19] investigated the use of an environmentally friendly inorganic exudates/resin product from Artocarpus altilis to prevent corrosion attack on concrete reinforcing steel. The results of corroded elements on the mechanical properties of reinforcing steel embedded in concrete and exposed to corrosive media show high flexural loads, center deviation and exudates/resin coating as well as maximum tensile strength compared to non-corroded elements. Controlled results have small and reduced deviations from the average range, higher loads on tensile strength and lower deformation rates compared to coated elements. All results show resistance to crack formation and decreased corrosion attack on the reinforced steel elements of the coated elements, whereas the corroded elements with internal deviation of the center spring are exposed to low loads, which leads to surface modification.

Nwabakata et al. [20] The use of naturally available Garcinia Cola extract as a protective coating for reinforced steel embedded in concrete has been investigated. The components are immersed in a highly corrosive environment and accelerated for 150 days with changes in the mechanical properties of the steel. The results of elemental corrosion show poor density limits with less load used, larger deviation from the average spring and elongation. The corrosion properties of the elements show signs of corrosion which affect the surface properties of the steel reinforcement and the general mechanical properties of the steel. The results of exudates/adhesive coatings show lower flexibility compared to corroded elements with a lower average range deviation. The markings indicate that the roofing elements have corrosion-resistant properties. Corrosion-free effects of the elements include high bending loads, low average spring deflection and density limit, elongation rate and high elongation value of corrugated elements.

2.1 Materials and Methods

2.1.1 Aggregates

Fine and coarse collections are purchased. Both meet BS882 [21] requirements

2.1.2 Cement

Class 42.5 limestone cement is the most common type of cement on the Nigerian market. Used for all concrete mixtures in this test. The cement complies with the BS EN 196-6 [22] requirements.

2.1.3 Water

Clean and contamination-free water samples. Water was obtained from the Civil Engineering laboratory of Kenule Beeson Saro-Wiwa Polytechnic, Bori, Rivers. Water meets BS 3148 [23] requirements

2.1.4 Steel reinforcement

Reinforcements were supplied directly from the market in Port Harcourt. Confirmed according to BS4449: 2005 + A3 [24]

2.1.5 Corrosion Inhibitors (Resins / Exudates) Lannea coromandelica

The light-dark brown exudates are obtained from the wounded tree trunk. Exudates are liquid but change to solid states with time. They are obtained from Aba Adetipe in Ife North Local Government Area of Osun state, Nigeria.

2.2 Method

This study evaluates the use of exudates/resins from natural extruded plants that demonstrate the environmental properties of the non-hazardous material from tree trunks. The exudate / viscous resin is machined sprayed to the reinforcing steel directly of varying thicknesses and inserted into the concrete beams into the concrete beam. Its uses are rated as corrosion resistance for reinforced concrete structures exposed to the harsh territorial marine environment.

This study aims to use materials from local areas to prevent the negative effects of corrosive attacks on steel reinforcement at the highest salt (sodium chloride) concentration in the marine environment. Concrete beams are modeled with dimensions 175mm x 175mm, 750mm, thickness, width, and length with four (4) numbers with a diameter of 16mm are implanted in the beam and after the first 28 days, they are completely immersed in 5% sodium chloride (NaCl) for 360 days of preservation. Corrosion is a natural, long-term process that can take years. However, the introduction of artificial sodium chloride (NaCl) accelerates and stimulates the corrosion rate, that is, the salt concentration in the coastal zone, and this process will be as short as possible. The purpose of this study was also to determine the role of exudates/resins in the reduction of harmful attacks on reinforcement through water tightness and durability (resistance) as well as surface modification of steel reinforcement due to coating.

2.2.1 Preparation and Casting of Model Concrete Beams

Standard methods of mixing to concrete ratios and manual handling of material weights are followed. The ratio of the concrete mixture is 1: 2: 4, the water-cement ratio is 0.65. Manual mixing is used to clean the concrete pavement and mixing is checked and water is added slowly to provide a complete concrete mix layout. Constant color and consistency are achieved by adding cement, water, fine and coarse aggregates. The concrete is poured into a steel mold measuring 175 mm x 175 mm x 750 mm and supplied with suction air, and 4 numbers of reinforcing steel with a diameter of 16 mm are installed. Samples were deformed after 72 hours and stored for 28 days using standard procedures and thereafter at room temperature in the aggregation tank for a 360-day rapid corrosion acceleration test with 3 months intervals of observations at 90 days, 180 days, 270 days, and 360 days and at the first crack occurrence and formation observations and records

2.2.2 Beam Bending Test

Per BS EN 12390-2, a Universal Testing Machine was used for the flexural and bending test and a total of 36 carrier models are tested. After 28 pretreatments and standards, 12 controlled samples remained under control to prevent corrosion-related reinforcement, while 24 uncoated (corroded) and exudate/resin samples were completely immersed in 5% sodium chloride (NaCl) for 360 days, with 3 months intervals observations on modifications and testings for 90 days, 180 days, 270 days and 360 days and a study of the effect of changing mechanical properties on uncoated (corroded) and coated samples. The flexural/bending test was performed on the Intron Universal Testing machine with a capacity of 100 kN. The sample is placed in the machine according to specifications and a bending test is carried out in the third stage on two carriers to a failure state. Cracks and bending were digitally recorded with computer-aided systems, average distance deformation and all relevant tests of the diameter of reinforcement measured before testing, the diameter of reinforcement - after corrosion, reduction/enlargement of cross-sectional area, deformation of tensile strength, elongation, the weight of reinforcement - Before testing, the weight of reinforcement - after corrosion and weight loss/gain of steel is monitored and recorded.

Table 3.1: Flexural Strength of Beam Specimens (Control

Samples	Samples A			Samples B			Samples C			Samples D		
Items	LC	LC1	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	LC10	LC11
Flexural Strength Load (KN)	85.23	84.42	83.94	86.16	84.36	82.38	85.18	84.50	85.43	85.37	83.38	84.47
Midspan Deflection (mm)	5.59	5.67	6.27	6.38	5.47	6.41	5.50	5.67	5.47	5.55	5.55	6.40
Nominal Bar Diameter (mm)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Measured Rebar Diameter Before Test(mm)	15.96	16.00	16.00	15.98	15.99	15.99	16.00	15.99	15.93	15.98	15.98	15.99
Rebar Diameter at 28 days(mm)	15.96	16.00	16.00	15.98	15.99	15.99	16.00	15.99	15.93	15.98	15.98	15.99
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
Yield Strength, fy (MPa)	411.74	410.85	410.35	410.37	4090.99	410.97	411.56	410.48	411.36	410.18	411.27	411.29
Ultimate Tensile Strength, fu (MPa)	578.50	573.45	565.13	570.91	574.44	564.86	564.66	565.46	564.06	576.61	569.11	577.97
Strain Ratio	1.41	1.40	1.38	1.39	0.14	1.37	1.37	1.38	1.37	1.41	1.38	1.41
Elongation (%)	13.34	13.41	13.54	12.74	14.54	14.88	12.34	12.91	11.84	14.44	13.38	12.67
Rebar Weights- Before Test	1.57	1.57	1.55	1.57	1.57	1.57	1.57	1.57	1.56	1.58	1.57	1.57
Rebar Weights- After at 28 days (Kg)	1.57	1.57	1.55	1.57	1.57	1.57	1.57	1.57	1.56	1.58	1.57	1.57
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 : Flexural Strength of Beam Specimen (Corroded specimens)

	LC1A	LC1B	LC1C	LC1D	LC1E	LC1F	LC1G	LC1H	LC1I	LC1J	LC1K	LC1L
Flexural Strength Load (KN)	68.17	67.51	66.88	66.86	67.30	66.41	68.12	67.44	68.37	65.32	65.82	69.10
Midspan Deflection (mm)	10.62	10.70	11.30	11.41	10.50	11.44	10.53	10.70	10.50	10.58	10.58	11.43
Nominal Rebar Diameter	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Measured Rebar Diameter Before Test(mm)	15.92	15.96	15.95	15.94	15.94	15.94	15.95	15.95	15.88	15.94	15.94	15.95
Rebar Diameter- After Corrosion(mm)	15.88	15.89	15.90	15.88	15.89	15.83	15.88	15.89	15.86	15.90	15.88	15.90
Cross- sectional Area Reduction/Increase (Diameter, mm)	0.03	0.07	0.06	0.06	0.06	0.07	0.07	0.06	0.02	0.04	0.06	0.05

Yield Strength, fy (MPa)	386.03	385.14	384.64	384.66	4065.28	385.26	385.85	384.77	385.65	384.47	385.56	385.58
Ultimate Tensile Strength, fu (MPa)	561.31	556.26	547.94	553.72	557.25	547.67	547.47	548.27	546.87	559.42	551.92	560.78
Strain Ratio	1.45	1.44	1.42	1.44	1.47	1.42	1.42	1.42	1.42	1.46	1.43	1.45
Elongation (%)	18.08	18.15	18.28	17.48	19.28	19.62	17.08	17.65	16.58	19.18	18.12	17.41
Rebar Weights- Before Test (Kg)	1.57	1.56	1.57	1.58	1.57	1.57	1.58	1.57	1.57	1.58	1.58	1.57
Rebar Weights- After Corrosion (Kg)	1.52	1.51	1.52	1.53	1.52	1.52	1.53	1.52	1.52	1.53	1.53	1.52
Weight Loss /Gain of Steel (Kg)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table 3.3: Flexural Strength of Lannea coromandelica Exudates / Resin Coated Beam Specimens

Table 3.4: Average Flexural Strength of Beam Specimens (Control, Corroded and Exudates/Resin Coated (specimens)

	Average Flexural Strength of Control Beam Specimens				Average Flexural Strength of Corroded Beam Specimens				Average Flexural Strength of Exudates / resin Coated Beam Specimens			
Flexural Strength Load (KN)	84.53	84.84	84.82	84.30	67.52	67.08	67.01	66.85	84.37	84.68	84.83	84.31
Midspan Deflection (mm)	5.85	6.11	6.04	6.09	10.87	11.14	11.07	11.12	5.92	6.18	6.11	6.16
Nominal Rebar Diameter	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Measured Rebar Diameter Before Test(mm)	15.99	15.99	15.99	15.98	15.94	15.95	15.94	15.94	15.99	16.00	15.99	15.99
Rebar Diameter- After Corrosion(mm)	15.99	15.99	15.99	15.98	15.89	15.89	15.89	15.87	16.05	16.06	16.06	16.05

	LC1A1	LC1B2	LC1C3	LC1D4	LC1E5	LC1F6	LC1G7	LC1H8	LC1I9	LC1J10	LC1K11	LC1L12
	150µm (Exudate/Resin) coated			300µm (Exudate/Resin) coated			450µm (Exudate/Resin) coated			600µm (Exudate/Resin) coated		
Flexural Strength Load (KN)	85.24	83.93	83.95	86.17	84.37	82.39	85.19	84.51	85.44	84.58	82.89	83.48
Midspan Deflection (mm)	5.66	5.74	6.34	6.45	5.54	6.48	5.57	5.74	5.54	5.62	5.62	6.47
Nominal Rebar Diameter	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Measured Rebar Diameter Before Test(mm)	15.97	16.01	16.00	15.98	15.99	15.99	16.00	16.00	15.93	15.99	15.99	15.99
Rebar Diameter- After Corrosion(mm)	16.06	16.06	16.04	16.07	16.07	16.01	16.07	16.06	15.97	16.04	16.03	16.05
Cross- sectional Area Reduction/Increase (Diameter, mm)	0.10	0.05	0.04	0.08	0.07	0.02	0.07	0.06	0.04	0.05	0.04	0.06
Yield Strength, fy (MPa)	411.75	410.86	410.36	410.38	409.36	410.98	408.57	410.49	411.37	410.19	411.28	411.30
Ultimate Tensile Strength, fu (MPa)	580.30	575.25	566.93	572.71	576.24	566.66	566.46	567.26	565.86	578.41	570.91	579.77
Strain Ratio	1.41	1.40	1.38	1.40	0.14	1.38	1.38	1.38	1.38	1.41	1.39	1.41
Elongation (%)	13.27	13.34	13.47	12.67	14.47	14.81	12.27	12.84	11.77	14.37	13.31	12.60
Rebar Weights- Before Test(Kg)	1.56	1.57	1.56	1.56	1.56	1.56	1.56	1.56	1.57	1.56	1.56	1.56
Rebar Weights- After Corrosion(Kg)	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63
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

Cross- sectional Area	0.00	0.00	0.00	0.00	0.05	0.06	0.06	0.07	0.06	0.06	0.07	0.06

Reduction/Increase (Diameter, mm)												
Yield Strength, fy (MPa)	412.23	411.77	414.49	418.7	388.44	388.88	389.65	386.84	413.55	410.84	414.82	412.59
Ultimate Tensile Strength, fu (MPa)	572.36	569.83	570.16	570.07	555.17	552.64	552.97	552.88	574.16	571.63	571.96	571.87
Strain Ratio	1.39	1.39	1.40	1.41	1.44	1.44	1.45	1.45	1.40	1.39	1.40	1.40
Elongation (%)	13.43	13.23	13.61	14.06	18.17	17.97	18.35	18.79	13.36	13.16	13.54	13.98
Rebar Weights- Before Test(Kg)	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.56	1.56	1.56	1.56
Rebar Weights- After Corrosion(Kg)	1.57	1.57	1.57	1.57	1.52	1.52	1.52	1.52	1.63	1.63	1.63	1.63
Weight Loss /Gain of Steel (Kg)	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.07	0.07	0.07	0.07

Table 3.5: Average Percentile Flexural Strength of Beam Specimens (Control, Corroded and Exudates Coated (specimens)

	Average Percentile Flexural Strength of Control Beam Specimens				Coated (specimens) Average Percentile Flexural Strength of Corroded Beam Specimens				Average Percentile Flexural Strength of Exudate/Resin Coated Beam Specimens			
Flexural Strength Load (KN)	25.20	26.47	26.58	26.09	-19.97	-20.78	-21.00	-20.70	24.96	26.23	26.59	26.10
Midspan Deflection (mm)	-46.22	-45.13	-45.40	-45.21	83.77	80.20	81.07	80.46	-45.58	-44.51	-44.77	-44.59
Nominal Rebar Diameter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Measured Rebar Diameter Before Test(mm)	0.389	0.389	0.389	0.389	0.379	0.382	0.387	0.379	0.381	0.384	0.385	0.379
Rebar Diameter- After Corrosion(mm)	0.61	0.66	0.63	0.75	-1.02	-1.04	-1.05	-1.13	0.93	0.95	0.97	0.94
Cross- sectional Area Reduction/Increase (Diameter, mm)	0.00	0.00	0.00	0.00	-16.86	-14.18	-13.61	-17.83	20.28	14.01	15.76	21.77
Yield Strength, fy (MPa)	6.67	6.68	1.60	1.60	-6.26	-6.26	-1.57	-1.57	6.68	6.68	1.60	1.60
Ultimate Tensile Strength, fu (MPa)	3.10	3.11	3.11	3.11	-3.31	-3.32	-3.32	-3.32	3.42	3.44	3.43	3.43
Strain Ratio	-3.35	-3.35	-3.08	-3.07	3.15	3.14	2.85	2.84	-3.05	-3.04	-2.77	-2.77
Elongation (%)	-26.06	-26.35	-25.81	-25.20	36.00	36.55	35.53	34.40	-26.47	-26.77	-26.22	-25.59
Rebar Weights- Before Test(Kg)	0.075	0.074	0.073	0.072	0.068	0.073	0.074	0.075	0.074	0.073	0.072	0.075
Rebar Weights- After Corrosion(Kg)	3.18	3.23	2.85	3.24	-6.85	-6.76	-6.46	-6.56	7.35	7.25	6.91	7.02
Weight Loss /Gain of Steel (Kg)	0.00	0.00	0.00	0.00	-23.46	-23.38	-23.89	-23.70	30.66	30.52	31.39	31.06

3.1 Results and Discussion of Concrete Beam Members and Midspan Deflection

Corrosion of reinforced concrete has led to the sudden collapse of many of the exposed structures in coastal areas with severe weather. The effect of corrosion on flexural forces has been investigated by a large number of investigators and is well understood. Many studies conducted in this area have been described by critical tests of their effectiveness in the effects of corrosion on the flexibility of reinforced concrete beams. These corrosion factors and the failure state-led Torres-Acosta et al. [25] investigated the loss of strength of steel due to embedded steel corrosion using concrete members with a cross-section of 100 mm × 150 mm and 1500 mm.

Charles et al. [26] also examined the effect/impact of corrosion inhibitors on the flexural strength of load, midspan deflection, tensile strength, and reinforcing steel stiffening resins coated with Mangifera indica extracts as corrosion inhibitors. The full results showed the effect of corrosion on the flexural strength of reinforcing which led to low load loading and high deviation midspan in damaged joints and flexural load in the failure of the load and lower midspan in the concrete beam members without barrel and binding led to attacks from facial stiffness. Considering the effect of corrosion on reinforced concrete structures built within the coastal areas of Niger Delta, Nigeria, with high salinity, the application of Lannea coromandelica exudates/resin extracts of tree sources with eco-friendly was introduced, applied directly to embedded reinforcing steel in concrete beams and assessed its effectiveness as an inhibitory substance against corrosion.

3.2 Results Flexural Strength Load and Midspan Deflection

Corrosion of reinforcing steel has been investigated and observed to be a major cause of damage to reinforced concrete structures which results in a decrease in the life of concrete structures. Significant research has been carried out in the past on the corrosion of reinforcing bars, addressing various problems related to the corrosion process, initiation and harmful effects. Evaluation of the flexural strength of corrosion-damaged reinforced concrete elements was investigated (Azad et al. [27]; Cabrera [28]; Huang and Yang [29]; Rodriguez et al. [30]; Uomoto and Misra [31]). A number of studies have also been carried out to predict the residual flexural strength of corrosive concrete beams (Azad et al. [32]; Mangat and Elgarf [33]; Nokhasteh and Eyre [34]; Ravindrarajah and Ong [35]; Tachibana et al. [36]; Wang and Liu [37]; Jin and Zhao [38]). The experimental data of flexural test of concrete beams samples are presented in tables 3.1, 3.2, and 3.3, summarized in 3.4 of average values and percentile in 3.5, and results graphically represented in figures 3.1 - 3.7b.

The computed minimum and maximum average and percentile values obtained from are flexural strength load from Instron Universal Testing machine with 100kN pressure load to failure state are controlled samples are 84.3kN and 84.84kN (25.2% and 26.58%), the corroded sample values are 66.85kN and 67.52kN (-21.25% and -19.97%), and the exudates/resin coated samples are 84.31kN and 84.83kN (24.96% and 26.59%). From the flexural strength load test, comparatively, the maximum values are controlled 26.58% against corroded and coated sample values of -19.97% and 26.59%. The differential averages and percentile ranges are controlled (0.54kN and 1.38%), corroded are (0.67kN and 1.03%), coated are (0.52kN and 1.63%).

The results showed that the reference percentile value of the controlled sample was placed in freshwater conforming to BS 3148 and the effect of corrosion was not noticed and hence, used as the reference value towards non-coated and coated that are immersed in corrosive media as described in the test program. The corroded sample failed at a lower load application while coated samples exhibited higher failure load application. Results further validated that the flexural failure load of controlled and coated samples maintained a close range of values over the corroded sample with averaged decreased and lower load application. The results of minimum and maximum average and percentile midspan deflection failure loads recorded of non-coated are 5.85kN and 6.11kN -46.22% and -45.13%), corroded samples are 10.87kN and 11.14kN (80.2% and 83.77%) and the coated samples are 5.92kN and 6.18kN -45.58% and -44.51%). Comparative results showed that the maximum obtained values to the failure state are controlled -45.13% against corroded 83.77% and coated -45.58%. The average and percentile differential values recorded are controlled (0.26kN and 1.09%), corroded (0.27kN and 3.57%) and coated are (0.27kN and 1.07%). The results showed lower failure deflection loads in controlled and coated samples with decreased values over the corroded sample with higher failure deflection load and increased values compared to the reference range (controlled) and the coated samples. The comparative results obtained of flexural strength and mid-span deflection failure loads of corroded samples showed the effect of corrosion on the mechanical properties of reinforcing steel with ribs peeled off, a high surface modification which resulted in low load carrying capacity and high midspan deflection as related to the works of (Gilbert et al., [17], Daso **e**t al., [18]; TrustGod et al.,[19] ; Nwabakata et al., [20]; Charles et al., [26]). From the obtained results, Lannea coromandelica exudates/resin has proven to be an anti-corrosive material in reinforced concrete structures exposed to corrosive media with high resistivity and waterproofing membrane towards corrosion effects. Corrosion rate directly affects the remaining life span of corroded reinforced concrete structure resulting to decrease on the residual capacity of the corroded.

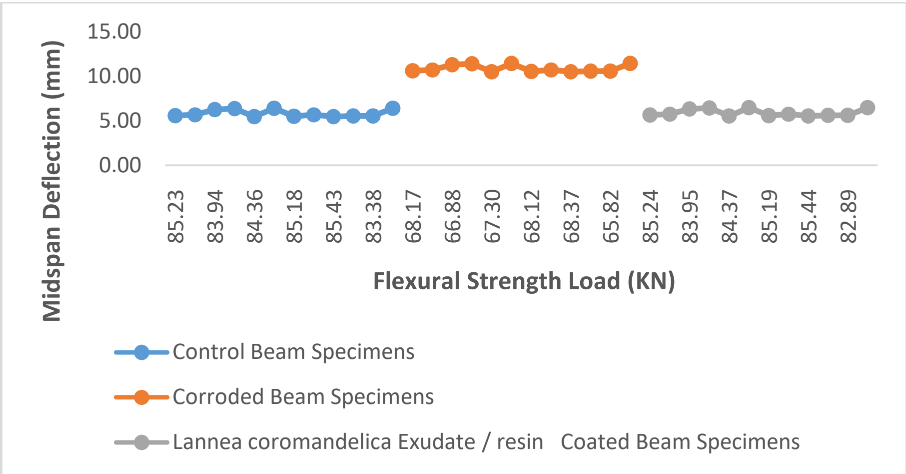

Figure 3.1: Failure Load versus Midspan Deflection of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

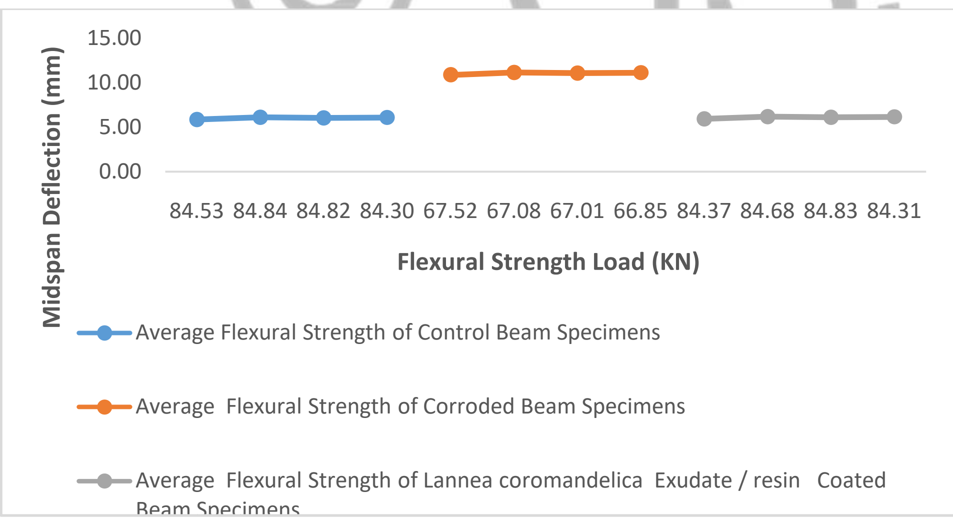

Figure 3.1A: Average Failure Load versus Midspan Deflection of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

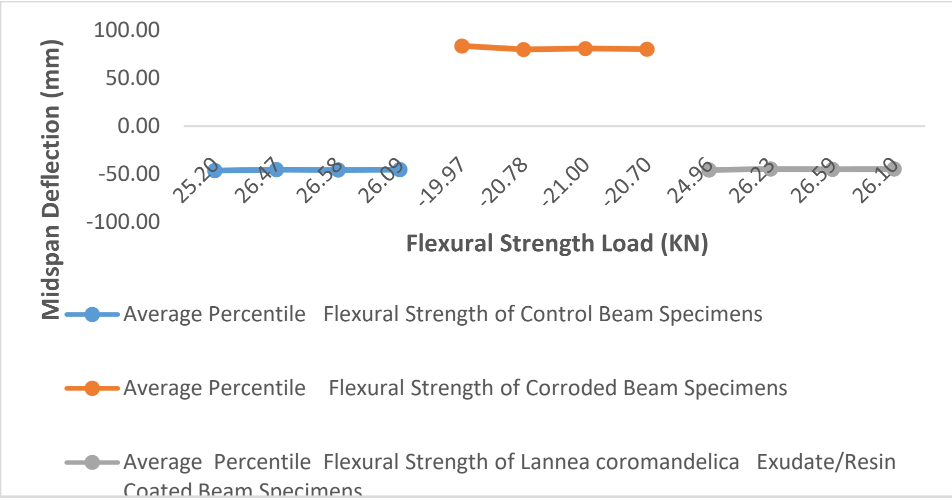

Figure 3.1B: Average Percentile Failure Load versus Midspan Deflection of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

3.3 Results of Measured Rebar Diameter Before and After Corrosion Test

Corrosion of steel reinforcement is one of the most significant types of damage to reinforced concrete structures, especially structures exposed to the marine environment [Castel et al., [39]; Molina et al.,[40]; Taha and Muhammad, [41]). Corrosion affects the structural integrity of the concrete structure and causes a decrease in the mechanical properties of steel reinforcement (Apostolopoulos, [42]; Graeff et al., [43]). The significantly worsening effect of corrosion is the reduction of the usable cross-sectional area of the reinforcing structural elements [Holly and Bilcik, [44], Sæther, [45]). The loss of cross-sectional area of steel is the destruction of steel to its original state, namely rust. The initiation and propagation phases are the two main stages which involve the formation of corrosion. So far, corrosion causes a reduction in the area of steel reinforcement and affects its dynamic and static behavior or mechanical behavior (Nayak et al., [46]).

The diameter of reinforcing steel before and after corrosion test were examined and evaluation on corrosion effects on the mechanical properties modifications were presented in tables 3.1 -3.3, averagely summarized in 3.4 and percentiles in 3.5.

The results obtained for the minimum and maximum mean and percentage values for the nominal valve diameter are 16 mm (100%) for all standard references. The rebar diameters measured before testing for the controlled sample were 15.98 mm and 15.99 mm (0.389% and 0.389%), the corroded ones were 15.94mm and 15.95mm (0.379% and 0.387% and the layers are 15.99mm and 16mm (0.379% and 0.385%). The results obtained indicate that the diameter of the reinforcing steel varies within a minimal limit due to the manufacture of reinforcement by different companies, the production form used leads to an average value and the percentile difference is not significant.

The average value and the minimum and maximum percentage of the anchor diameter - after the corrosion test, the controlled ones were 15.98 mm and 15.99mm (0.61% and 0.75%), the corroded sample value was 15.87 mm and 15.89mm (-1.13% and -1.02%), the values of the coated samples were 16.05 mm and 16.06mm (0.93% and 0.97%).

The comparative results obtained during and after the corrosion test the maximum value of the rebar diameter was controlled by 0.75% in relation to the corroded -1.02% and the sample with the coating 0.97%. The calculated mean differential and percentile values were checked (0.01% and 0.14%), the corroded values were (0.02kN and 0.13%) and the covered values were (0.03kN and 0.04%).

The results showed the effect of corrosion on the mechanical properties of reinforcing steel with a smaller diameter, where the average value and the percentage of corroded samples decreased, while the controlled and coated samples showed a preserved condition, with an increase in the diameter of the coating such as due to different layer thickness with exudates/resin. The use of exudates/resins protects reinforcing steel from severe corrosion damage. The mean and percentile values determined after and before the correction check have a negative effect on the diameter of the reinforcing steel, leading to a decrease and an increase in the cross-sectional area resulting from surface modifications and varying coating thicknesses from the exudates/resin materials.

The minimum and maximum "decrease/increase in cross-sectional area (diameter)" of the controlled samples was 0.00 mm, at (100%) for all samples indicated that the corroded samples were 0.05 mm and 0.07mm with percentile values of (17.83% and -13.61%) and coated samples were 0.06 mm and 0.07 mm (14.01% and 21.77%). The corroded sample cross-sectional area of the reinforcing steel registers distinguished average and percentage value of 0.02mm and 4.22%) and coated values (0.01 mm and 7.76%).
The results obtained showed the effect of corrosion on the mechanical properties of reinforcing steel with a decrease in the diameter of the reinforcement in the corroded sample, while the coated sample showed an increase due to the thickness of the exudates paste layer. The reduction in cross-sectional area was due to the corrosive effect on reinforced concrete structures built in marine coastal environments and the increased protective layer provided as verified by the work-related exudates/resins of (Gilbert et al., [17], Daso **e**t al., [18]; TrustGod et al.,[19] ; Nwabakata et al., [20]; Charles et al., [26]).

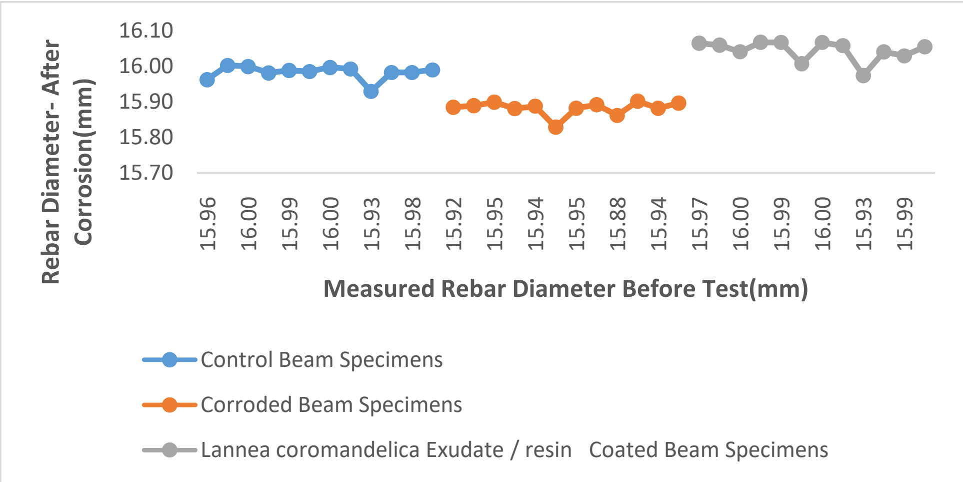

Figure 3.2: Measured Rebar Diameter Before Test versus Rebar Diameter- After Corrosion

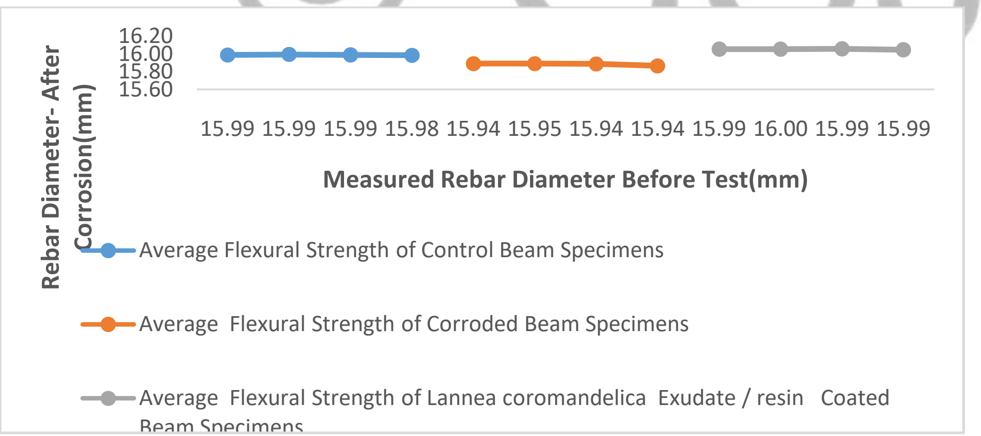

Figure 3.2A: Average Measured Rebar Diameter Before Test versus Rebar Diameter- After Corrosion

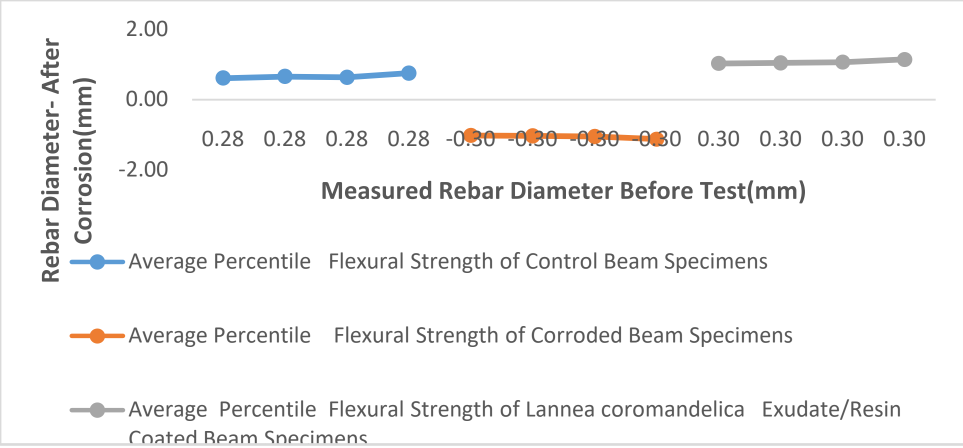

Figure 3.2B: Average Percentile Measured Rebar Diameter Before Test versus Rebar Diameter- After

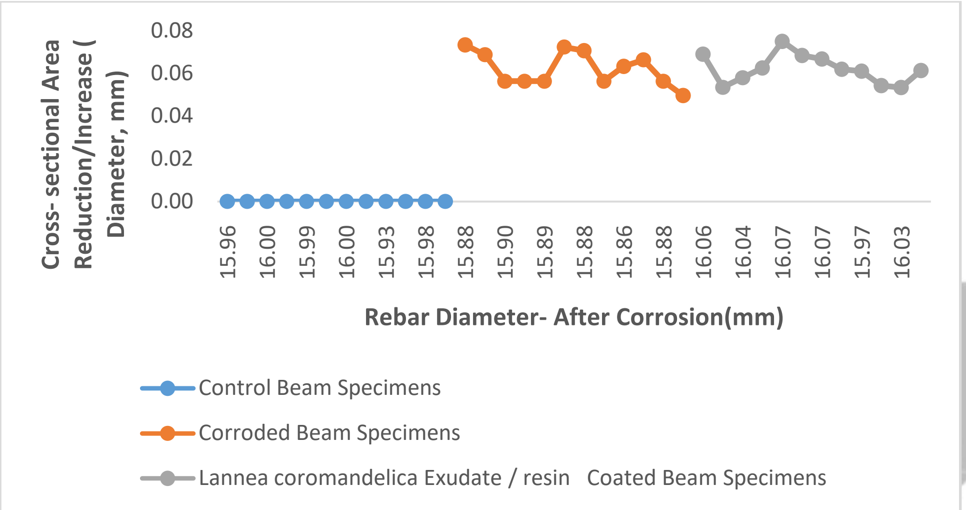

Figure 3.3: Rebar Diameter- After Corrosion versus Cross- Sectional) Reduction/Increase (Diameter

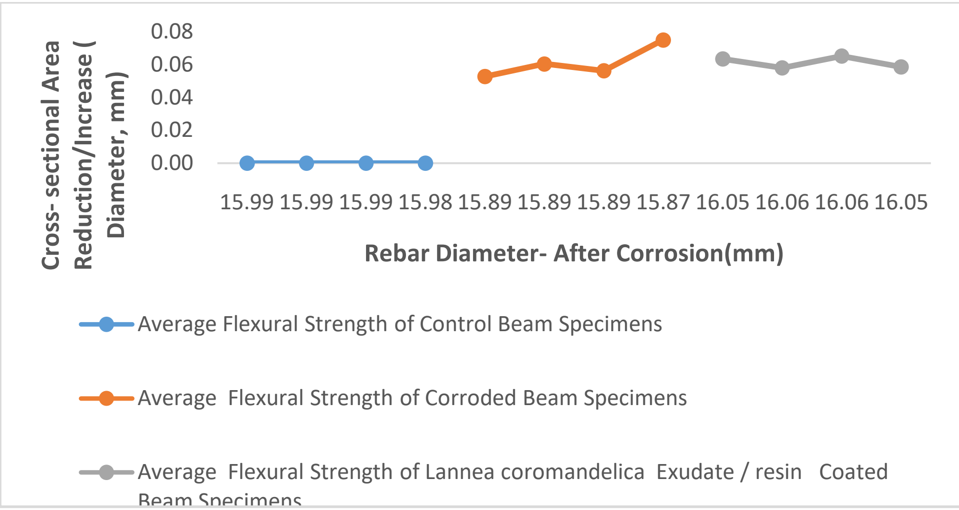

Figure 3.3A: Average Rebar Diameter- After Corrosion versus Cross- sectional Area Reduction/Increase (Diameter)

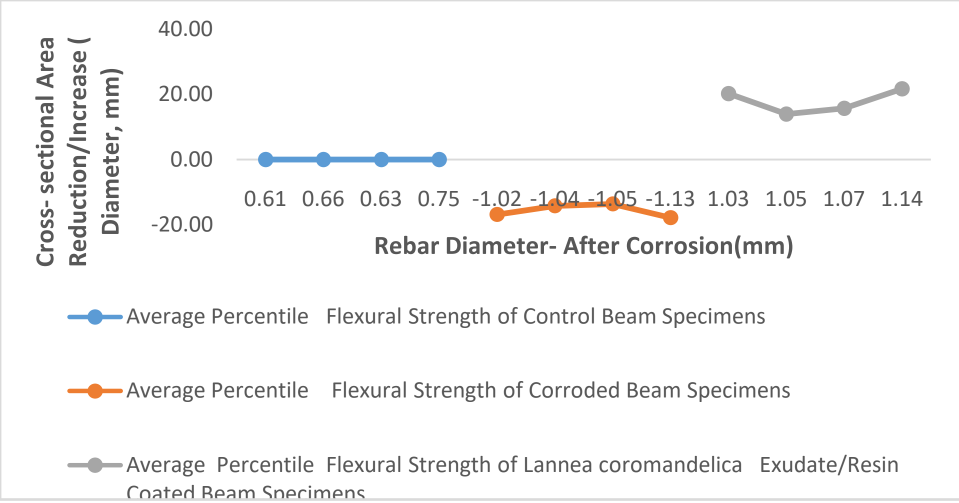

Figure 3.3B: Average Percentile Rebar Diameter- After Corrosion versus Cross- sectional Area Reduction/Increase (Diameter)

3.4 Results of Ultimate Tensile Strength and Yield Strength

The rate of corrosion development is a determining factor that can describe the evolutionary model of safety and residue use (Alonso et al., [47]). The effect of reinforcing corrosion on the residual strength of steel reinforcement is very interesting; Corrosion has a negligible effect on the yield point and flexural strength of reinforcing steel (Xia et al. [48]). The residual strength of the corroded reinforcement decreases faster than its average cross-sectional area. It also significantly reduces the residual strength of corroded reinforcement, measured in terms of tensile strength. The residual capacity of the corroded reinforcement not only decreases in the presence of corrosion, but also varies depending on the diameter and type of reinforcement (Du et al., [49]).

The results of the mean and minimum and maximum percentile values calculated in Tables 3.4 and 3.5, which were obtained from Tables 3.1 - 3.3 yield strength of the sample controlled values, were 411.77MPa and 418.7MPa (1.6% and 6.68%), the corroded sample had 386.84MPa and 389.65 (-6.26% and -1.57%) and the coated sample was 410.84MPa and 414.82MPa (1.6% and 6.68%).

The ultimate tensile strength values of controlled samples were 569.83MPa and 572.36MPa (3.1% and 3.11%), corroded samples 552.64MPa and 555.17MPa -3.32% and -3.31% and coated samples of 571.63MPa and 574.16MPa (3.42% and 3.44%). The results of the calculation of the maximum comparative value for both yield strength and tensile strength for the controlled sample are 6.68% and 3.11% based on the corroded and coated values of -1.57% and -3.31% are the coated values of 6.68 % and 3.44%.

The difference in the average and percentile of the yield strength and tensile strength calculations are (6.58MPa and 5.08%) and (2.83MPa and 0.04%) for the corroded samples and (2.86MPa and 4.69%) and (2.58MPa and 0.01%) for the controlled and the values of coated are (3.75MPa and 5.08%) and (2.53MPa and 0.02%). From the data obtained and compared, the yield strength and tensile strength values of the corroded samples account for the mean and percentile values that decrease with low load applications. The low bearing capacity was caused by corrosive effect on the mechanical properties of reinforcing steel through surface modifications affecting the ribs and fibers, whereas the coated samples at higher loads recorded an increase in the mean and percentage values of the reference range (controlled sample) in relation to the works of (Gilbert et al., [17], Daso **e**t al., [18]; TrustGod et al.,[19] ; Nwabakata et al., [20]; Charles et al., [26]). The ratio of yield strength to ultimate strength fy/fu reflects the deformability of steel bars and is the most desirable warning against damage to reinforced concrete. Usually, the deformability of corroded steel bars decreases with increasing fy/fu. Exudates / resins exhibit efficiency and strength in protecting reinforced concrete structures exposed to corrosive media

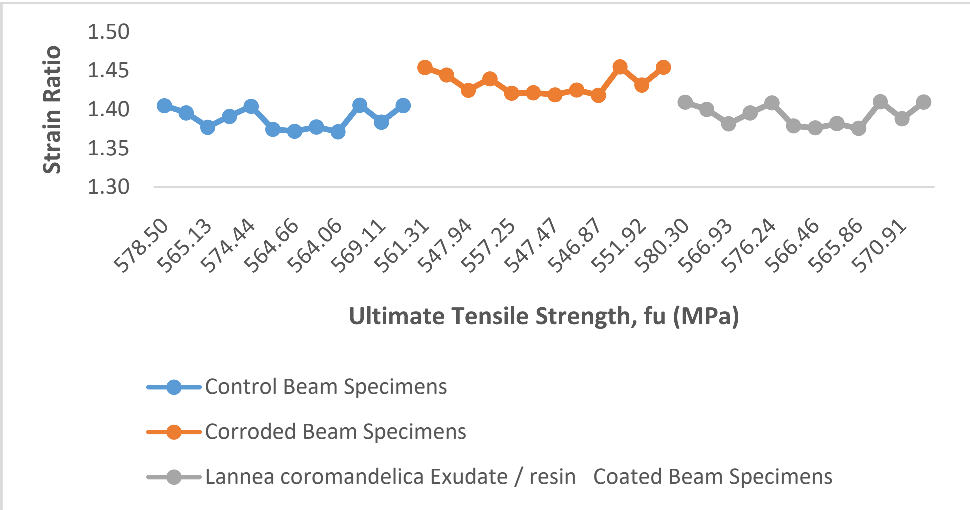

Figure 3.4: Ultimate Tensile Strength versus Yield Strength of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens

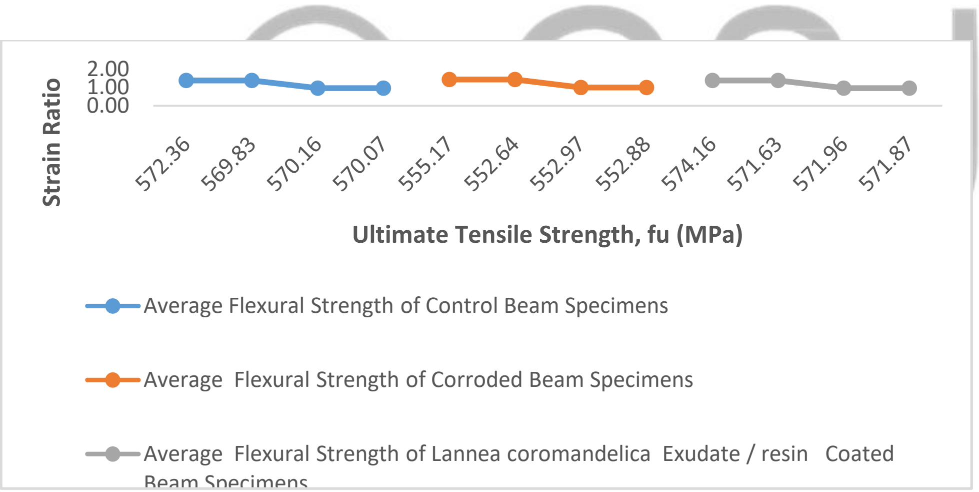

Figure 3.4A: Average Ultimate Tensile Strength versus Yield Strength of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens

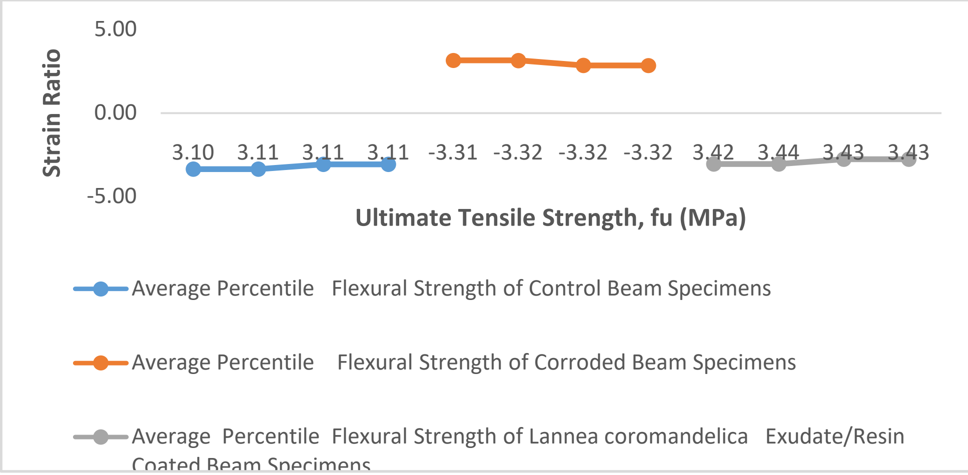

Figure 3.4B: Average percentile Ultimate Tensile Strength versus Yield Strength of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens

3.5 Results of Strain Ratio, Elongation, Rebar Weights- Before and After Corrosion and Weight Loss /Gain of Steel

The corrosion effect of reinforcing steel embedded in concrete and exposed to corrosive media 0-670 becomes more critical when evaluating the mechanical properties of corroded steel bars. Changes in the behavior of corroded steel reinforcement, which are tested under monotonous tensile loads, have various causes. At the material level, the inhomogeneous cross-sectional distribution of various material phases derived from a modern production system called TEMPCORE is often seen as a key factor (Apostolopoulos and Papadakis [50]; Apostolopoulos et al. [51]; Fernandez et al. [52]; Santos and Henriques [53]; Apostolopoulos [54] ; Caprili et al. [55]). An additional mechanism to explain the observed changes in mechanical properties of corroded steel bars includes consideration of the geometric effects resulting from non-uniform reduction in the cross section of the bar. These effects include the appearance of a local bending moment due to a shift in the center of gravity relative to the original non-corroded cross section and the stress concentration at the top of the hole caused by a sudden change in cross section, also known as the gap effect (Fernandez et al. [56], [57]; Apostolopoulos et al. [58]; Tang et al. [59]). Due to the strong correlation between this effect and the actual form of corrosion, as reported by (Zhu et al. [60]; Zhu and François [61]), assuming that this effect is valid, shows that the actual hole shape, ie. The depth and width of the hole and the proportion of uniform or corrosive corrosion have a negligible influence on the actual behavior of the steel bar. The results of the minimum and maximum mean and percentile values calculated in Tables 3.4 and 3.5 obtained from Tables 3.1-3.3 the elongation values obtained from the controlled sample are 1.39 and 1.41 (-3.35% and - 3.07%), the corroded samples were recorded at 1.44 and 1.45 (2.84% and 3.15%), the values for the coated samples were 1.39 and 1.4 (-3.05% and -2.77%).

The ratio of the maximum calculated strain (deformation) ratio for the mean and the percentile value for the controlled is -3.07% compared to the corroded and coated values of 3.15% and -2.77%, respectively. The mean differential and percentage values obtained for the control were (0.02 and 0.28%), corrosion values (0.01 and 0.31%) and coated values (0.01 and 0.28%).

The results showed that corroded specimens had a higher percentage of deformation due to lower breaking loads and higher yield strengths, while coatings had higher breaking loads with lower yield strengths. The lower stress and yield strength and higher stress are the result of the corrosive effect on the mechanical properties of reinforcing steel, which has affected the interface, surface modification, reduction of fibers and ribs detached. The above factors have decreased the load bearing capacity of work-related reinforced concrete structures (Gilbert et al., [17], Daso **e**t al., [18]; TrustGod et al.,[19] ; Nwabakata et al., [20]; Charles et al., [26]). The results of the mean and percent of minimum and maximum elongation (%) for controlled samples were 13.23% and 14.06% (-26.35% and -25.2%), corrosion values were 17.97% and 18.79 % (34.4% and 36.55%), coated sample values were 13.16% and 13.98% (-26.77% and -25.59%). The maximum elongation comparative values for the controlled sample were -25.2% compared to the corroded and coated sample of 36.55% and -25.59%, respectively. The mean differential and percentage values obtained for the controlled samples were (0.83% and 1.15%), corrosion values (0.82% and 2.15%), and values with coating (0.82% and 1.18 %). In comparison, the corroded samples showed higher stress values and also higher elongation rates, whereas the coated state of the coated samples was lower stress and reduced elongation. Corrosion effect affects the mechanical properties of reinforcing steel, leading to low loads leading to higher failure states; coated samples show a range of values closer to the reference (controlled sample). The application of exudates material to rebar has reduced the scourge and tendency of corrosion attack on reinforced concrete structures in rough coastal areas in the work context (Gilbert et al., [17], Daso **e**t al., [18]; TrustGod et al., [19] ; Nwabakata et al., [20]; Charles et al., [26]).

The rebar unit weight - the mean and percentage values of the minimum and maximum before the test, calculated in Tables 3.4 and 3.5 and obtained from Tables 3.1 - 3.3, the unit weight parameters before and after the corrosion test value of the control sample 1.57kg and 1.57kg (0.072% and 0.075%), corrosion values 1.57kg and 1.57kg (0.068% and 0.075%) and coating values 1.56 kg and 1.56 kg (0.072% and 0.075%) and anchor weight - the average and percentage values of the minimum and maximum obtained after corrosion (kg) were checked 1.57kg and 1.57kg (2.85% and 3.24%), corrosion values were 1.52kg and 1.52kg (-6.85% and -6.46%), the values covered are 1.63kg and 1.63 kg (6.91% and 7.35%). The difference values obtained for the mean and percentile of the controlled sample are (0.03 and 0.39%), corrosion values (0.04kg and 0.39%) and coated values (0.005 kg and 0.44%). The results of the weight loss/gain of the average minimum and maximum steel and controlled percentage values (100%) for the controlled sample, which leads to their combination in fresh water without any trace of corrosion attack, corroded sample values of 0.05 kg and 0.05 kg (- 23.89% and -23.38%, coated samples were 0.07 kg and 0.07 kg (30.52% and 31.39%).

The calculated data for the maximum percentage of reinforcement weight before corrosion test for controlled, corroded and coated values were 0.05%, 0.05% and 0.07%. The maximum comparison values recorded after the corrosion test for the controlled samples remained the same, without any trace of corrosive effects, because they were collected in fresh water, the values were -6.46% and 7.35% for corrosion and layered samples.

Percentages of maximum weight loss/gain for corroded and coated samples were -23.38% and 31.39%, respectively. The calculated data showed a decrease in the values of the samples that were corroded due to corrosive attack, which led to a loss of weight, whereas the coated samples, due to different coating thicknesses, showed an increase in weight compared to the reference range values of the controlled samples, which the work refers to (Gilbert et al., [17], Daso **e**t al., [18]; TrustGod et al.,[19] ; Nwabakata et al., [20]; Charles et al., [26]).

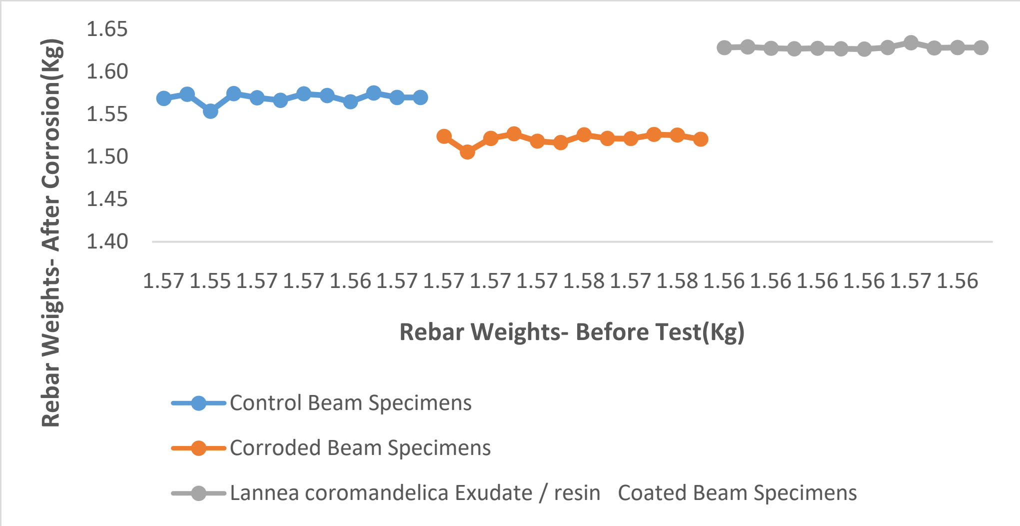

Figure 3.5: Ultimate Tensile Strength versus Strain Ratioof Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens

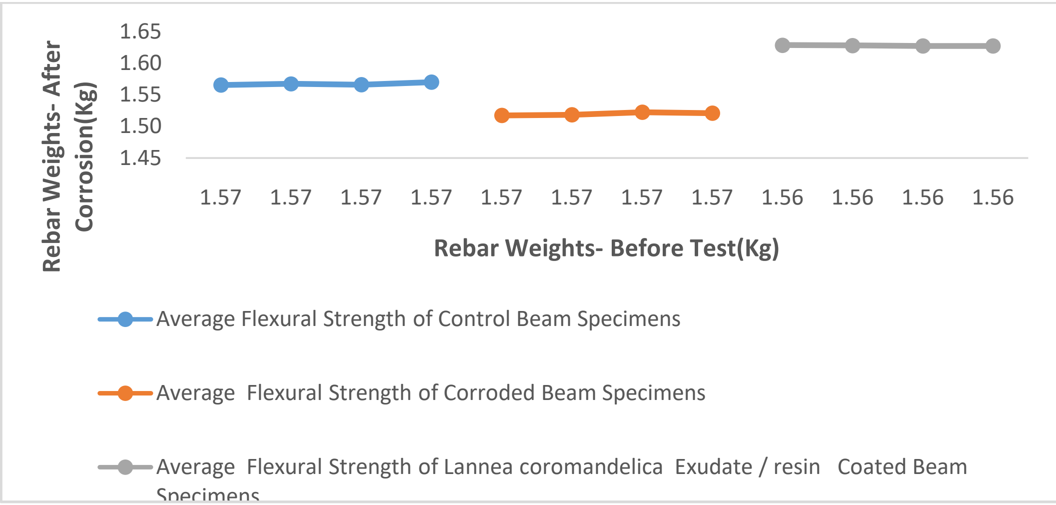

Figure 3.5A: Average Ultimate Tensile Strength versus Strain Ratioof Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens

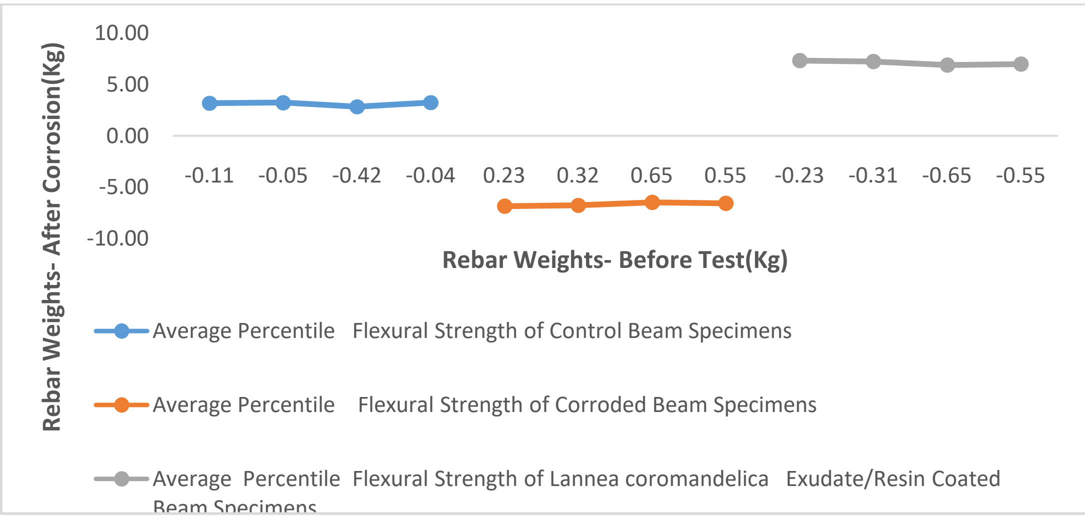

Figure 3.5B:Average Percentile Ultimate Tensile Strength versus Strain Ratioof Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens

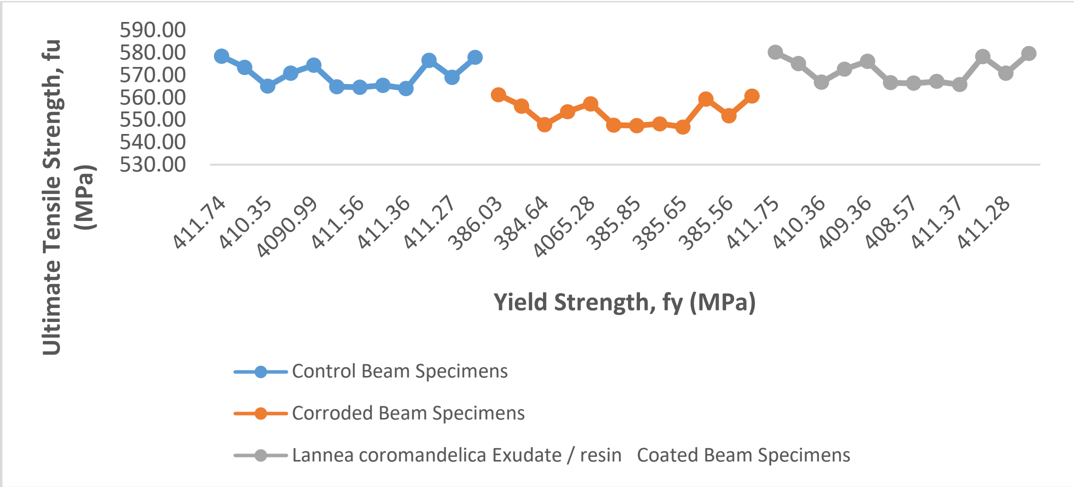

Figure 3.6: Ultimate Tensile Strength versus Strain Ratioof Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens

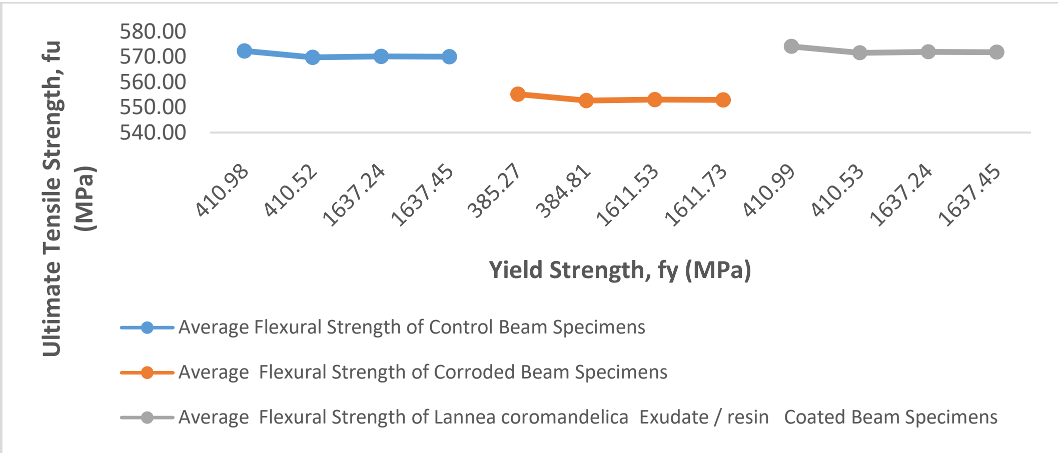

Figure 3.6A: Average Ultimate Tensile Strength versus Strain Ratio of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens

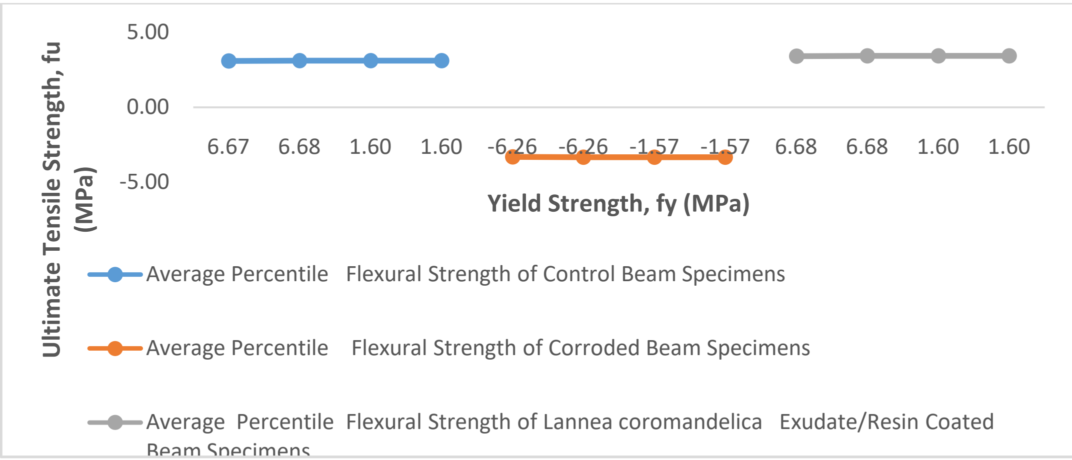

Figure 3.6B: Average Percentile Ultimate Tensile Strength versus Strain Ratio of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens

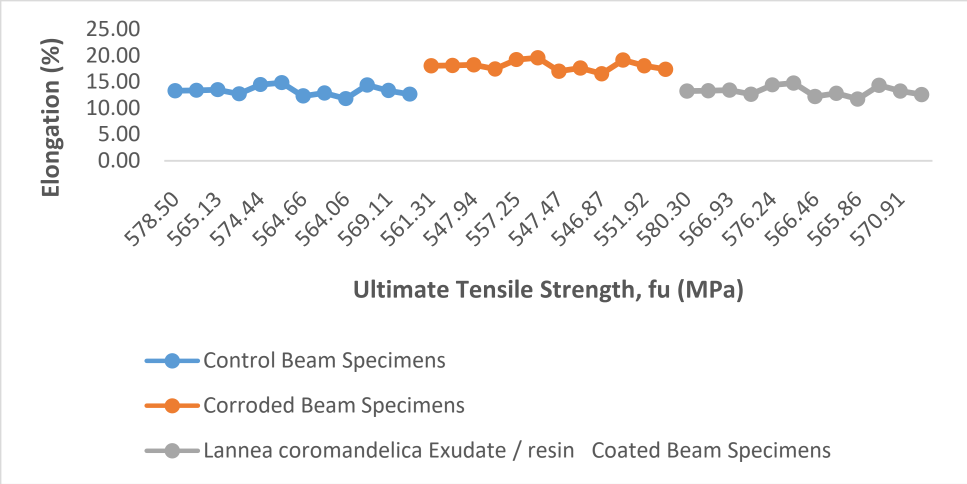

Figure 3.7: Rebar Weights- Before Test versus Rebar Weights- After Corrosion (Non-Corroded, Corrode and Resin Coated Specimens

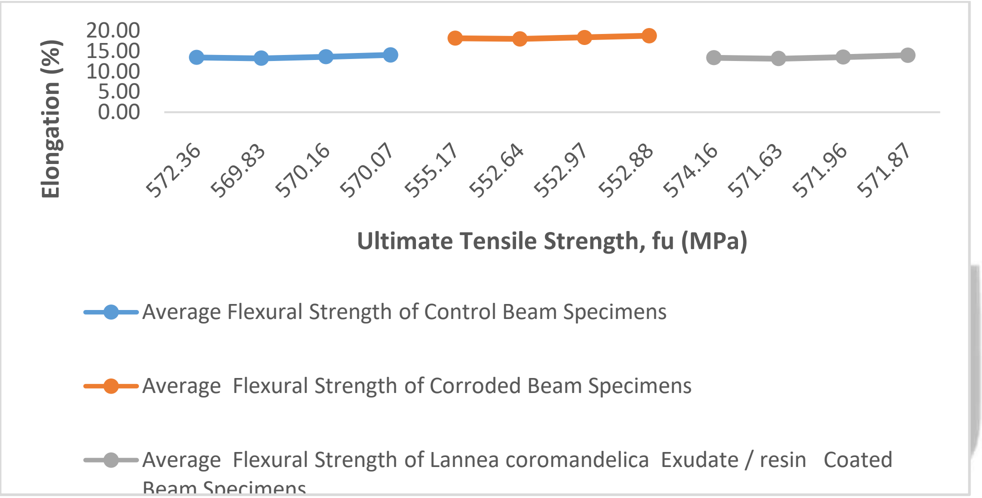

Figure 3.7A: Average Rebar **Weights- Before Test versus Rebar Weights- After Corrosion (Non-Corroded, Corrode and Resin Coated Specimens**

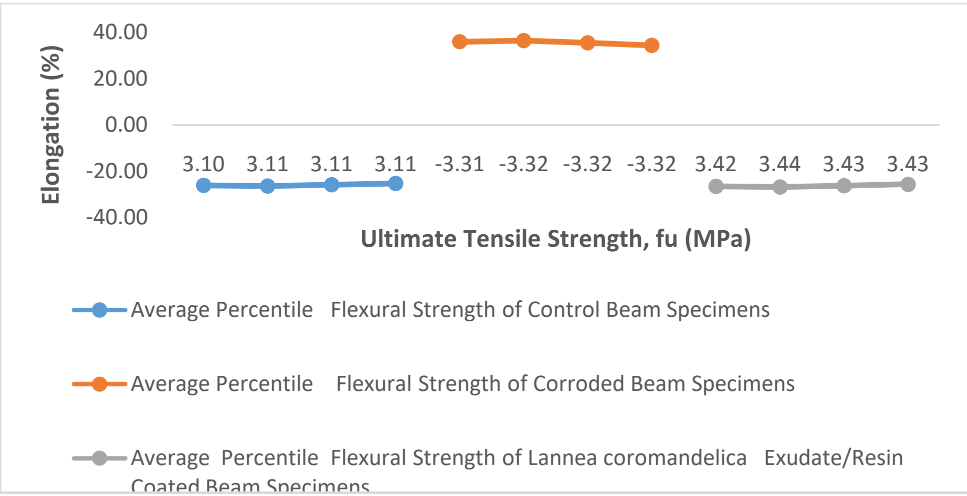

Figure 3.7B: Average Percentile Rebar **Weights- Before Test versus Rebar Weights- After Corrosion (Non-Corroded, Corrode and Resin Coated Specimens**

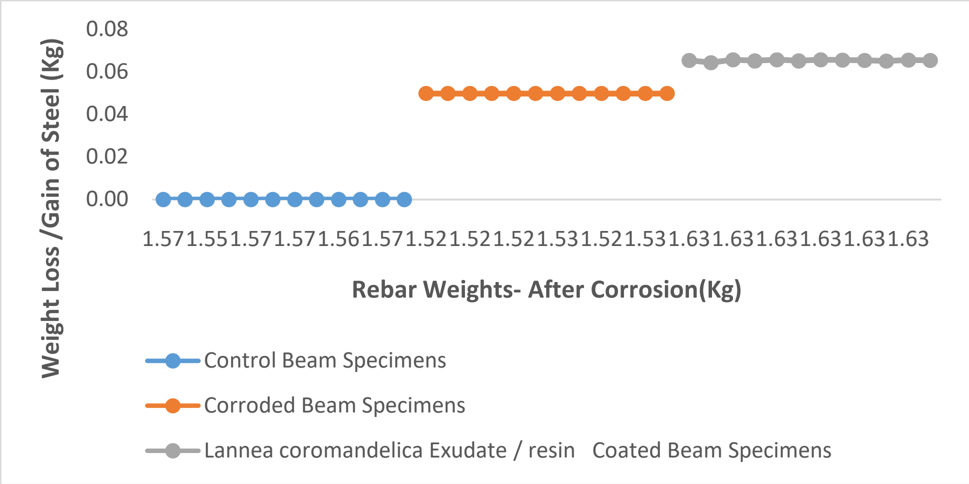

Figure 3.8: Weights- After Corrosion versus Weight Loss /Gain of Steel (Kg) (Non-Corroded, Corrode and Resin Coated Specimens

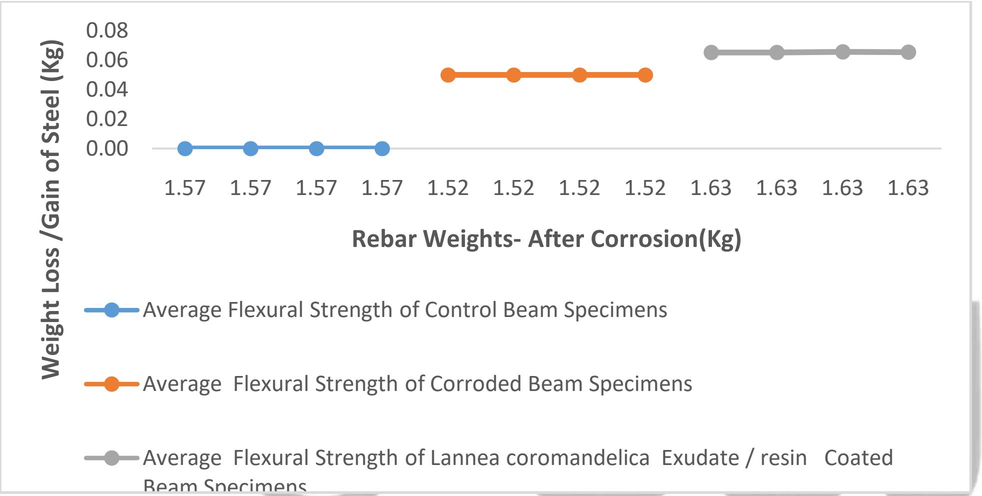

Figure 3.8A: Average Weights- After Corrosion versus Weight Loss /Gain of Steel (Kg) (Non-Corroded, Corrode and Resin Coated Specimens

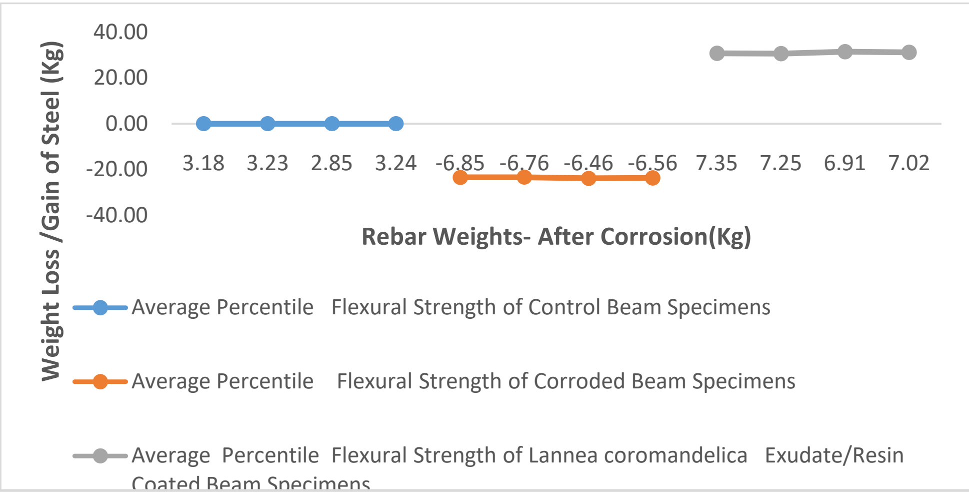

Figure 3.8B: Average Percentile Weights- After Corrosion versus Weight Loss /Gain of Steel (Kg) (Non-Corroded, Corrode and Resin Coated Specimens

4.0 Conclusion

The experimental results obtained are summarized as follows:

i. The combined results of the controlled samples on the corroded samples showed that the controlled samples replaced the corroded samples with low flexural elongation, low deviation in the medium elongation range, normal limits, high tensile strength, low elongation / elongation ratio.
ii. The results showed that exudates/resin is a corrosion-resistant material in reinforced concrete structures exposed to a corrosive environment, with high resistance and as a waterproof membrane against corrosion.
iii. Corrosion test results show high flexural stresses; stretching speed is faster than the average range.
iv. Reduced cross-sectional area due to corrosive effects on reinforced concrete structures built in marine coastal environments and work-related increase in exudates/resins
v. Exudates / resins have been proven to be effective and efficient in protecting reinforced concrete structures exposed to corrosive environments.
vi. Results show lower elongation loads for controlled and coated samples with lower values than for corroded samples with higher elongation loads and increased values compared to reference ranges (controlled) and coated samples.
vii. The results of the comparison of flexural strength and elongation load in the center of the corroded sample show the effect of corrosion on the mechanical properties of reinforcing steel with bent reinforcement, high surface modification, low load carrying capacity, high tensile strength and deformation of reinforcing steel.
viii. The results obtained showed the effect of corrosion on the mechanical properties of reinforcing steel with a decrease in the diameter of the reinforcement in the corroded sample, while the coated sample showed an increase due to the thickness of the exudates paste layer Shows high resistance to cracking and the adhesive effect of corrosion attack on reinforcing steel elements

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