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Inhibitory Action of Exudates / Resins Extracts on the Corrosion of Steel Bar Yield Strength in Corrosive Media Embedded in Concrete

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Abstract

The end results of steel corrosion are manifested as a reduction in the bar diameter, wear and tear of the mechanical properties of the reinforcing steel. This research examined the surface changes and mechanical properties deterioration of reinforcing steel in concrete structures built in salt water related environments with the introduction of milicia excelsa exudates / resins to reinforcing steel aimed at curbing the negative trends encountered by reinforced concrete structures in corrosive media with initiated corrosion acceleration process for 150 days and determined corrosion probability. Results obtained of flexural strength of beam failure load averaged percentile collation of -33.1172% against 49.51535% and 47.14752% against non-corroded and milicia excelsa exudates coated specimens. Midspan deflection average values percentile collation of 88.73239% against -47.0149% and -52.6715% non-corroded and coated specimens. Average yield strength of 100% with 0.00% percentile collation. Average ultimate tensile strength with percentile collation of -13.5952% against 15.7343% and 15.33289% of non-corroded and coated specimens. Average strain ratios with percentile difference values of -16.4032% against 19.62187% and 21.19673% of non-corroded and coated specimens. Averaged elongations with percentile collation of -59.4698% against 146.7295% and 139.8539% of non-

corroded and coated specimens. Corrosion properties of spalling and cracks noticed in non-coated members, Entire experimental results showed indications of low flexural failure load with high; midspan deflection, elongation, strain ratio and ultimate yields. Effect of corrosion on mechanical properties of reinforcing steel not noticed on non- corroded (controlled) members. Values obtained of non-corroded are of standard state to corroded members. Coated members showed low; midspan deflection, elongation and ultimate yields, high flexural failure load is required and compared to corroded members. Effect of corrosion not noticed in the mechanical properties of reinforcing steel experimented.

Keywords: Corrosion, Corrosion inhibitors, Flexural Strength, Concrete and Steel Reinforcement

INTRODUCTION

Reinforcing steel corrosion is of great concern in the construction industries and other related industries. The effect of corrosion of steel embedded in concrete creates spalling, reduction in bonding effect between concrete and steel, cracking in concrete surrounding sections and weakens the bond between reinforcement and concrete, seriously affecting the durability, reduces the effective cross-sectional area of reinforcing bars and the service-life of structures (Almusallam *et al*. 1995, Cabrera 1996, Rashid *et al*. 2010).

Embedded steel reinforcement in concrete has been studied using mass loss method, the specimens are exposed to known environments for long periods of time, and then the corroded surface products are removed, and the corrosion rate is determined as the difference in mass of steel before and after corrosion. However, this method takes a long time and more recently electrochemical techniques with modern electronic hardware and software are used to predict corrosion properties including corrosion potential, breakdown potential and corrosion rate (Pruckner 2001). Corrosion products are highly porous, weak, and often form around reinforcing steel, thus decreasing the bond strength between the reinforcement and concrete (Wang and Monteiro, 1996). In addition, steel reinforcement cross- sectional area reduction is noticed thereby causing decreased in ductility of the structure, especially during the occurrence of corrosion pitting. Concrete produced with low water/cement ratio has low permeability that reduces the penetration factors that induced-corrosion, such as moisture, chloride and carbon dioxide to the steel surface (Ahmad, 2003). Steel reinforcement in concrete is normally immune from corrosion due to high alkanilty of concrete; however, steel corrodes when attacked by aggressive agents.

Broomfield (1997) stated that concrete integrity is adversely attacked by sulphates ions before it extends to steel which normally takes long time except on accelerated conditions.

Rengaswamy *et al.*(1988) studied the properties of the inhibited and sealed cement slurry coating system applied to steel rebars (mechanical, electrochemical and corrosion resistance) for its corrosion protection. It was concluded that inhibited and sealed cement slurry coating lead to economy and efficiency higher than other coating systems.

Charles et al. (2018) 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 (2018) 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. This high yield was attributed to corrosion attack.

Charles et al. (2018) 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. 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. For corroded concrete beam members, failure load decreased to 22.505, midspan deflection increased by 39.30%, tensile strength decreased to 10.17% while elongation increased by 46.30%. 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 midspan deflection on non-corroded and coated concrete beam members resulting to attack on surface condition of reinforcement from corrosion.

Charles et al. (2018) investigative study was carried out to ascertain 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. 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. (2018) investigated the effects of corrosion on the residual structural steel bar capacity of resins/exudates inhibited and non-inhibited reinforced concrete beam members. 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 Kennedy (2017) investigated 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 (dacryodes edulis-African Pear). The steel reinforcement members were embedded in concrete and exposed to harsh and saline environments (NaCl solution). Corrosion accelerated test were conducted on uncoated and dacryodes edulis resin pastes coated thicknesses of 150µm, 250µm and 300µm on steel reinforcement before corrosion test for 60 days to simulated corrosion process. 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%, elongation increased by 23% and 32% respectively, while the mid-span deflection decreased by 40%.. The resin (mdacryodes edulis) added strength to the reinforcement.

Charles et al. (2018) 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. 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. This showed lower load and higher deflection in corroded members and higher in non-corroded and coated, higher elongation in corroded and lower in non-corroded and coated.

Charles et al. (2018) performed and investigated on uncoated and corrosion inhibitors (Symphonia globulifera linn) resins / exudates paste coated steel reinforcing bar. 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. Thus, results showed decreased in failure load and tensile strength of corroded members while increased in midspan deflection and elongation. This attributes was due to effect of corrosion and reduction in strength from degradation properties. Resins / exudates coated members showed higher failure load with low deflection.

Rasheeduzzafar *et al.* (1992) conducted seven years site exposure tests and evaluated the performance of corrosion resisting steels in chloride media concrete. Evaluation of bare mild steel, galvanized, epoxy-coated and stainless steel clad reinforcing steels examined by embedment process in concrete with three different levels of chloride content (0.6, 1.2 and 4.8% by weight of cement). Conclusion was drawn that bare mild steel bars suffer severe rust related damage in all the three chloride levels whereas the use of galvanized steel in concrete with high levels of chloride merely delay the concrete failure, while epoxy-coated bars offer good corrosion resistant properties in low chloride levels.

Ballim and Reid (2003) conducted and tested beams of 160 x 100 x 1500 mm, reinforced with a single 16 mm diameter bottom bar and a pair of 8 mm diameter top bars with initiated corrosion carbonation and accomplished by placing the beams in a CO2 filled pressure chamber (that was kept at 80kPa) and supplying a current of 400 µA/cm2. The beams were simultaneously corroded and loaded to 23% and 34% of the ultimate load (p_u), deflection ratios were observed which were calculated by dividing the average deflections of the corroded beams with those of the control beams. The researchers attributed this initial increase in deflection to early crack formation, as the crack creation and widening progressed at a slower rate after a certain point.

MATERIALS AND METHODS FOR EXPERINMENT

Aggregates

The fine aggregate and coarse aggregate were purchased. Both met the requirements of BS 882

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 BS EN 196-6

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 BS 3148.

Structural Steel Reinforcement

The reinforcements are gotten directly from the market in Port Harcourt. BS 4449:2005+A3

Corrosion Inhibitors (Resins / Exudates) Milicia excelsa

The study inhibitor (Milicia excelsa Exudates) of natural tree resins/exudates extracts.

METHODS

Present study involves direct application of resins / exudates of trees extract known as inorganic inhibitor milicia excelsa exudates, layered/coated on reinforcement steel ribbed surface. The objective of this study was to determine the usefulness of locally available surface-applied corrosion inhibitors under severe corrosive environments and with chloride contamination. The test setup simulates a harsh marine environment of saline concentration.

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. The determination of the contribution of the resins will be observed through its adhesive ability with the reinforcement through surface coating application and the bonding relationship between the coated specimens and concrete, its waterproofing and resistive nature (resistance) against accelerator penetration into the bare reinforcement.

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.

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. After 150 days, the accelerated corrosion subjected samples were examined to determine residual flexural strength. Beam specimens were simply supported on a span of 650mm.

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. Load was applied to failure with cracks noticed and corresponding values recorded digitally in a computerized system.

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.

RESULTS AND DISCUSSIONS

Results of 27 samples in tables 1, 2 and 3 are derived into averaged values in 4 and summarized into summary of averages, percentile values and percentile values difference in 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 crack s observation and 30days extended period and graphically represented in figures 1 - 3A.

Non-corroded Concrete Beam Members

Derived flexural strength of beam specimens from table 1 into 4 and 5 flexural failure load averaged values of non-corroded samples are 80.07kN, 79.9566kN, 80.4266kN, collated to 80.15111kN with percentile collation of 49.51535% over -33.1172% corroded specimens. Midspan deflection average values are 7.43333mm, 7.67666mm, 7.13666mm, collated to 7.415556mm with percentile collation of -47.0149% over 88.73239% corroded specimens. Average yield strength, fy 460MPa, collated to 100% with 0.00% with percentile collation. Average ultimate tensile strength, fu, 631.383MPa, 631.116MPa, and 630.816MPa, collated to 631.1056MPa with percentile collation of 15.7343% over -13.5952% corroded specimens. Average strain ratios are 1.301667, 1.305, and 1.295, collated to 1.300556 with percentile collation of 19.62187% over -16.4032%. Averaged elongations are 29.028%, 29.028%, 29.428%, collated to 29.25389% with percentile collation of 146.7295% over -59.4698%. Effect of corrosion on mechanical properties of reinforcing steel not noticed on non- corroded (controlled) members. Values obtained of non-corroded are of standard state to corroded members.

Corroded Concrete Beam members

Derived flexural strength of beam specimens from table 2 into 4 and 5 flexural failure load averaged values of corroded samples are 54.28283KN, 53.2295kN, 53.3095kN, collated to 53.60728kN with percentile collation of -33.1172% against 49.51535% and 47.14752% against non-corroded and Milicia excelsa exudates coated specimens. Midspan deflection average values are 14.16666mm, 13.93333mm, 13.8866mm, collated to 13.99556mm with percentile collation of 88.73239% against -47.0149% and -52.6715% non-corroded and coated specimens. Average yield strength, fy 460MPa, collated to 100% with 0.00% percentile collation. Average ultimate tensile strength values are 546.2833MPa, 544.75MPa, 544.883MPa, collated to 545.3056MPa with percentile collation of -13.5952% against 15.7343% and 15.33289% of non-corroded and coated specimens. Average strain ratios are 1.0883, 1.095, and 1.0783, collated to 1.087222 with percentile difference values of -16.4032% against 19.62187% and 21.19673% of non-corroded and coated specimens. Averaged elongations are 11.943%, 11.7233%, 11.903%, collated to 11.85667% with percentile collation of -59.4698% against 146.7295% and 139.8539% for non-corroded and coated specimens. Corrosion properties of spalling and cracks noticed in non-coated members, Entire experimental results showed indications of low flexural failure load with high; midspan deflection, elongation, strain ratio and ultimate yields.

Milicia excelsa Resins/Exudates Steel Coated Concrete Beam Members.

Derived flexural strength of beam specimens from table 3 into 4 and 5 flexural failure load averaged values of coated samples are 78.8206kN, 78.9273kN, 78.8973kN, collated to 78.88178kN with percentile collation of 47.14752% over -33.1172% over corroded specimens. Midspan deflection average values are 6.59166mm, 6.64833mm, 6.63166mm, collated to 6.623889mm with percentile collation of -52.6715% over 88.73239% corroded specimens. Average yield strength, fy 460MPa, collated to 100% with 0.00% percentile collation. Average ultimate tensile strength, fu, 628.9167MPa, 628.95MPa, 628.883MPa, collated to 628.9167MPa with percentile collation of 15.33289% over -13.5952% corroded specimens. Average strain ratios are 1.326567, 1.3099, and 1.31656, collated to 1.317678 with percentile collation of 21.19673% over -16.4032% of corroded specimens. Averaged elongations are 28.4209%, 28.477%, 28.4175%, collated to 28.43868% with percentile collation of 139.8539% over -59.4698% of corroded specimens. Coated members showed low; midspan deflection, elongation and ultimate yields, high flexural failure load is required and compared to corroded members. Effect of corrosion not noticed in the mechanical properties of reinforcing steel experimented.

Table 1: Flexural Strength of Beam Specimens (Non-Corroded specimens)

s/no	**Non-corroded Control Beam**									
Beam	Samples	WAK	WBK	WCK	WDK	WEK	WFK	WGK	WHK	WIK
TBW1-1	Failure Load (KN)	80.13	80.13	79.95	79.92	79.92	80.03	80.73	79.7	80.85
TBW1-2	Midspan Deflection (mm)	7.18	7.26	7.86	7.97	7.06	8	7.09	7.26	7.06
TBW1-3	Bar diameter (mm)	16	16	16	16	16	16	16	16	16
TBW1-4	Yield Strength, fy (MPa)	460	460	460	460	460	460	460	460	460
TBW1-5	Ultimate Tensile Strength, fu (MPa)	630.55	632.45	631.15	629.95	632.45	630.95	630.75	631.55	630.15
TBW1-6	Strain Ratio	1.325	1.285	1.295	1.325	1.295	1.295	1.295	1.285	1.305
TBW1-7	Elongation (%)	29.205	29.405	29.305	29.375	28.805	28.905	29.405	29.375	29.505

Table 2 : Flexural Strength of Beam Specimen (Corrode specimens)

s/no		Corroded Beam								
Beam	Samples	WAK1	WBK1	WCK1	WDK1	WEK1	WFK1	WGK1	WHK1	WIK1
TBW2-1	Failure load (KN)	54.6395	55.3195	52.8895	52.3695	54.6595	52.6595	52.4295	54.8595	52.6395
TBW2-2	Midspan Deflection (mm)	14.27	14.3	13.93	13.9	13.5	14.4	13.93	13.53	14.2
TBW2-3	Bar diameter (mm)	16	16	16	16	16	16	16	16	16
TBW2-4	Yield Strength, fy (MPa)	460	460	460	460	460	460	460	460	460
TBW2-5	Ultimate Tensile Strength, fu (MPa)	548.35	544.95	545.55	544.85	544.55	544.85	544.25	545.55	544.85
TBW2-6	Strain Ratio	1.095	1.085	1.085	1.125	1.075	1.085	1.085	1.075	1.075
TBW2-7	Elongation (%)	11.96	12.1	11.77	11.3	12.29	11.58	12.1	11.8	11.81

Table 3: Flexural Strength of Beam Specimens (Exudates/Resins Coated specimens)

		Milicia excelsa exudates (steel bar coated specimen)								
s/no		150µm (Exudate/Resin) coated			300µm (Exudate/Resin) coated			450µm (Exudate/Resin) coated		
Beam	Samples	WAK2	WBK2	WCK2	WDK1	WEK2	WFK2	WGK2	WHK2	WIK2
TBW3-1	Failure load (KN)	78.404	79.354	78.704	78.744	79.104	78.934	78.704	78.744	79.244
TBW3-2	Midspan Deflection (mm)	6.695	6.095	6.985	6.795	6.355	6.795	6.775	6.775	6.345
TBW3-3	Bar diameter (mm)	16	16	16	16	16	16	16	16	16
TBW3-4	Yield Strength, fy (MPa)	460	460	460	460	460	460	460	460	460
TBWE-5	Ultimate Tensile Strength, fu (MPa)	628.45	629.35	628.95	628.95	628.95	628.95	628.55	629.05	629.05
TBW3-6	Strain Ratio	1.3199	1.3399	1.3199	1.3099	1.3099	1.3099	1.2999	1.3199	1.3299
TBW3-7	Elongation (%)	28.1809	28.8009	28.2809	28.2509	28.7009	28.4809	28.3909	28.1009	28.7609

Table 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		
TBW4-1	Failure load (KN)	80.07	79.9566	80.4266	54.28283	53.2295	53.3095	78.8206	78.9273	78.8973
TBW4-2	Midspan Deflection (mm)	7.43333	7.67666	7.13666	14.16666	13.93333	13.8866	6.59166	6.64833	6.63166
TBW4-3	Bar diameter (mm)	16	16	16	16	16	16	16	16	16
TBW4-4	Yield Strength, fy (MPa)	460	460	460	460	460	460	460	460	460
TBW4-5	Utimate Tensile Strength, fu (MPa)	631.383	631.116	630.816	546.2833	544.75	544.883	628.9167	628.95	628.883
TBW4-6	Strain Ratio	1.301667	1.305	1.295	1.0883	1.095	1.0783	1.326567	1.3099	1.31656
TBW4-7	Elongation (%)	29.305	29.028	29.428	11.943	11.7233	11.903	28.4209	28.477	28.4175

Table 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		
TBW5-1	Failure load (KN)	80.1511	53.6072	78.8817	149.515	66.8827	147.147	49.5153	-33.117	47.1475
TBW5-2	Midspan Deflection (mm)	7.41555	13.9955	6.62388	52.9850	188.732	47.3285	-47.0149	88.7323	-52.6715
TBW5-3	Bar diameter (mm)	16	16	16	100	100	100	0	0	0
TBW5-4	Yield Strength, fy (MPa)	460	460	460	100	100	100	0	0	0
TBW5-5	Ultimate Tensile Strength, fu (MPa)	631.105	545.305	628.916	115.734	86.4048	115.332	15.7343	-13.595	15.3328
TBW5-6	Strain Ratio	1.30055	1.08722	1.31767	119.621	83.5967	121.196	19.6218	-16.403	21.1967
TBW5-7	Elongation (%)	29.2538	11.8566	28.4386	246.729	40.5302	239.8539	146.7295	-59.469	139.8539

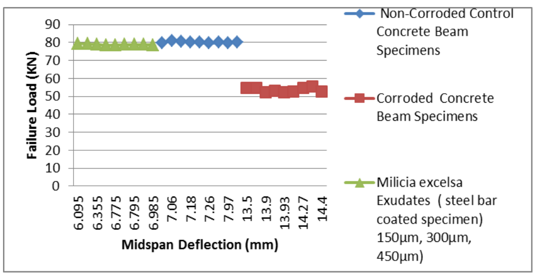

Figure 1: Failure Load versus Midspan Deflection of Beam Specimens (Non-Corroded, Corroded and Resin Coated Specimens)

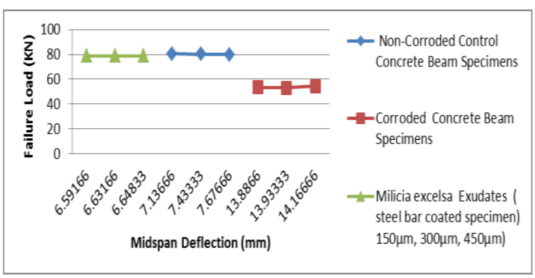

Figure 1A: Average Failure Load versus Midspan Deflection of Beam Specimens (Non-Corroded, Corroded and Resin Coated Specimens)

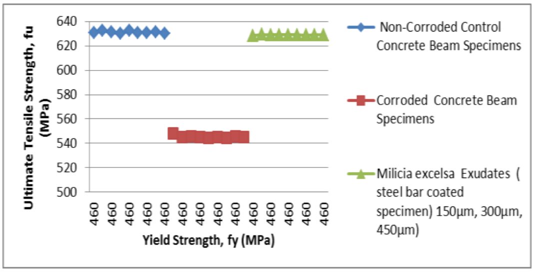

Figure 2: Ultimate Tensile Strength versus Yield Strength of Beam Specimens (Non-Corroded, Corroded and Resin Coated Specimens)

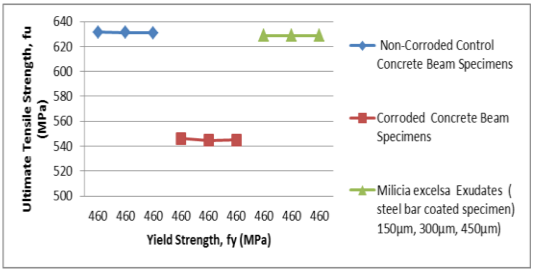

Figure 2A: Average Ultimate Tensile Strength versus Yield Strength of Beam Specimens (Non-Corroded, Corroded and Resin Coated Specimens)

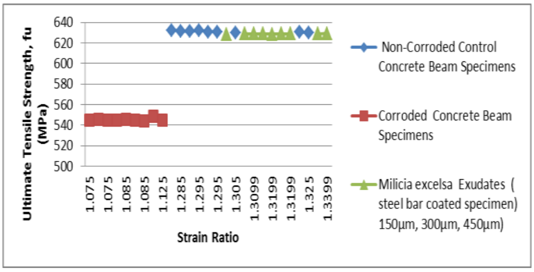

Figure 3: Ultimate Tensile Strength versus Strain Ratio of Beam Specimens (Non-Corroded, Corroded and Resin Coated Specimens)

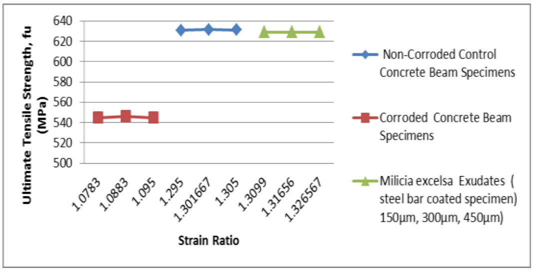

Figure 3A: Average Ultimate Tensile Strength versus Strain Ratio of Beam Specimens (Non-Corroded, Corroded and Resin Coated Specimens)

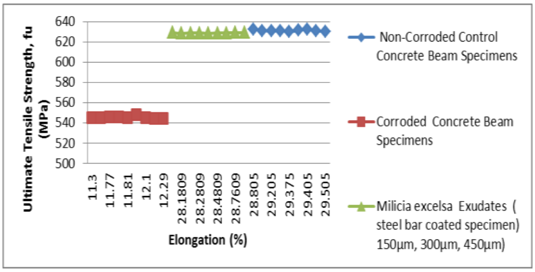

Figure 4: Ultimate Tensile Strength versus Elongation of Beam Specimens (Non-Corroded, Corroded and Resin Coated Specimens)

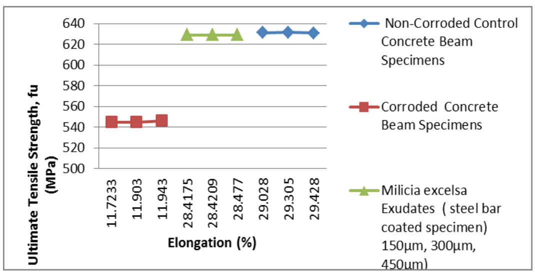

Figure 4A: Average Ultimate Tensile Strength versus Elongation of Beam Specimens (Non-Corroded, Corroded and Resin Coated Specimens)

CONCLUSIONS

Experimental results gotten from tables 1 – 5 and figures 1 – 3A, the below conclusions were drawn:

i. Coated members showed low; midspan deflection, elongation and ultimate yields, high flexural failure load is required as compared to corroded members.
ii. Effect of corrosion not noticed in the mechanical properties of reinforcing steel experimented.
iii. Corrosion properties of spalling and cracks noticed in non-coated members.
iv. Entire experimental results showed indications of low flexural failure load with high; midspan deflection, elongation, strain ratio and ultimate yields.
v. Effect of corrosion on mechanical properties of reinforcing steel not noticed on non- corroded (controlled) members.

Values obtained of non-corroded are of standard state to corroded members.

vi. Non-corroded members do not changed in any form of mechanical properties of reinforcing steel.

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