Mechanical Properties Behavior of Corroded and Coated Reinforced Concrete structures in Coastal Marine Environment

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ABSTRACT

The presence of chloride in sufficient concentration at steel concrete interface causes damage to reinforcement by attacking the passive layer and cut short expected life span of concrete structures. The experimental work utilizes an environmentally friendly inorganic product of artocarpus altilis exudates / resins in curbing the trend of corrosion attack on reinforcing steel embedded in concrete. Evaluation of surface changes of non-coated and coated reinforcement with varying thicknesses, embedded in concrete, immersed in harsh corrosive environment for 150 days. Obtained results of corroded members' flexural failure load percentile difference are -29.3227% against 41.48817% and 42.07334% of non-corroded and exudates coated specimens. Average midspan deflection percentile difference is 96.8233% against -49.193% and -47.6168% non-corroded and coated specimens. Yield strength percentile difference is -12.5691% against 14.3761% and 13.94357% of non-corroded and coated specimens. Strain ratios percentile difference of -14.2058% against 16.55795% and 18.61014% of non-corroded and coated specimens. Elongation percentile difference of -57.8147% against 137.0497% and 128.4363% for non-corroded and coated specimens. Results obtained of corroded specimens has it that the effect the on mechanical properties of reinforcing steel, embedded in concrete media has higher flexural failure load, midspan deflection and ultimate tensile strength against exudates / resins coated and non- corroded members. Results of non-corroded (controlled) has high midspan deflection, normal yield strength with high ultimate strength and low strain ration compared to corroded specimens. Exudates / resins coated members exhibited low flexural load, midspan deflection, strain ratio and ultimate tensile strength. Results showed high resistance to crack and spalling effects from corrosion attacks on reinforcing steel members.

Key Words: Corrosion, Corrosion inhibitors, Flexural Strength, Concrete and Steel Reinforcement

1.0 Introduction

The load-carrying capacity, stiffness and force redistribution of reinforced concrete structure is affected by the corrosion of reinforcement embedded into concrete. The decreased shear and moment capacities, decreased stiffness in the structures are caused by reduction of the cross-sectional area of the reinforcing steel, corrosion of steel in concrete in relation to bar diameter and cover thickness, and residual flexural strength of corroding reinforced concrete structures. The presence of chloride in sufficient concentration at steel concrete interface causes damage to reinforcement by attacking the passive layer. A change in rebar ductility directly influences the possibility of force and moment redistribution and limits the load-carrying capacity of a statically indeterminate structure, and may also severely reduce the capacity of a structure under seismic loads. Huang and Yang [1] experimented on corroded reinforced concrete beams; dimensioning 150 mm × 150 mm × 500 mm, of the 30 beams, 16 had predestined cracks, to enable the study the flexural effect and behavior of the beams due to reinforcing steel bar area loss. Two numbers of 4 bars were experimented as flexural reinforcement and no provision for shear reinforcement. There was decreased in the load carrying capacity of the beam due to an impressed current application to the beams which accelerated corrosion rate. The load carrying capacity of RC beams decreased as the corrosion product increased. The loss of reinforcing load carrying capacity was calculated to ascertain percentage reduction of the steel bar diameter resulting from corrosion. Experimemetal results showed that loading capacity was reduced by 10%.

Uomoto and Misra [2] established different method in contrast that the cause of structural deterioration resulting from the reinforcement corrosion is indirectly interrelated to the loss of strength of the bars resulting from cross-sectional area reduction, caused by factors like crack development in concrete and bond could lead to greater reduction loss of strength of the structure.

AI-Sulaimani *et al.* [3] investigated the characteristics of beam failure on bond due to corrosion of reinforcement, two series of tests were conducted; one of studies evaluated the behavior of beams designed to fail in flexure. These beam tests were simulated with uniform corrosion, while pullout tests were used to simulate severe local corrosion. In the series aimed at the study of corrosion-bond behavior for beams analyzed to failure in flexure, except that the embedment length was increased to 300mm. They found that the ultimate bond stress in the pullout bonds test of similar level of corrosion was due to failure resulting from yielding of steel bars but not from bond failure.

Minkarah and Ringo [4] investigated the loss of concrete cover of beams to debonding of reinforcing steel nar at tension due to corrosion damage was simulated. Beam section, which contained 0.95% reinforcement, and span were tested with a varying length of bar exposed. Single point load offset from mid-span for all beam specimens were adopted and the load was applied at a section where reinforcement remained bonded to concrete. They noted a marked difference in the pattern of crack formation was noted in specimens with bars disbanded. Exposure of reinforcement results to about 20% of the span of the beam in a slight loss of carrying capacity of load, however, exposure of over 60% of the span of the beam resulted in a strength loss of around 20%.

Charles et al [5] investigated the residual yield strength structural capacity effect of non-corroded, corroded and inhibited steel bar. The results of coated steel bar with three different resins / exudates extracts of Symphonia globulifera linn, ficus glumosa and acardium occidentale l.) versus corroded on comparison, the flexural strength failure load are 29.50%, 28.505,29.57% against 22.30% corroded, midspan deflection are 31.14%,25.30%, 22.30% against 39,30% corroded, tensile strength 11.84%, 12.13%, 12.14% against 10.17% and elongation are 32.40%, 32.13%, 32.40% against 46.30% corroded. Overall results indicated that coated steel bar showed higher values increased in failure load and tensile strength while corroded decreased in elongation and midspan deflection.

Charles et al [6] investigated the effect on flexural residual yield strength capacity of three different resins/exudates extract of trees of dacryodes edulis, moringa oleifera lam, mangifera indica paste coated reinforcement on the concrete beam. Flexural strength failure loads of coated members with dacryodes edulis, moringa oleifera lam, mangifera indica are 35.78%, 27.09%, 29.42% against 22.30% decreased in corroded, midspan deflection are 18.57%, 28.30%, 27.43% against 39.30% increased in corroded, elongation are 28.75%, 31.50%, 31.60 against 46.30% increased in corroded and tensile strength are 14.18%, 12.29%, 12.08% as against 10.17% decreased in corroded respectively. Entire results showed that low load subjection is recorded in coated members at failure loads as against in corroded with high deflection and elongation.

Charles et al. [7] examined the effect/impact of corrosion inhibitors on flexural strength of failure load, midspan deflection, tensile strength and elongation of steel reinforcement layered with resins/exudates of magnifera indica extracts as corrosion inhibitors. More results recorded on experimental work showed flexural strength failure load, midspan deflection, tensile strength and elongation as 29.09%,31.20%, 11.75% and 31.50% for non-corroded, 29.42%, 27.43%, 12.09% and 31.60% for coated concrete beam respectively. Entire results showed the effect of corrosion on the flexural strength of reinforcement that led to low load on failure load and higher midspan deflection on corroded beams and higher load on failure load and low mid-span deflection on non-corroded and coated concrete beam members resulting to attack on surface condition of reinforcement from corrosion.

Charles et al. [8] investigative study was carried out to ascertaine the utilization of natural inorganic extracts of tree resin/exudates to assess the yield strength capacity of reinforced concrete beam members under corrosion accelerated medium. resins/exudates pasted of thickness ranges of 150µm, 250µm and 350µm were directly coated on steel bar, embedded into concrete and performed corrosion acceleration process performed on both uncoated and coated reinforced concrete members. Non – corroded and coated members in comparison with corroded recorded increasing values on flexural strength failure load by 23.8% and 29.59% against 22.30% of corroded, tensile strength non – corroded and coated increased by 12.03%, 12.14% over 10.17 % of corroded while decreasing values on midspan deflection of 28.30% and 22.30%, elongation 31.5% and 32.46% recorded on non-corroded and coated concrete beam members as against 39.30% and 46.30% of corroded respectively. Overall results indicated lower failure loads on corroded and tensile strength on corroded members, higher load on midspan and elongation, resulted from an attack and degradation on the yield strength capacity due to corrosion potentials.

Charles et al. [9] investigated the effects of corrosion on the residual structural steel bar capacity of resins/exudates inhibited and non-inhibited reinforced concrete beam members. Steel reinforcements were coated with moringa oleifera lam resins/exudates from trees extract (Inorganic inhibitors), embedded into concrete beam members and exposed to sodium chloride medium representing laboratory harsh saline marine environment. Further recorded results on non-corroded flexural strength test of failure load 29.09%, midspan deflection 28.30%, tensile strength 12.03% and elongation 31.50%, for coated beam members, failure load 29.42%, midspan deflection 27.42%, tensile strength 12.09% and elongation 31.80%, for corroded beam members, failure load decreased by 22.50%, midspan deflection increased by 39.30%, tensile strength decreased to 10.17% and elongation by increased 46.30%. The entire experimental results showed that corroded specimens has lower flexural load, higher midspan deflection, lower tensile strength and higher elongation due to loss of steel bar fibre from degradation effect from corrosion, inhibitors served as protective coating against corrosion, but no strength was added to steel members.

Otunyo and Charles [10] carried out to investigate the effect of corrosion on the flexural strength and mid-span deflection of steel reinforcements coated with resins / exudates of trees extract known as inorganic inhibitors. For the corroded steel reinforcement members, result of flexural strength test of failure loads was lower than the dacryodes edulis coated and non-corroded steel reinforcement members, while mid-span deflection was higher for the corroded steel reinforcement members compared to the non- corroded and dacryodes edulis coated steel reinforcement members. Results obtained indicated that the flexural failure strength, and elongation increased by (29%) and (48%) respectively for the dacryodes edulis coated steel members, the mid-span deflection decreased by 26%. Similar results were obtained for the flexural failure strength, elongation and mid-span deflection for the (the resin coated and non-corroded steel members). For the corroded beam members, the flexural failure strength and elongation increased by 23% and 32% respectively, while the mid-span deflection decreased by 40%. The resin (dacryodes edulis) added strength to the reinforcement.

Charles et al. [11] experimented on the effects of corrosion and inhibitors (Inorganic origin) extracts known as resins/exudates from trees barks on the residual flexural strength of concrete beam members immersed in corrosion accelerated medium for 90 days to ascertain possible changes on surface conditions of investigated samples. Further results obtained of corroded concrete beam members were 22,50%, 39.30%, 10.19% and 46.30 of failure load, midspan deflection, ultimate tensile strength and elongation, for non- 29.09%, 28.30%, 12.03% and 31.50%, for coated beam members , 28.5%, 25.30%, 12.13% and 32.12% respectively. These results indicated increased in flexural failure load and ultimate tensile strength and decreased in midspan deflection and elongation respectively in corroded concrete beam members.

Charles et al. [12] performed and investigated on uncoated and corrosion inhibitors (Symphonia globulifera linn) resins / exudates paste coated steel reinforcing bar. This was to determine the coating effects of corrosion on flexural load and midspan deflection on structural capacity of reinforced concrete beam members under harsh saline marine environment, represented in the laboratory with sodium chloride (NaCl) as corrosion accelerator. Corrosion test was performed on uncoated and coated concrete beam members with varying coating thickness of 150μm, 250μm and 350μm , embedded into concrete and cured for 90 days. Further results obtained on comparison between uncoated (corroded) and coated are flexural failure load 22.50% to 29.50%, midspan deflection 39.30% to 31.14%, tensile strength 10.17% to 11.84% and elongation 46.30% to 32.40% respectively.

2.0 Materials and Methods for Experiment

2.1 Aggregates

The fine aggregate and coarse aggregate were purchased. Both met the requirements of [13].

2.1.2 Cement

Portland limestone cement grade 42.5 is the most and commonly type of cement in Nigerian Market. It was used for all concrete mixes in this investigation. The cement met the requirements of [14].

2.1.3 Water

The water samples were clean and free from impurities. The fresh water used was gotten from the tap at the Civil Engineering Department Laboratory, Kenule Beeson Polytechnic, Bori, and Rivers State. The water met the requirements of [15].

2.1.4 Structural Steel Reinforcement

The reinforcements are gotten directly from the market in Port Harcourt [16].

2.1.5 Corrosion Inhibitors (Resins / Exudates) Artocarpus altilis

The study inhibitor (Artocarpus altilis Exudates) of natural tree resins/exudates extracts.

2.2 METHODS

Present study involves direct application of resins / exudates of trees extract known as inorganic inhibitor Artocarpus altilis exudates, layered/coated on reinforcement steel ribbed surface. The samples of reinforced concrete beams of 150 mm x 150 mm × 650 mm, thickness, width and length specimens and ribbed bars of 16 mm embedded for corrosion test and flexural test for beam was investigated. This was aimed at achieving the real harsh and corrosive state, concrete specimens were ponded in solutions (NaCl) and the depth of the solution was maintained for the given period of experiment as to observe the significant changes that resulted from the actions of the accelerator (NaCl) and the specimens.

2.2.1 Specimen Preparation and Casting of Concrete Beams

Standard method of concrete mix ratio was adopted, batching by weighing materials manually. Concrete mix ratio of 1:2:4 by weight of concrete, water-cement ratio of 0.65. Manual mixing was used on a clean concrete banker, and mixture was monitored and water added gradually to obtain perfect mix design concrete. Standard uniform color and consistency concrete was obtained by additions of cement, water and aggregates. The test beams were cast in steel mould of 150mm x 150 mm x 750 mm. Fresh concrete mix for each batch was fully compacted by tamping rods, to remove trapped air, which can reduce the strength of the concrete and 16 mm reinforcements of coated and non-coated were spaced at 150 mm with concrete cover of 25 mm had been embedded inside the beam and projection of 100 mm for half-cell potential measurement. Specimens were molds are removed from specimen after 24hrs and cured for 28 days. The specimens were cured at room temperature in the curing tanks for accelerated corrosion test process and testing procedure allowed for 120 days first crack noticed and a further 30 days making a total of 150 days for further observations on corrosion acceleration process.

2.2.2 Flexure testing of Beam Specimens

Universal Testing Machine in accordance with BS EN 12390-2 was used for the flexural test and a total of 27 beam specimens were tested. After curing for 28 days, 6 controlled beams (non-corroded) was kept in a control state, preventing corrosion of reinforcement, while 18 beam samples of non-coated and exudates /resins coated were partially place in ponding tank for 150 days and examined accelerated corrosion process. An Instron Universal Testing Machine of 100KN capacity at a slow loading rate of 1 mm/min was used in the flexural test. Beam samples were placed in the machine to specification, flexural test were conducted on a third point at two supports.

2.2.3 Tensile Strength of Reinforcing Bars

To ascertain the yield and tensile strength of tension bars, bar specimens of 16 mm diameter of non-corroded, corroded and coated were tested in tension in a Universal Testing Machine and subjected to direct tension until failure; the yield, maximum and failure loads being recorded. To ensure consistency, the remaining cut pieces from the standard length of corroded and non-corroded steel bars were subsequently used in the bond and flexural test.

3.0 RESULTS AND DISCUSSIONS

Results of 27 samples in table 3.1, 3.2 and 3.3 are derived into average values in 3.4 and summarized into summary of averages, percentile values and percentile values difference **in** 3.5 of flexural strength of concrete beam members as sampled, arbitrarily cast, cured for 28 days on normal and standard method, accelerated in corrosion medium environment for 120days at first cracks observation and 30days extended period and graphically represented in figures 3.1 - 3.3A.

3.1 Non-corroded Concrete Beam Members

Results of flexural failure load values of non-corroded samples at average are 79.87kN, 79.75667kN, 80.22667kN, summarized to 79.95111kN with percentile value difference of 41.48817% over -29.3227% corroded specimens. Average results of midspan deflection are 6.733333mm, 6.733333mm, 6.436667mm, summarized to 6.715556mm with percentile difference of -49.193% over 96.8233% corroded specimens. Average yield strength, fy, 460MPa, summarized to 100% with 0.00% of percentile value and difference. Average ultimate tensile strength, fu, 631.9833MPa, 631.7167MPa, and 631.4167MPa, summarized to 1.290556, percentile difference of 14.3761% over -12.5691% corroded specimens. Average strain ratios are 1.291667, 1.295, and 1.285, summarized to1.290556 with percentile difference values of 16.55795% over -14.2058%. Average elongations are 29.1055%, 28.82883%, 29.22883%, summarized to 29.05439% with percentile difference values of 137.0497% over -57.8147%. Results of non-corroded (controlled) has high midspan deflection, normal yield strength with high ultimate strength and low strain ration compared to corroded specimens.

3.2 Corroded Concrete Beam members

Obtained results of flexural failure load average corroded value are 57.182833kN, 56.1295kN, 56.2095kN, summarized to 56.50728kN with percentile difference of -29.3227% against 41.48817% and 42.07334% non-corroded and exudates coated specimens. Average midspan deflection values are 13.433333mm, 13.133333mm, 13.08667mm, summarized to 13.217788mm with percentile difference of 96.8233% against -49.193% and -47.6168% non-corroded and coated specimens. Average yield strength, fy is 460MPa, summarized to 100% with 0.00% percentile value and difference. Average ultimate tensile strength, fu, 553.28333MPa, 551.75MPa, 551.8833MPa, summarized to 552.3056MPa, percentile difference of -12.5691% against 14.3761% and 13.94357 of non-corroded and coated specimens. Average strain ratios are 1.1083333, 1.115, and 1.098333, summarized to 1.107222 with percentile difference values of -14.2058% against 16.55795% and 18.61014% of non-corroded and coated specimens. Average elongations are 12.343333%, 12.123333%, 12.30333%, summarized to 12.25667% with percentile difference value of -57.8147% against 137.0497% and 128.4363% for non-corroded and coated specimens. Results obtained of corroded specimens has it that the effect the on mechanical properties of reinforcing steel, embedded in concrete media has higher flexural failure load, midspan deflection and ultimate tensile strength against exudates / resins coated and non- corroded members.

3.3 Artocarpus altilis Resins/Exudates Steel Coated Concrete Beam Members.

Obtained average flexural failure load of exudates / resins coated samples are 80.020667kN, 80.427333kN, 80.39733kN, summarized to 80.28178kN with percentile difference of 42.07334 over -29.3227% corroded specimens. Midspan deflection average values are 6.8916667mm, 6.9483333mm, 6.931667mm, summarized to 6.923889mm, percentile difference of -47.6168% over 96.8233% corroded specimens. Average yield strength, fy 460MPa, summarized to 100% with 0.00% of percentile difference. Average ultimate tensile strength, fu, 629.3167MPa, 629.35MPa, 629.2833MPa, summarized to 629.3167MPa, percentile difference of 13.94357%

over -12.5691% corroded specimens. Average strain ratios are 1.322167, 1.3055, and 1.312167, summarized to 1.313278mm, percentile difference of 18.61014% over -14.2058% corroded specimens. Average elongations are 27.9809%, 28.03757%, 27.97757%, summarized to 27.99868% with percentile difference values of 128.4363% over -57.8147% of corroded specimens. Exudates / resins coated members exhibited low flexural load, midspan deflection, strain ratio and ultimate tensile strength. Showed high resistance to crack and spalling effects from corrosion attacks on reinforcing steel members.

Table 3.1: Flexural Strength of Beam Specimens (Non-Corroded specimens)

s/no	**Non-corroded Control Beam**									
Beam	Samples	HAK	HBK	HCK	HDK	HEK	HFK	HGK	HHK	HIK
JBK1-1	Failure Load (KN)	79.93	79.93	79.75	79.72	79.72	79.83	80.53	79.5	80.65
JBK1-2	Midspan Deflection (mm)	6.48	6.56	7.16	7.27	6.36	7.3	6.39	6.56	6.36
JBK1-3	Bar diameter (mm)	16	16	16	16	16	16	16	16	16
JBK1-4	Yield Strength, fy (MPa)	460	460	460	460	460	460	460	460	460
JBK1-5	Ultimate Tensile Strength, fu (MPa)	631.15	633.05	631.75	630.55	633.05	631.55	631.35	632.15	630.75
JBK1-6	Strain Ratio	1.315	1.275	1.285	1.315	1.285	1.285	1.285	1.275	1.295
JBK1-7	Elongation (%)	29.0055	29.2055	29.1055	29.1755	28.6055	28.7055	29.2055	29.1755	29.3055

Table 3.2 : Flexural Strength of Beam Specimen (Corroded specimens)

s/no		**Corroded Beam**								
Beam	Samples	GAK1	GBK1	GCK1	GDK1	GEK1	GFK1	GGK1	GHK1	GIK1
JBK2-1	Failure load (KN)	57.5395	58.2195	55.7895	55.2695	57.5595	55.5595	55.3295	57.7595	55.5395
JBK2-2	Midspan Deflection (mm)	13.67	13.5	13.13	13.1	12.7	13.6	13.13	12.73	13.4
JBK2-3	Bar diameter (mm)	16	16	16	16	16	16	16	16	16
JBK2-4	Yield Strength, fy (MPa)	460	460	460	460	460	460	460	460	460

JBK2-5	Ultimate Tensile Strength, fu (MPa)	555.35	551.95	552.55	551.85	551.55	551.85	551.25	552.55	551.85
JBK2-6	Strain Ratio	1.115	1.105	1.105	1.145	1.095	1.105	1.105	1.095	1.095
JBK2-7	Elongation (%)	12.36	12.5	12.17	11.7	12.69	11.98	12.5	12.2	12.21

Table 3.3: Flexural Strength of Beam Specimens (Exudates/Resins Coated specimens)

		Artocarpus altilis Exudates (steel bar coated specimen)								
s/no		150µm (Exudate/Resin) coated			300µm (Exudate/Resin) coated			450µm (Exudate/Resin) coated		
Beam	Samples	HAK2	HBK2	HCK2	HDK1	HEK2	HFK2	HGK2	HK2	HIK2
JBK3-1	Failure load (KN)	79.004	80.854	80.204	80.244	80.604	80.434	80.204	80.244	80.744
JBK3-2	Midspan Deflection (mm)	6.995	6.395	7.285	7.095	6.655	7.095	7.075	7.075	6.645
JBK3-3	Bar diameter (mm)	16	16	16	16	16	16	16	16	16
JBK3-4	Yield Strength, fy (MPa)	460	460	460	460	460	460	460	460	460
JBKE-5	Ultimate Tensile Strength, fu (MPa)	628.85	629.75	629.35	629.35	629.35	629.35	628.95	629.45	629.45
JBK3-6	Strain Ratio	1.3155	1.3355	1.3155	1.3055	1.3055	1.3055	1.2955	1.3155	1.3255
JBK3-7	Elongation (%)	27.7409	28.3609	27.8409	27.8109	28.2609	28.0409	27.9509	27.6609	28.3209

Table 3.4: Average Flexural Strength of Beam Specimens (Non-Corroded, Corroded, Exudates/Resins Coated Specimens)

s/no	Samples	Non-Corroded Specimens Average Values			Corroded Specimens Average Values			Coated Specimens Average Values		
JBK4-1	Failure load (KN)	79.87	79.75667	80.22667	57.182833	56.1295	56.2095	80.020667	80.427333	80.39733
JBK4-2	Midspan Deflection (mm)	6.733333	6.976667	6.436667	13.433333	13.133333	13.08667	6.8916667	6.9483333	6.931667
JBK4-3	Bar diameter (mm)	16	16	16	16	16	16	16	16	16

JBK4-4	Yield Strength, fy (MPa)	460	460	460	460	460	460	460	460	460
JBK4-5	Utimate Tensile Strength, fu (MPa)	631.9833	631.7167	631.4167	553.28333	551.75	551.8833	629.3167	629.35	629.2833
JBK4-6	Strain Ratio	1.291667	1.295	1.285	1.1083333	1.115	1.098333	1.322167	1.3055	1.312167
JBK4-7	Elongation (%)	29.1055	28.82883	29.22883	12.343333	12.123333	12.30333	27.9809	28.03757	27.97757

Table 3.5: Summary of Percentile Flexural Strength of Beam Specimens (Non-Corroded, Corroded, Exudates/Resins Coated Specimens)

Beam	Samples	Summary of Averages			Percentile Values			Percentile Difference		
JBK5-1	Failure load (KN)	79.95111	56.50728	80.28178	141.4882	70.67729	142.0733	41.48817	-29.3227	42.07334
JBK5-2	Midspan Deflection (mm)	6.715556	13.21778	6.923889	50.80699	196.8233	52.38315	-49.193	96.8233	-47.6168
JBK5-3	Bar diameter (mm)	16	16	16	100	100	100	0	0	0
JBK5-4	Yield Strength, fy (MPa)	460	460	460	100	100	100	0	0	0
JBK5-5	Ultimate Tensile Strength, fu (MPa)	631.7056	552.3056	629.3167	114.3761	87.43085	113.9436	14.3761	-12.5691	13.94357
JBK5-6	Strain Ratio	1.290556	1.107222	1.313278	116.558	85.79423	118.6101	16.55795	-14.2058	18.61014
JBK5-7	Elongation (%)	29.05439	12.25667	27.99868	237.0497	42.18525	228.4363	137.0497	-57.8147	128.4363

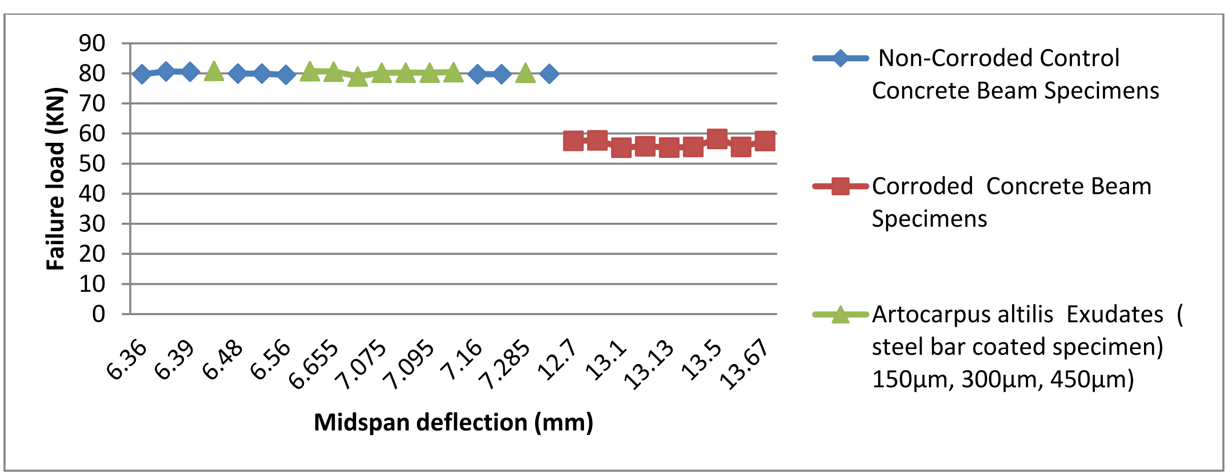

Figure 3.1: Failure Load versus Midspan Deflection of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

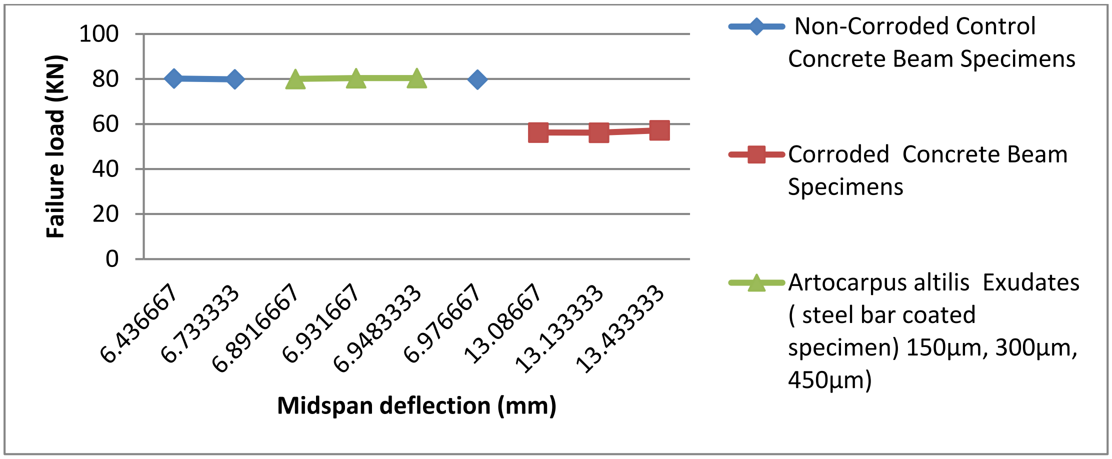

Figure 3.1A: Average Failure Load versus Midspan Deflection of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

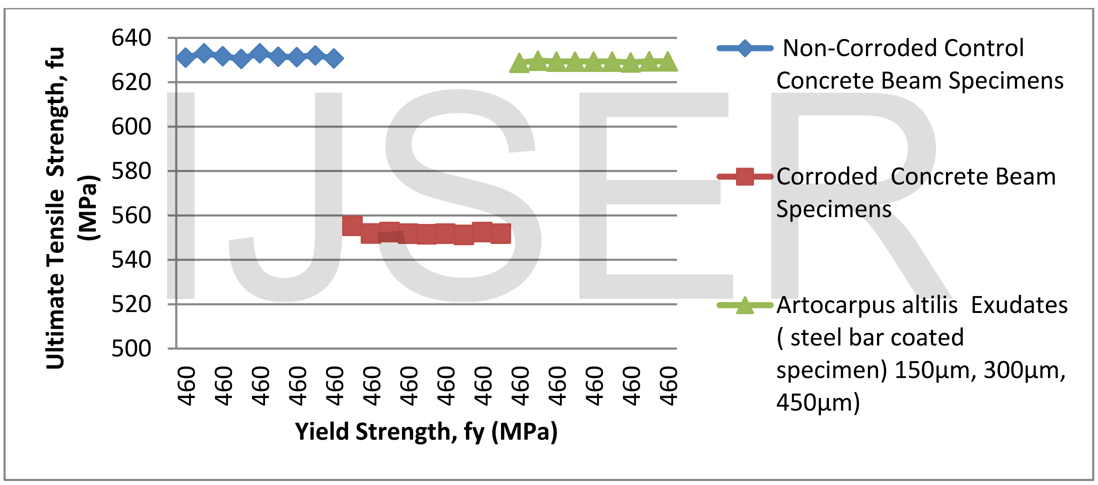

Figure 3.2: Ultimate Tensile Strength versus Yield Strength of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

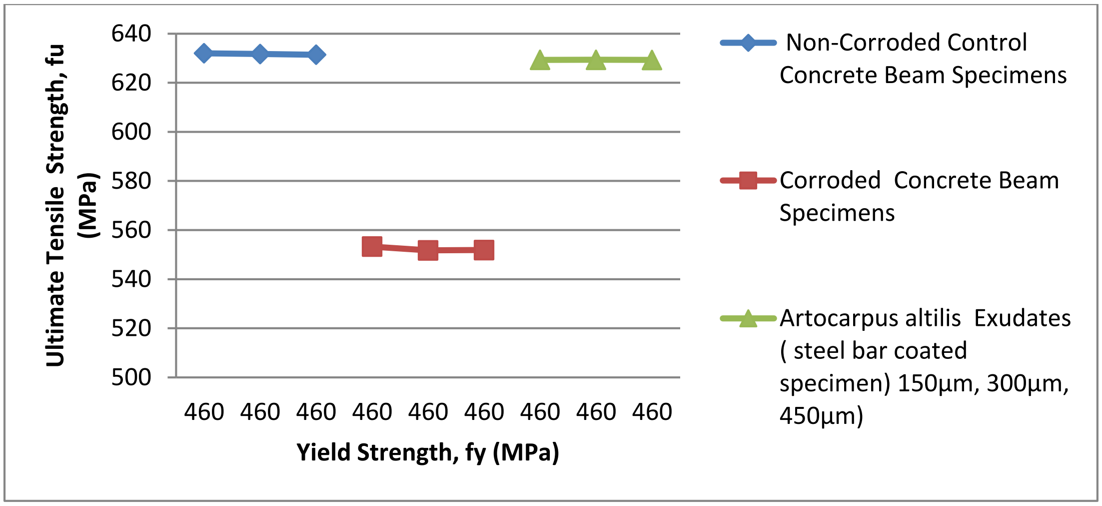

Figure 3.2A: Average Ultimate Tensile Strength versus Yield Strength of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

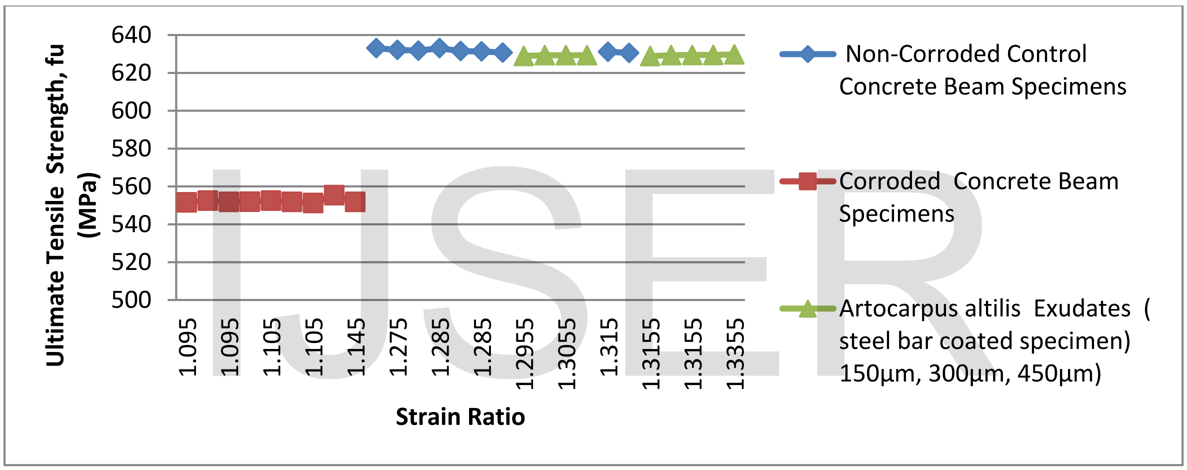

Figure 3.3: Ultimate Tensile Strength versus Strain Ratio of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

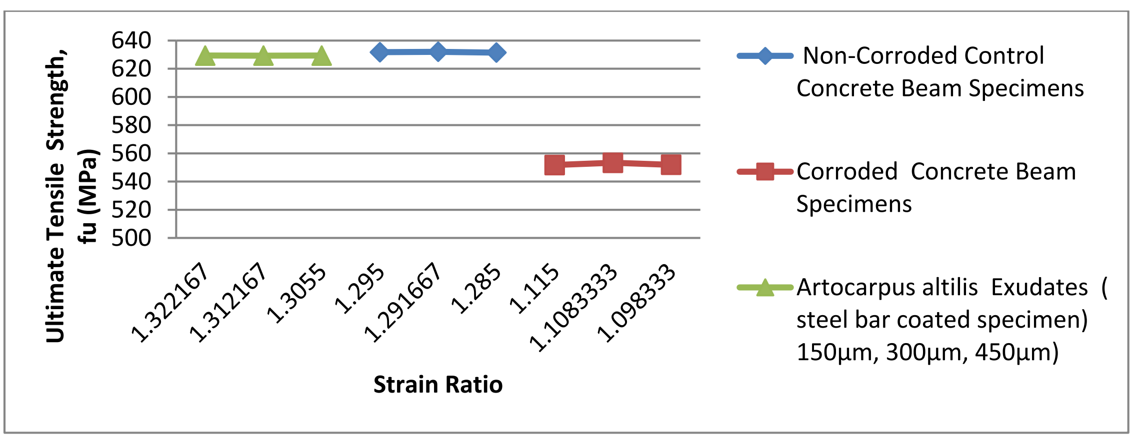

Figure 3.3A: Average Ultimate Tensile Strength versus Strain Ratio of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

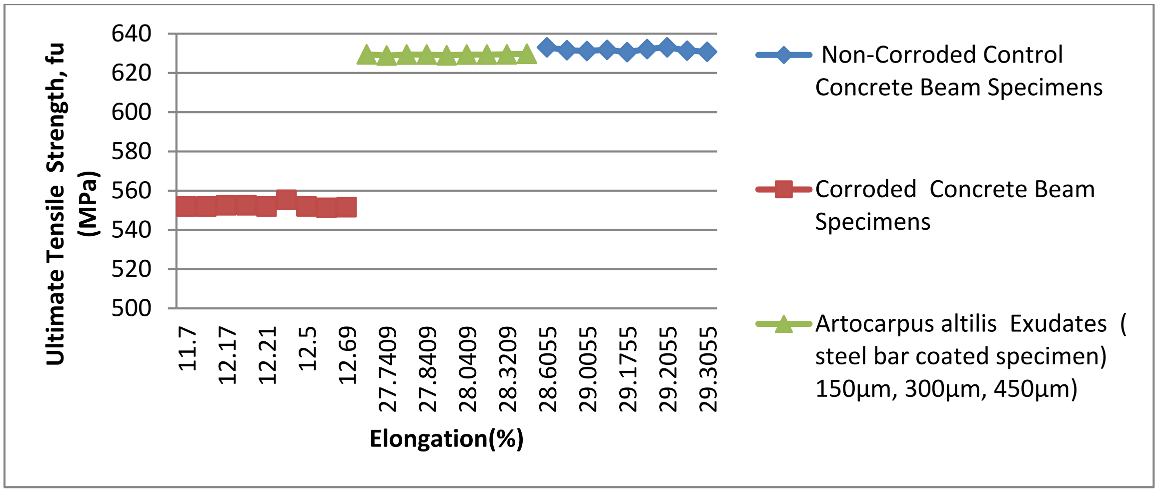

Figure 3.4: Ultimate Tensile Strength versus Elongation of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

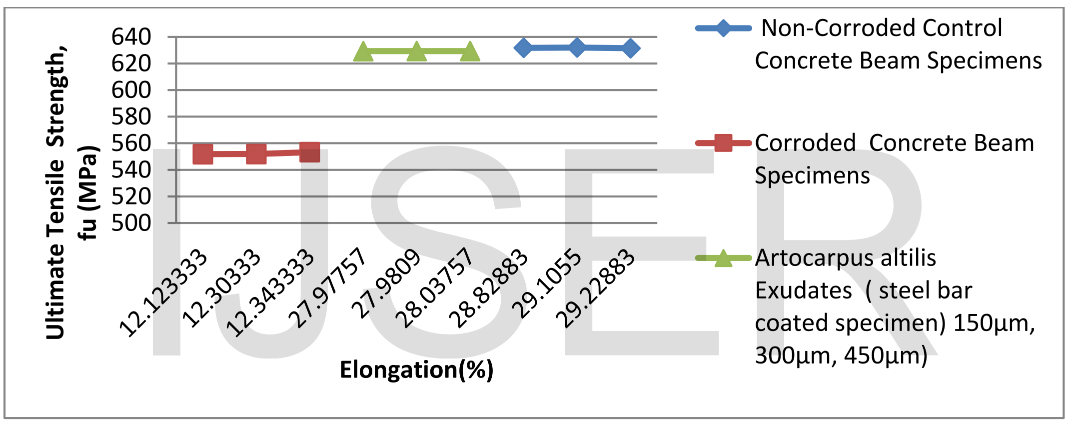

Figure 3.4A: Average Ultimate Tensile Strength versus Elongation of Beam Specimens (Non-Corroded, Corrode and Resin Coated Specimens)

4.0 Conclusions

Experimental results gotten from tables 3.1 – 3.5 and figures 3.1 – 3.3A, the below conclusions were drawn:

i. Results obtained of corroded specimens has it that the effect the on mechanical properties of reinforcing steel, embedded in concrete media has higher flexural failure load, midspan deflection and ultimate tensile strength against exudates / resins coated and non- corroded members.

ii. Results of non-corroded (controlled) has high midspan deflection, normal yield strength with high ultimate strength and low strain ration compared to corroded specimens.

iii. Exudates / resins coated members exhibited low flexural load, midspan deflection, strain ratio and ultimate tensile strength.

iv. Showed high resistance to crack and spalling effects from corrosion attacks on reinforcing steel members

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