CHAPTER 2

REVIEW OF LITERATURE

The research work pertaining to different types of corrosion of steel rebar in the concrete and their protection methodology of different varieties of the surface modification of steel and concrete is reviewed in this chapter. Only limited literature is available for this study involving the different types of protective coatings to steel rebar in concrete.

2.1 LITERATURE STUDY

The literature related to the experimental investigation of various methods carried out by various researchers has been discussed below:

Kobayashi (1984) studied the deterioration of surface coating on steel structure. This study aimed at clarifying the corrosion mechanism of steel with surface coating in a marine environment and the corrosion progress of steel materials with tar-epoxy coatings that had been exposed in a marine environment for one and 19 years, and a steel material with a tar-epoxy coating that had been submerged in a chloride solution at 40°C for 1200 hours, were investigated. Some specimens were provided with artificial defects to investigate the effect of a coating defect on the progress of deterioration. In the splash zone, corrosion of steel extends from the defect in a radial direction, and the speed of corrosion depends on the size of the defect. In the tidal zone and the submerged zone, on the other hand, corrosion of steel extends in a vertical direction at the edge of the defect and not in a radial direction.
Rozental (1989) studied the polarization resistance test to study the corrosion rate of steel in concrete. Concrete specimens with two steel rods with lead soldered to their ends were used. After preparation, the specimens were held for 28 days in a normal storage chamber and then immersed in a 3 M NaCl solution. The specimens were held in a chamber with a relative humidity of 70–85% at room temperature, the polarization curves were recorded. The results of the study agreed with the corrosion rates obtained by other methods.

Cusens & Yu (1992) studied the pull out tests of epoxy coated reinforcement in concrete. Single pull-out and double pull-out tests were conducted and the results were compared with control uncoated bars. In the single pull out tests, slip values at both ends were measured for each increment of load until failure. In the double pull out tests, 20 cycles of load were applied at levels of steel stress between zero and 0.5 times the characteristic steel strength. Strains were measured by electrical resistance strain gauges glued inside the bars. Single pullout test results suggested that epoxy-coated bars exhibited more loaded end, free end slip as compared to equivalent uncoated bars. In double pull out tests, the epoxy-coated bars also exhibited more slip under load cycles accompanied by lesser stress gradient which indicated lower friction bond. Finally, it was concluded that epoxy coating was found to increase the slip values and thereby reduce the bond performance of coated bars.

Rasheeduzzafar et al. (1992) evaluated the performance of corrosion resisting steels in chloride bearing concrete by conducting seven year site exposure tests. Performance of bare mild steel, galvanized, epoxy-coated and stainless steel clad reinforcing steels was evaluated by embedding them in concrete with three different levels of chloride content. It was concluded 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. Although barrier type epoxy-coated bars offer good corrosion resistant properties in low chloride levels, it offers a finite tolerable limit for chloride upon the addition of chloride at higher levels. For the best durability, performance was exhibited by stainless steel clad reinforcing bars. There was no sign of corrosion observed after the exposure period.

Sehgal et al. (1992) determined the corrosion rate by using the various principles of corrosion rate measuring instruments (3LP, Nippon Steel Company, and GECOR devices). The corrosion rate obtained by these devices was compared to the standard electrochemical and non electrochemical corrosion rate measuring methods. A linear relationship was observed between the results obtained by the Nippon device and impedance spectroscopy for small mortar specimens irrespective of the test solution. The significance of this relationship was discussed and compared to the testing of large concrete specimens. The results show that, for passive steel-in-concrete systems all devices were incapable of confining the signal distribution from the counter electrode to the rebar area directly below the counter electrode when the size of the working electrode far exceeded that of the counter electrode. The reason may be either the inherent difficulty in confining signal distribution in a passive steel-in-concrete system or the small size of the counter electrode used.

Baweja et al. (1993) studied the relationships between anodic polarization and its application to the corrosion of steel in concrete. There is no method of assessment that would enable the rapid and accurate prediction of the extent of corrosion of reinforcing steel in concrete on site. The Half-cell potential techniques commonly used in situ and give only the probabilistic information on corrosion activity. The research effort was to assess more accurately the corrosion characteristics of steel in concrete with an ultimate view of site application. The Long-term investigations on chloride-induced
corrosion of steel reinforcement have a relationship between electro-
chemically induced corrosion of steel reinforcement. Potentio Dynamic
Polarization (PDP) procedures were used to monitor the corrosion of steel
reinforcement in concrete slab specimens over a period of 4 years. A
statistically significant relationship between the area under the corrosion
current-time relationship and the weight loss of steel reinforcement was
established and the assessments of corrosion rates of steel in the concretes
studied were thus verified. Finally the reinforcement corrosion was found to
be localized under the high chloride conditions occurring mainly in an area
adjacent to the chloride source.

Glass et al. (1993) evaluated the galvano-static transient methods
used to study their application in corrosion rate of steel in concrete. The
sensitivity of the time constants describing the galvano-statically induced
potential-time transients to corrosion rate changes was examined on steel
embedded in concrete. While it was noted that the shape of the transients
changed significantly with changes in corrosion rate, the decay was not an
exponential function which would be expected if it were determined by
activation controlled reactions. In fact the time constraints resulting from an
assumed exponential decay were insensitive to corrosion rate changes.

Thangavel et al. (1995) stressed the need for protective coatings to
steel reinforcement in order to develop necessary bond strength at the rebar
concrete interface for the reliable performance of the concrete structures. Pull
out tests were conducted on coated and uncoated rebars of 10mm diameter
and 450mm in length, placed centrally in a 100 mm concrete cube as per
Indian standards. The bond behaviour of the galvanized inhibited cement
slurry and FBEC bars with two different coating thickness was assessed and
compared. They concluded that the coating improves the bond strength when
compared to the uncoated mild steel rebars. Galvanized coating and Epoxy
coating reduce the bond strength at higher thickness of coatings. On the other
hand, for inhibiting cement slurry coated rebars improves the bond strength at a higher thickness of coatings.

Manjrekar et al. (1996) studied the role of polymer cement inhibited co-matrix in corrosion control of reinforcing steel. Salt spray test, hydrogen embrittlement test and stress corrosion tests were carried out with coated steel rebars and prestressing wires. It was proved that polymer cement inhibitor co-matrix offers good corrosion resistance properties because of its ability to reduce chloride ion penetration towards steel and reducing transmission of gases like air, carbon dioxide, oxygen and water vapour.

Pyc et al. (1997) evaluated the performance of epoxy coated reinforcing steel and corrosion inhibitors in a Simulated Concrete Pore (SCP) water solution. Immersion tests were conducted at 40°C in SCP with and without the addition of corrosion inhibitors. Sodium chloride (NaCl) was added after 7 days pre-treatment period and tests were continued for 90 days with sufficient aeration. Bare steel specimens were examined for the initiation and progress of corrosion process and epoxy coated reinforcements were checked for blister formation and the presence of corrosion products. Adhesion tests and hardness test were conducted for FBEC reinforcement before and after immersion tests. It was observed that bare steel specimens immersed in the pore solution with calcium nitride based inhibitor with oxygen had no signs of corrosion for the chloride concentration below the 0.6 moles/litre. The study performed on FBEC reinforcement showed that coating thickness and damage present in the coating would influence the adhesion loss between the coatings and steel surface and blister formation.

Sanchez (1998) studied the behaviour of steel rebar coated with Electroless Nickel (EN) in chloride-contaminated concrete. The steel rebars were coated in an EN bath for 1, 2 and 3 hours. They were then subjected to heat treatment at 40°C for periods of 1, 2 and 3 hours. The nickel-coated rebars were embedded in concrete samples with NaCl concentrations at 0.0,
0.10, 0.15 and 0.20 %, based on concrete weight. Their behaviour was evaluated by the measurement of potentials, polarization resistance, potentiodynamic polarization curves, electrical resistance and visual inspection. Corrosion rates were less than 0.01 µA/cm² after 40 months testing.

Rengasamy et al. (1998) studied the mechanical, electrochemical and corrosion resistance properties of the inhibited and sealed cement slurry coating system that applies to steel rebars for its corrosion protection. Performance evaluation tests such as exposure studies on the precracked model slabs, alternate wetting and drying test and performance in the presence of chloride admixture were also discussed elaborately. It was concluded that this coating leads to economy and efficiency higher than other coating systems.

Freedman (1998) presented the mechanism of corrosion of reinforcement and the condition under which corrosion can occur in reinforced concrete. Chloride ingress and carbonation were discussed together with the importance of concrete cover and impervious concrete surface. Criteria for evaluating the crack widths were also discussed. Methods of protecting reinforcement such as galvanized and epoxy coating were also discussed. It was concluded that the corrosion of reinforcement is usually not a problem in architectural precast concrete elements. But the high quality concrete with strength between 34.50 and 41.4 MPa and a w/c ratio of 0.4 is less adequate in preventing corrosion.

Vedalakshmi et al. (2000) evaluated the effect of prior damage on the performance of cement based coatings on rebar by conducting macrocell corrosion studies. The effect of prior coating damage produced during concrete pouring has been studied on inhibited cement slurry coating. To stimulate marine substructure environment, the macrocell corrosion condition has been created through a chloride ion concentration gradient. A Macrocell
corrosion test was conducted as per ASTM G 109-92. Macrocell corrosion current and corrosion potential measurements were taken during the test period. It was concluded that inhibited cement slurry coating has better tolerance towards coating damage caused by pouring in chloride contaminated concrete as compared to epoxy based coating systems. It was also found that the performance of the coating was independent of the height of concrete pouring.

Belaid et al. (2001) studied the effect of rebar properties on the bond strength of galvanized corrosion deposit in the heated cracks. It was observed that for an unheated crack, the portion of the steel rebar located at the root of the crack act as an anode and the other portions as cathode and also microcell corrosion at the cracked region is higher than the uncracked region. It was found that the macro cell corrosion process and the degree of macro and micro cell corrosion are significantly influenced by the reinforcement. Galvanized coating is used to prevent the corrosion of reinforcing bars. Contrary to ordinary steel, this coating reacts with the surrounding aqueous phase of the cement paste and includes a delay in the hydration of the interfacial zone. The result concluded that the effect on the bond strength of the reinforcement indicated that the lower bond performance of galvanized bar. And the failure zone of concrete depends on the type of bar and rib height of the bar in the concrete which affects the bond failure of galvanizing bars.

Pismenny (2001) studied the stray current corrosion of carbon steel coated with Electroplated Nickel and Electroless Nickel in an alkaline environment. The stability of metal parts in electrolytic environment is a function of external and internal cellular field bias. Therefore, in order to achieve long-term integrity of electrolysis cell components, the alloys and plated metals were evaluated with respect to stray current corrosion. For this purpose, three different materials were tested in this study in specially designed electrochemical cells. The materials were carbon steel,
Ni-electroplated carbon steel, and electroless Ni plated on carbon steel. In this comparative study, the corrosion of the three materials was investigated using both thermodynamic predictions and potentiostatic and weight loss data obtained from the immersion testing for the three materials. Effects of turbulence, hydrogen gas, and temperature variation on corrosion were also examined for the above materials. Finally, electroplated Ni and electroless Ni plated carbon steel showed excellent resistance to stray current corrosion under the specific electrolysis conditions.

Deshpande (2002) reported the feasibility of various coatings for the protection of reinforcing steel corrosion and bond testing. The objective of this research project was to investigate the corrosion and bond performance of different coatings and non-traditional metals in salt contaminated concrete. An accelerated macrocell corrosion test was carried out to determine the behavior of galvanized, stainless steel clad, epoxy coated, PVC coated, nylon-coated and 304 stainless steel reinforcing bars cyclically exposed to a chloride solution. Pull out test was conducted to compare the bond behavior of bars with different polymer coatings. There were not any significant differences observed in the bond behavior of the epoxy, PVC, and nylon coatings. Each coating type was able to achieve a similar maximum applied pullout force and exhibited similar load slip behavior during testing. The nylon-coated specimens experienced weld fracture prior to pull out. Despite the different concrete strengths and failure modes, each coating type achieved a similar maximum applied pullout force and exhibited similar slip stiffness during testing. In each case, the reinforcing bar was coated with a polymer that prevents adhesion and decreases or prevents friction, which leaves bearing on the bar deformations as the primary development force.

Tarek ud din et al. (2003) discussed the corrosion of steel bars in cracked concrete under marine environment. This investigation deals with the micro cell corrosion behavior of steel rebar in cracked concrete exposed to the
marine environment. Short term accelerated and long term exposure laboratory tests were conducted. Test items include electrochemical and physical evaluations of corrosion, chloride ion content in concrete and oxygen permeability through concrete. SEM and electron probe microanalysis were also carried out to conform the w/c ratio. It was concluded that when the specimen was in a natural marine environment, narrower cracks heal due to the deposition of ettringite, calcite and brucite in the crack. This enhances reduction in the corrosion rate significantly at the cracked region.

Zivica et al. (2003) studied the influence of the w/c ratio on the rate of chloride induced corrosion of steel reinforcement and its dependence on the ambient temperature. When the ambient temperature is increased, the permeability of the embedded cement material for the rate of chloride induced corrosion has found to be a dominant criterion. The importance given to the permeability in this progress was based on the fact that represents a factor controlling the possibility of escaping the unambiguous reaction partners such as oxygen and water vapour from the system embedding cement material. The resulting effect of a slowdown of the corrosion rate when the water cement ratio over 0.6 and the ambient temperature is over 40°C. It was concluded that due to the similarity of the chemision of the corrosion pores of steel reinforcement, independent of the action of aggressive species, these relationships are generally valid in corrosion due to the carbonation.

Tamer et al. (2003) examined the effectiveness of the impressed current technique to simulate corrosion of steel reinforcement in concrete. In this study, the influencing of varying the impressed current density level between 100 and 500µA/cm² on the actual degree of steel reinforcing bar corrosion as well as on the concrete products was investigated experimentally. Corrosion was induced by means of impressed current using electric power supplies. To de-passify the steel reinforcement 5% Sodium Chloride (NaCl)
by weight of cement was added to the concrete mix. The strain response due to the expansion of corrosion products was measured at each face of the prism. At the end of the corrosion phase, all the corroded reinforcing bars were removed and cleaned according to the ASTM G 190 and weighed to get the actual degree of mass loss. The result showed that, up to the mass there was 7.27% and the accelerated corrosion using the impressed current technique was effective in inducing corrosion of the steel reinforcement in concrete with respect to Faraday’s law. It was inferred that the use of different current densities has no effect on the percentage of mass loss. However, increasing the level of current density above 200µA/cm² resulted in a significant increase in the strain response and crack width due to the corrosion of the steel reinforcement.

Yeih et al. (2004) studied the influence of adding fly ash in concrete on the bond strength characteristics of epoxy coated steel. The experimental data showed that when the weight ratio of fly ash to epoxy is 0.5, the largest improvement in bond strength is achieved. Other combinations by using different weight ratios were resulted in bond improvement only comparable to a plain epoxy coating. The specimens with a fly ash to the epoxy weight ratio of 0.5 develops bond strength at the level of uncoated rebars. It was further predicted that the shear stiffness per length and critical debonding shear force per length follow the same trend as bond strength.

Vaysburd & Emmons (2004) studied some of the protective options to prevent rebar corrosion. The effect of corrosion inhibiting admixtures in concrete and the concrete repair was also discussed in detail. The complex issue related to the effectiveness of inhibitors in repairs was addressed based on the analysis of the differences between electrochemical activities in new and repaired structures. It was concluded that the protection methods for newly constructed structures should not be used blindly for concrete repair...
works. It was also emphasized that a broader understanding of the electrochemical differences between new and repaired concrete is necessary for effective protection of reinforcement in repairing structures.

Singh & Ghosh (2006) evaluated the Electroless Nickel–Phosphorus (ENP) coated steel reinforcement bars under chloride induced corrosion. ENP alloy coatings deposited on steel surfaces provide a high degree of protection against corrosion in comparison to the bare steel exposed in chloride-contaminated Simulated Concrete Pore Solution (SPS). The coatings deposited at higher pH, however, show an increasing rate of corrosion with time.

Terry (2006) evaluated the corrosion resistance of different steel reinforcement types. The effective corrosion resistance could improve the life expectancy and cost effectiveness of bridges. From the evaluation test, to measure the difference in corrosion resistance between MMFX composite steel, epoxy coated reinforcement and uncoated reinforcement in bridge decks to determine whether MMFX steel provides corrosion resistance superior to epoxy coated steel and to determine the inhibition of corrosion and the rate of corrosion growth in these three reinforcement materials.

Ha-Won Song & Velu Saraswathy (2007) reviewed the corrosion monitoring of reinforced concrete structures. In reinforced concrete structures the potential to be very durable and capable of withstanding a variety of adverse environmental conditions. The failures in the structures still occur as a result of premature reinforcement corrosion and the maintenance and repair of bridges and buildings for their safety require effective inspection and monitoring techniques for assessing the reinforcement corrosion. These methods need to be able to identify any possible durability problems within structures before they become serious. This research work reviews all the electrochemical and non-destructive techniques from the point of view of
corrosion assessment and their applications to bridges, buildings and other civil engineering structures.

Zuo Quan Tan (2007) studied the effect of galvanized steel corrosion on the integrity of concrete. During zinc corrosion in ordinary Portland cement (OPC) concrete, calcium hydroxyl zincate formed on untreated HDG steel provided sufficient protection against corrosion. Therefore, it was concluded that treating HDG rebar with dilute chromic acid is unnecessary as a method of passivating zinc. A layer of zinc oxide and zinc carbonate formed through the weathering on HDG bars slightly increased the initial corrosion rate and passivation time compared with the non-weathered rebars. HDG steel with an alloyed coating, i.e. Consisting of Fe-Zn intermetallic phases, required a longer time to passivate than those with a pure zinc surface layer. But in the case of the lower zinc content of the surface limited the rate of CHZ formation and, hence, delayed passivation. However, apart from the surface condition, the coating depth loss after two days of embedment in OPC concrete was insignificant. Through porosity assessment of cements adjacent to HDG bars, it was found that hydrogen evolution accompanying zinc corrosion did not have an impact on the pore volume of cements.

Cullen (2008) examined the reactive porcelain enamel coatings for reinforcing steel to enhance the bond to concrete and reduce corrosion. Initial testing has shown that the specialised porcelain enamel coating has significantly increased the bond strength developed between OPC mortar and steel reinforcement materials. By include the unhydrated cement into the vitreous enamel coatings in the mild steel rods, the bond strength +were found to increase the maximum bond strength up to 3.25% compared to uncoated steel samples from corrosion tests. Finally, it was concluded that the coated steel corroded only the metal where the metal was intentionally exposed. And also the specialized porcelain enamel coatings can potentially be used to
Florica Simescu & Hassane Idrissi (2008) evaluated the effect of zinc phosphate chemical conversion coating on corrosion behaviour of mild steel in the alkaline medium protection of rebars in reinforced concrete. The ability of zinc phosphate coatings obtained by chemical conversion protects the mild steel rebars against localized corrosion, generated by chloride ions in alkaline media is outlined. The corrosion resistance of coated steel, in comparison with uncoated rebars and coated steel rebars embedded in mortar, was evaluated by OCP, PDP, cronoamperometry and EIS. The coated surfaces were characterized by XRD and SEM. The test was carried out by two ways. First, the coated mild steel rebars were studied in an alkaline solution with and without chloride simulating a concrete pore solution. The results showed that the slow dissolution of the coating generates hydroxyapatite $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$. After a long time immersion, the coating became dense and provided an effective corrosion resistance compared with the mild steel rebar. Secondly, the coated and uncoated steel rebars embedded in mortar and immersed in chloride solution. The results showed that there was no corrosion or deterioration of the coated steel and the corrosion rate was considerably lowered by this phosphate coating.

Pari et al. (2008) studied the performance of EN coating on aluminium for cylinder liners. The cylinder components contribute to around 30% of total friction in an engine. The most important requirements for the satisfactory service life of the cylinder component in an engine are higher life, higher temperature resistance and higher mechanical properties. Most of the parts inside the cylinder should undergo surface treatment. The choice of the process depends on the functional efficiency and cost. Generally cast iron is used for cylinder components which exhibit outstanding wear characteristics, high strength properties even at high temperatures, but the disadvantages are
high weight and excess fuel consumption. So aluminium alloys replace them as they are light weight but the wear resistance against the piston and piston ring is poor. Hence there is a need to investigate methods to improve the performance of Aluminium alloys to enable the practical applications. One such method is an EN coating on aluminium. EN coated aluminium was investigated for its tribological properties through experimental methods and strengthen through Finite Element Analysis (FEA). The investigation results showed that EN coated aluminium has superior tribological properties when compared with Cast Iron (CI) and it has adequate strength. Finally, it was concluded that EN coated aluminium has a high potential to be used as cylinder liners.

Saraswathy & Ha-Won Song (2009) evaluated the cementitious repair mortars for corrosion resistance. The repair and rehabilitation of deteriorated concrete structures are essential not only to utilize them for their intended service life, but also to assure the safety and serviceability of the associated components. A good repair improves the function and performance of the structure, thus prevents ingress of aggressive species to the steel/concrete interface and improves its durability. It is important to evaluate the performance of repair materials available for repairing the deteriorated concrete structures. This investigation was carried out to evaluate the durability characteristics of five types of modified cement based repair mortars. The corrosion resistance of the repair materials was evaluated by conducting various tests such as water absorption, rapid chloride ion penetration test, impressed voltage, 90 days bonding test, macro cell corrosion test, weight loss measurement, etc. the details of the test and their results were discussed. Finally, it was concluded that the modified cement based repair mortars formulated with different mineral admixtures (fly ash and/or silica fume) showed improved corrosion resistance.
Ming-Gin Lee (2009) studied the corrosion performance of EN plated steel. The bond strength test results showed excellent corrosion resistance for EN plated steel embedded in concrete specimen exposed to outdoor or sea water. The chlorine contents of concrete specimens increase as the days of immersing time in the seawater pool increases during 500 days. Another steel bond strength test revealed that the EN plated steel has similar performance as the conventional one. This means that the electroplating has no significant impact on steel bond strength and the reinforcing steel bar which was coated with an EN plated film showed a reduced corrosion probability.

David Trejo et al. (2009) reported the corrosion performance tests for reinforcing steel in concrete. The test method that was used to assess the corrosion performance of reinforcing steel embedded in concrete, mainly ASTM G 109 was labour intensive, time consuming, slow to provide comparative results, and expenditure. This research work evaluated four accelerated test procedures (rapid macrocell, ACT test, CCIA test, and a modified ASTM G109 test) and compared these tests with the standard ASTM G 109 tests. The reasonableness of the test results, test simplicity, test cost, and test duration were all assessed. Results indicate that the rapid macrocell, Accelerated Chloride Threshold (ACT), and Chloride Ion threshold (CCIA) tests can reduce the time required to perform the tests by approximately 90% compared to standard ASTM G 109 test. Not considering the one-time equipment cost, the four test decrease the cost by approximately 75, 58, and 67% compared to the standard ASTM G 109 test, respectively. The rapid macrocell test was determined to be relatively simple while the CCIA and ACT tests were considered to be more complex to perform. Based on the research findings, it was proposed that TxDOT (Texas Department of Transportation) uses the rapid macrocell test to evaluate the corrosion performance of most materials. To evaluate the performance of dielectric coatings on reinforcement, it was recommended that the MG 109 test be used.
to evaluate these system types. For specific testing needs, other tests may be appropriate.

Shamsad Ahmad (2009) studied the techniques for inducing accelerated corrosion of steel in concrete. The research studies evaluated the loss of bond and loss of load-bearing capacity of corroding reinforced concrete members, the effect of mineral admixtures in reducing reinforcement corrosion, the performance of coated or alloyed reinforcing bars against reinforcement corrosion, and the effectiveness of electrochemical techniques applied for the prevention of reinforcement corrosion. In this research, an attempt has been made at first to describe the impressed current technique commonly used for accelerating reinforcement corrosion in small-as well as large-sized concrete specimens in the light of the state of the art information available in the literature. And then calculating the degree of induced corrosion in percentage by mass and in terms of average corrosion current density using the intensity and duration of the applied current. Finally concluded that the effectiveness of the applied current in inducing reinforcement corrosion was effective in their bond and the load bearing capacity of the corroding reinforced concrete members.

Manindra Manna & Nikhilesh Bandyopadhyay (2010) evaluated the EN coating kinetics on Thermo Mechanically Treated (TMT) rebar surface and the coating. The corrosion resistant Nickel Phosphorous Ferrous alloy coating that was obtained on rebar surface by an electroless process by making use of glycolic acid as a complexing agent. The coating obtained under longer coating time showed higher amounts of Phosphorous which contributed to maximum surface smoothness. However, the bond strength was higher than the necessary strength requirement according to Indian standard specifications.
Hiromu Inagawa (2010) reported the EN plating bath without containing harmful metal species. EN plating bath contained an iron source and an iodide ion source. With the use of the EN plating bath containing at least the iron ion source and the iodide ion source as an oxidizing agent, it was possible to suppress decomposition of the plating bath without using harmful metal species. And concluded that the plating path was stable without using harmful species and the metal concentration was lowered with the progress for the EN plating bath.

Siva Chidambaram & Thirugnanam (2010) evaluated the performance of protective coatings for corrosion resistance in transmission line tower foundations. Transmission line towers running close to coastal area attacked by chlorides and sulphates and the towers in the vicinity of chemical, petrochemical, fertilizer and other industries were subjected to aggressive chemical attacks. Because of the extreme climatic conditions prevailing in certain areas, transmission line tower concrete have severely been deteriorated and stub angle has been corroded very much. During submergence of stub steel above concrete chimney for some period in rainy season, the water acting as salt dissolved electrolyte, the corrosion process is aggravated particularly in the presence of chlorides and phosphates. By the application of protective coating to steel angles and addition of admixtures to the concrete is one of the best methods of controlling corrosion in steel angle. The effect of providing coatings on stub angle, the addition of admixtures in stub concrete, corrosion inhibitors and barrier coatings on stub concrete against corrosion had been investigated in the laboratory under accelerated environmental condition. Individual and combined effect of coatings has been evaluated using a half cell potentiometer test. The parameters involved in the deterioration of stub concrete and the stub angle of transmission tower foundations had been discussed and concluded that three level coatings performs effectively in resisting corrosion of transmission tower stubs.
Hua et al. (2010) investigated the corrosion behavior of low carbon steel in Cement Extract (CE) in the presence of very low concentration polymeric nanoaggregates (PEO113-b-PS70 micelles). The steel electrodes were investigated in Cl containing CE as corrosion medium, compared to chloride free CE as a reference case. The results from the electrochemical measurements (Electrochemical Impedance Spectroscopy (EIS) and Potentiodynamic Polarization (PDP)) indicate that the presence of micelles leads to increased corrosion resistance of the steel, but pronounced only at early stages (1h and 3h), whereas no significant influence was observed within longer immersion periods (5d). To some extent, this result was as expected, considering the used low concentration of micelles for this test. The surface analysis, however, shows that the presence of the micelles in the cement extract, results in a more homogeneous and compact layer on the steel surface, compared to the steel immersed in the micelles-free solutions.

Jayanta Kumar et al. (2010) evaluated the performance of different organic coatings on steel substrate by accelerating and in atmosphere exposure test. Organic coatings act as a barrier to a corrosive solution and check the transfer of electrical charge from the corrosive solution. High performance organic paint systems were applied on plain carbon steel substrate with two applied on plain carbon steel substrate with two different primers viz Epoxy Zinc (Zn) phosphate and Epoxy Zinc rich base primer. Identical intermediate and top coats were applied on them having equal dry film thickness. Both uncontrolled long term testing and controlled laboratory testing were conducted to evaluate the performance of the coatings. Salt spray and EIS were carried out on fresh coated panels withdrawn from field exposure racks using different electrolytes. Polarization resistance, coating capacitance, water absorption and corrosion potential were studied to understand the causes of deterioration and to have faster assessment of the durability of these paint formulations. Corrosion products were characterized
by SEM through morphology and Raman spectra through phase identification. The performance of epoxy Zn Phosphate base primer is very much comparable with epoxy Zn rich base primer. The rust formed under the atmospheric condition is non protective lepodocrocite. The results confirmed the same findings in the short duration of two years under climatic conditions with sulphate ion. The pitting nature of the steel substrate with different primer could be the same within the exposure period.

Aritra Khan & Tata Satya Teja (2010) studied the prevention of reinforcement corrosion in concrete structures. To visualize the surface-state of the steel embedded in concrete, though the interpretation of potential time data, the potential being recorded. Some easily available common materials have been used to see their performance on the potential development of the metal solution interface like Polystyrene, red oxide, black Japan and aluminum paint have been examined. Bond strength development between the reinforcement and concrete was also taken into consideration while using paint as an anticorrosive material. Red oxide has been tested as a concrete admixture. Chemicals like sodium Hexa-Meta Phosphate (HMP) and calcium chloride have been tested for their positive and negative behavior of the maintenance/deterioration of stable potential.

Abdulkareem Mohammed Ali Alsamuraee & Hani Aziz Ameen (2011) evaluated the effect of Zinc, Tin, and Lead coating for corrosion protection effectiveness of steel reinforcement in concrete. The research was aimed at developing new reinforcement materials by using different coating materials, included zinc, tin and lead. The experimental works included examination of coating defect, coating adhesion study, adhesion between concrete and coated bars, and different techniques are employed to assess the performance of the reinforcement embedded in concrete in a saline environment of 3.5% NaCl solution. Some improvement to the ASTM G109
standard test method were suggested and led to get more useful results in a shorter period. The trend of the corrosion rate results of the all specimens can be arranged as Galvanized CRS, untreated CRS, tin coated CRS, lead coated CRS, SST316. The plated process of all types had no effect on the tensile strength. The adhesion strength tests between the surface of the uncoated reinforcing bar and PMMA was 0.27 MPa were all the coated reinforcing bars showed the adhesion strength, range between 0.47 to 0.57 MPa, and the photography for PMMA showed no coating material at the surface for adhesion. And the coating films have good adhesion force on the surface of steel bar. The compressive strength of the concrete specimens was measured and used to identify the bond force. The test results of the new concrete specimens (after 30 days) revealed that the bond strength between the steel bar and the strength of concrete is high and similar to each other. Bond pullout never occurred with all the coated bars and shape of the stress-slip curves varied little, but the bond stress magnitude did not vary. The results of the improved accelerated corrosion test ASTM G109 include the estimation of the corrosion potentials of the anode and cathode. The average corrosion potentials for the anode bars recorded that the bond strength between the steel bar and the strength of concrete was high and similar to each other.

Abosrra (2011) investigated the corrosion of steel bars embedded in concrete admixed with 0%, 2% and 4% Calcium Nitrite (CN), having compressive strengths of 20 and 46 MPa. Reinforced concrete specimens were immersed in 3% NaCl solutions for 1, 7 and 15 days. An external current 0.4amps (A) were applied to accelerate the chemical reactions. Corrosion rate was measured by retrieving electrochemical data via PDP technique. Pull out tests of reinforced concrete specimens was then conducted to assess the corroded steel-concrete bond characteristics. Experimental results showed that the corrosion rate of steel bars and steel concrete bond strength were dependent on concrete strength, amount of CN added and
accelerated corrosion period. As concrete strength increased from 20 to 46 MPa, the corrosion rate of embedded steel decreased. The addition of 2% CN to concrete of 20 MPa was not effective in retarding corrosion of steel at long time of exposure. However, the combination of higher strength concrete and 2% or 4% CN appear to be a desirable approach to reduce the effect of chloride-induced corrosion of steel reinforcement. After a day of corrosion acceleration, specimens without CN showed higher bond strength in both concrete mixes than those with CN. After 7 and 15 days of exposure, the higher concentration of CN, the highest bond strength in both concrete mixes achieved, except for the concrete specimen of 20 MPa compressive strength with 2% CN that recorded the highest deterioration in bond strength at 15 days of exposure.

Omotosho (2011) evaluated the electrochemical potential experiments on mild steel rebars embedded in concrete, admixed with aniline inhibitor and fixed amount of sodium chloride salt, partially immersed in sulfuric acid and sodium chloride solution. The OCP corrosion monitoring technique was employed and potential readings were taken in accordance with ASTM C 876. Repressive quality and consistency of the inhibitor was then estimated by the Weibull probability density distribution to study the performance, effectiveness and to predict the most efficient inhibitor concentration in each media. Aniline effect on the compressive strengths of the reinforced concrete samples was also investigated and reported. Varying concentrations of the inhibitor were used and its performance improved as concentration changed in NaCl medium, while no particular order of performance was noted in sulfuric medium. In the statistically analyzed experimental results for each of the inhibitor concentrations employed, 0.34 and 0.41 M aniline admixed samples are identified as exhibiting the best inhibiting quality in sodium chloride (NaCl) while 0.14 M aniline was predicted as showing the lowest probability of corrosion risk in sulfuric acid.
medium. The overall effective inhibiting performance in sulfuric acid was less when compared to the sodium chloride medium. Concrete sample admixed with 0.41 M aniline had the highest improvement in compressive strength in both media.

Strojniški vestnik et al. (2011) studied the corrosion behavior of EN coated SiC particle reinforced squeeze cast aluminum based composite was investigated by Scanning (PDS) and Electrochemical Impedance Spectroscopy (EIS) techniques in aerated and deaerated chloride solutions. Microstructural and interfacial characterization of the composite was carried out by using an optical microscope, Scanning Electron Microscope (SEM), Energy Dispersion Spectroscopy (EDS) and X-Ray Diffractometer (XRD). It has been observed that EN coating of SiC particles is not an effective method to improve its corrosion resistance in structural applications containing halide solution.

Hua et al. (2011) investigated the corrosion behavior of carbon steel in model alkaline medium in the presence of very low concentration of polymeric nano aggregates (0.0024 wt %), polyethylene oxide (PEO113b PS70 micelles). The steel electrodes were investigated in chloride-free and chloride-containing cement extracts. The electrochemical measurements like EIS and PDP indicate that the presence of micelles alters the composition of the surface layers, i.e., micelles were indeed absorbed to the steel surface and influences the electrochemical behavior of the steel, i.e., The micelles lead to increase the corrosion resistance of the steel initially, whereas no significant improvement was observed within longer immersion periods. Surface analysis, performed by environmental SEM, EDAX, and XRD photoelectron spectroscopy, supports the corrosion performance. The product layers in the micelles containing specimens are more homogenous and compact, presenting protective Fe$_2$O$_3$ and/or Fe$_3$O$_4$, whereas the product layers in the micelles-free
specimens exhibit mainly Ferric Oxy Hydroxide (FeO(OH)), Iron Oxide (FeO), and Iron Carbonate (FeCO₃), which are prone to chloride attack. Therefore, the increased barrier effects along with the layers composition and altered surface morphology denote for the initially increased corrosion resistance of the steel in chloride containing alkaline medium in the presence of micelles.

Rajaguru (2012) investigated the EN plating on PerFactory TM rapid prototype model built on PerFactory TM R05 material. PerFactory TM R05 is acrylic based photo sensitive resin. It is a popular material in rapid prototyping using PerFactory TM method which employs addictive manufacturing techniques to build prototypes for visual inspection, assembly etc. Metallization of such a prototype can extend the application envelope of the rapid prototyping technique as they can be used in many functional applications. Unlike the electroless nickel plating on metal substrate, the process on an acrylic resin substrate is not autocatalytic. Hence, etching and activation are necessary for initiating the process. The final coating is then investigated using SEM together with EDS and XRD analysis to identify the morphology and structure of the coating. The SEM & EDS analysis of surface and chemical composition of model surface after each preliminary surface treatment are also presented. Finally the layer is tested on the Vickers micro hardness tester.

Jiaan Liu et al. (2012) studied the preparation and corrosion resistance of Electroless Ni-P coating on open-cell aluminum foams. The Electroless Ni-P coatings were deposited on open-cell aluminum foam substrate by using hypophosphite as a reducing agent. Ni-strike was developed as a pre-treatment for Ni-P coatings to interlock between the substrate and coatings. Thereby, it improves the corrosion resistance of Ni-P coatings on open-cell aluminum foam substrate. The surface morphology,
Yong xin Li (2012) developed the Electroless Synthesis of Ni-P and Ni-P-Zn Alloy coatings for protecting steel rebar from chloride-induced corrosion. Ni-P based alloy coatings on the surface of carbon steel was prepared by the electroless deposition method and their microstructure, chemistry and corrosion behaviors were investigated using SEM, EDX, linear polarization, cyclic voltammetry and electrochemical noise techniques, respectively. The bath solution chemistry was found to play a significant role in the microstructure and properties of the ENP and Ni-P-Zn coatings. With a dense and homogeneous surface microstructure, the best Ni-P coating featured the corrosion behaviour nearly comparable to 304 stainless steel coupons in neutral 3% NaCl. The cyclic voltammetry measurements indicated positive risks of localized corrosion (either crevice corrosion or pitting) for the bare steel rebar (ASTM A615) and all the Ni-P and Ni-P-Zn coatings tested considerably reduced such risks. The corrosion behavior of the selected coatings or bare steel rebars was determined by exposing the rebars in a Simulated Pore Solution (SPS) at pH 13.6 to 1 wt% NaCl media for up to 72h. The electrochemical noise measurements showed that the corrosion resistance of Nickel Phosphorous (Ni-P) and Nickel Phosphorous Zinc (Ni-P-Zn) coating was significantly higher than that of bare steel rebar in the basic and salty environment. On average, they featured corrosion protection against chloride induced corrosion nearly to the level of protection by 316 stainless steel. These alloy coatings provided enhanced corrosion protection for the
commercially available steel rebar as such, they show great promise as an effective and convenient way of treating steel rebars for concrete applications.

Veleva (2012) studied the characteristics of passive films formed on manganese nickel-free stainless steel (SS) exposed to Simulated Concrete Pore (SCP) environment. Manganese (Mn) is a key component in low-cost SS formulations when nickel is replaced by Mn. Passive layers grown on Cr18Mn12 free-nickel SS samples after immersion in saturated Ca(OH)$_2$ and Portland CE test solutions, containing different chloride additions, were studied. The corrosion behavior of the passive films was monitored at open circuit potential in both alkaline solutions. In the presence of chloride ions the passivation process is perturbed and competes with the dissolution one. The surface becomes irregular, rough and Mn was found enriched in areas of nonmetallic inclusions in the passive layer, while the Fe/Mn and Fe/Cr ratios tend to decrease. The formed film is N-richer at the metal-oxide interface, as a consequence of its anodic segregation during dissolution-passivation process. Surface protuberances in the morphology of the SS could be explained in terms of intact oxide inclusions that still remain in the formed passive film or due to manganese insoluble compounds, which aid the corrosion resistance of the studied steel.

Arthanareeswari (2012) developed the anticorrosive performance of zinc phosphate coatings on mild steel by using galvanic coupling. The anticorrosive performance of zinc phosphate coatings developed by galvanic coupling technique on mild steel substrates using the cathode materials such as titanium (Ti), copper (Cu), brass (BR), nickel (Ni), and stainless steel (SS) is elucidated in this study. Thermal and chemical stability tests, immersion test in 3.5% NaCl, salt droplet test, and salt spray test were carried out. The study has revealed that the mild steel substrates phosphates under galvanically coupled condition show better corrosion resistance than the one coated
without coupling. The open circuit potential (OCP) of phosphate mild steel panels in 3.5% NaCl was found to be a function of phosphate coating weight and porosity of the coating.

Fernando (2013) investigated the development of new technologies and the replacement of some special alloys in the equipment used in oil production, such as valves, tubing, sucker rod joints, pumps, riser, manifolds and subsea Christmas trees. These studies began with Brenner and Riddel who developed, in the 1940s, formulations for Ni-P deposition on carbon steel without using an electric current. Joint deposition of nickel and phosphorus on a metallic surface (carbon steel) without applying an external current is accomplished using cathodic reduction with hydrogen (H) from a reducing agent (sodium hypophosphite) and nickel salts. To assure good performance of a Ni-P coating, the deposit quality must be inspected and evaluated during the chemical deposition process or in the end product. The recommended test parameters are thickness, layer uniformity, hardness, adhesion, porosity, corrosion resistance and chemical composition of the nickel-phosphorus coating. The purpose of this research is to investigate the Ni-P coating process, to evaluate the behaviour of Ni-P in a saline environment using aqueous brine (3.5% - 30% sodium chloride by mass) and to present possible defects that could compromise the coating.

Rosa Vera et al. (2013) studied the protective effect of organic coatings used in reinforced concrete in an acid environment similar to those existing in certain metallurgic processes, in which the concrete degradation and the steel corrosion cause significant costs for the metal production. A 0.50 w/c concrete was prepared and then characterized through physical and mechanical tests such as electrical resistance, capillary absorption, total absorption, total porosity, chloride permeability, and tensile and compressive strength. The uncoated, acrylic, and epoxy coated concrete cylinders were
exposed to an artificial acidic solution for 589 days. The corrosion of the steel reinforcement was evaluated by means of corrosion potential and polarization resistance. The morphology of the corrosive attack was observed using SEM and the composition of the corrosion products was determined using an XRD. The deterioration of the concrete and its level of contamination were evaluated by measuring the concentration profiles of chloride, acidity and sulfate. The results show that the reinforcing steel reached an active state in the uncoated concrete and in the acrylic coated concrete, whereas it remained in a passive state in the epoxy coated concrete. Under the conditions established in this study and based on chemical analyses and on the electrochemical tests, it was determined that the coating which performed better as a barrier in an acidic medium was the epoxy coating.

Abdulrasoul Salih Mahdi (2014) studied the inhibition effect of urea fertilizer on corrosion of reinforced steel in concrete immersed in SCP solution using OCP and PDP technique. SCP solution consists of 2% potassium hydroxide (KOH) and 3% NaCl solution was used. Various percentages of urea from 0.2%, 0.5%, and 1% in SCP solutions were examined in this experiment. The OCP tests showed that the potential of reinforced steel samples immersed in SCP solutions containing urea fertilizer was moved more positive than that in the control sample. PDP measurements showed a shifting in Corrosion potential (Ecorr) toward positive direction and a decreased in corrosion current density (Icorr), corrosion rate (CR) of steel samples immersed 2 hours and for 7 days in SCP solutions containing urea inhibitor compared with control sample which is an indication of the formation of the protective passive film on the steel surface. It indicated that urea fertilizer maintained stable passivity even in the presence of aggressive chloride ions. Polarization curves showed that urea acts as a mixed type inhibitor controlling the anodic reaction predominantly. The results explained that after 7 days of immersion in SCP solutions the highest inhibition
efficiency was 86.15% at 0.5% urea concentration. Falling the inhibition efficiency of urea inhibitor to 72.6% at 1% concentration indicate that increasing the concentration is not useful and that an appropriate amount of inhibitor must be used. The experimental results of this research showed that urea is an effective inhibitor, gave good corrosion inhibition for concrete reinforced steel immersed in SCP solutions during the period of this study.

Ilangovan (2014) investigated the various properties and behaviours of EN-P Plated mild Steel. In the present study the mild steel (MS) specimens were coated with Nickel-Phosphorus (Ni-P) using an acrylic bath. Heat treatment was carried out on specimens under different temperatures and time periods in an inert atmosphere. The various mechanical and tribological tests were performed on specimens. Using weight loss method, the corrosive nature of the samples under different environments was also studied. The results showed that there was a significant effect in mechanical and chemical properties of the plated specimens. The properties of the heat treated specimens increased significantly with modest loss in fatigue properties.

Katta Venkataramana et al. (2014) reported the corrosion leads to premature deterioration in the Reinforced Concrete (RC) structures. The interaction mechanism that enables force transfer between reinforcing the surrounding bars and concrete is through the bond between re-bars and concrete. The bond behavior is influenced by the reduced adhesion and cohesion of the reinforcing bars. Local bond stress slips relationship is generally adopted to determine the mechanical properties of the interface between rebars and concrete. The increase in corrosion intensity decreases the axial load carrying capacity of the columns and hence leads to a reduction in strength and ductility. Therefore, the bond performance of the rebars plays a major role in the behavior of RC structures and their parameters that affect the loss of bond strength in rebars.
Kearsley & Joyce (2014) investigated the effect of corrosion products on bond strength and the flexural behaviour of reinforced concrete slabs. New performance based design codes are currently being developed, where the design life of reinforced concrete structures will be estimated by taking into account not only the time to initiation of reinforcement corrosion, but also the time it would take for the extent of corrosion to reach a level where the structure is no longer fit for purpose. It is therefore important to establish what level of corrosion, if any, can be permitted before the structural behaviour of the reinforced concrete member is affected. The effect of corrosion products on the bond strength and flexural behaviour of reinforced concrete slabs was investigated. Pull out tests confirmed that low levels of corrosion (less than 2% loss in the steel cross-sectional area) can result in an improved bond between the reinforcing bars and the concrete. At higher corrosion levels the empirical bond decay functions proposed by various researchers accurately predict the bond strength. The flexural behaviour of the slabs is affected by the reduced bond between the steel and the concrete, and this manifests during the load tests in a reduction in the number of cracks but an increase in crack width, with increased corrosion levels. At high corrosion levels (more than 8% loss in the steel cross-sectional area) the flexural behaviour of the slabs is affected to such an extent that brittle failure occurs.

Osifuye et al. (2014) investigated the effect of varying bath concentration, operating temperature and plating time on the ENP and Zn-P on the class AISI 1045 carbon steel. 0.4 g/L to 0.7 g/L for Ni and Zn concentration was used as bath formulation while other components were kept constant. The operating temperature was varied from 70°C- 100°C and the plating time was between 15 minutes and 35 minutes., It was observed that a bath concentration of 0.50 g/L -0.60 g/L for Ni-P, deposition time of 25-35 minutes and 80°C temperature gave brightness and uniform film deposition on the carbon steel. Bath instability was observed as the
temperature of the bath increased beyond 80°C. Increased concentration of the metal source showed a down effect on the plating process and plating time below 25 minutes led to a dull bright nickel deposit. Zn-P maintained continuous bright deposition from 0.55 g/L to 0.70 g/L. Zinc Chloride salt as the temperature increased from 70°C to 100°C. Increasing the deposition time resulted in a positive effect on the bright deposit of Zn-P on the substrate. It was also observed that increasing time of plating served to increase the amount of deposit per unit area. Both coatings had good wear resistance at the best plating parameter. SEM result revealed the continuous film surface morphology. The plating parameters obtained could be applied on low carbon steel for decorative or improved wear resistance where the cost of another method of coating is high-priced.

Balasubramaniyan et al. (2014) evaluated the corrosion resistance performance of Mild Steel (MS) in SCP solution (pH >12) containing a) 0.5 M sodium Nitrite b) 0.2 M sodium citrate c) 0.4 M sodium benzoate inhibitors in 0.5 M NaCl solution contamination by electrochemical studies. The observed inhibition efficiencies were compared with the gravimetric weight loss method after 30 days of immersion, for inhibited and uninhibited system. The maximum inhibition efficiency of 0.5 M sodium nitrite +0.2 M sodium citrate +0.4 M sodium benzoate mixed inhibitor system was found to be 75%. The inhibition efficiencies for the mixed inhibitor system were compared with control and single inhibitor system. From these studies, it was found that the role of nitrite ion present in the mixed inhibitor system repassivated the mild steel that drastically reduce the corrosion rate even in the presence of high chloride concentration.

Akshatha Shetty et al. (2014) studied the effect of corrosion on flexural bond strength. Corrosion is one of the main causes affecting the durability of structures. Corrosion effects on structures cannot be ignored and
replaced. In order to understand the performance of structures there is a need to study the rate at which different corrosion levels occur. Hence the present investigation has been taken up to study the behaviour of NBS (National Bureau of Standard) beam specimens made up of Ordinary Portland Cement (OPC) and Portland Pozzolana Cement (PPC) concrete matrix was subjected to accelerate corrosion for different corrosion levels of 2.5% to 10% at 2.5% intervals. The results were compared with those for control beam specimen. And it was concluded that the bond stress value decreases with the increase in corrosion levels. Also corrosion leads to the decline of load carrying capacity.

Naiming Lin et al. (2015) evaluated the improvements in the wear and corrosion resistance of RB400 anchor rod steel by ENP plating. Engineering components with high wear and corrosion resistant surfaces are essentially required to meet the ever increasing demands for rapid developments of engineering applications upon the subjections to complex and/or harsh conditions. The need for supporting anchor rods is to resist both corrosion and wear attacks during operation. In the present work, electroless plating was employed to prepare Ni-P coating on RB400 steel for improving surface performance and increasing usage of anchor rod in bracing project. Surface and cross-section morphologies of the obtained coating were measured by SEM and optical microscope (OM). Phase constitution and sectional element distribution were analyzed by XRD and glow discharge optical emission spectrometry (GDOES). A ball-on-disc type tribometer and electrochemical workstation were applied to make comparative evaluations on wear and corrosion resistance of anchor rod steel and Ni-P coating respectively. The results showed that the uniform and compact Ni-P coating was formed on RB400 steel anchor rod substrate. The surface hardness of substrate had tripled after electroless plating treatment. The obtained Ni-P coating indicated good antifriction effect and possessed excellent wear resistance, which was validated friction coefficient, mass loss and worn-out
appearance. The Ni-P coating exhibited higher corrosion potential and lower corrosion current density in comparison with a bared anchor rod. The surface performance of the steel anchor rod was significantly improved by Ni-P coating.

Balasubramaniyan et al. (2015) evaluated the novel corrosion inhibitor for mild steel in SPS with chloride. The corrosion resistance performance of mild steel in SPS (pH >12) containing 0.5 M sodium nitrite, 0.2 M sodium citrate and 0.4 M sodium benzoate inhibitors in 0.5 M Sodium Chloride (NaCl) solution contamination was evaluated by electrochemical studies. From these studies, it was found that the role of nitrite ion present in the mixed inhibitor system repassivated the mild steel that drastically reduces the corrosion rate even in the presence of high chloride concentration.

Xin SHU et al. (2015) evaluates the EN coatings for magnesium alloys. EN plating is a widely used surface modification technology due to superior hardness and corrosion resistance of the deposit. By applying EN coatings on magnesium alloy components can enhance the wear and corrosion performance of the components greatly. However, delicate pre-treat of the substrates and precise control of the plating parameters are essential to get the best quality of EN coating on Mg alloys. This work reviews the EN coatings on magnesium alloys with emphasis on pretreatment steps, showing the improvement achieved, the limitations exist still and shed light on the future trend of this technology on Mg alloys.

2.2 RESEARCH GAPS AND IMPORTANCE OF CURRENT STUDY

From the above review of literature, it was clearly evident that corrosion of steel in concrete is inevitable but can be controlled. Many researchers have worked on the performance evaluation of various protective coating systems and admixtures and corrosion inhibitors. Extensive research
works have been carried out in this area during the last ten decades and as a result different systems and different inhibitors were emerged. CECRI, Karaikudi developed various methods for the protective coating systems. One among them is EN coating. Moreover, very few researchers have analysed the performance of EN coating by using sodium hypophosphate as a reducing agent. In India two types of High Yield Strength Deformed (HYSD) bars confirming to BIS-1786:1985 are used in construction. These are Cold Twisted Deformed (CTD) bars and Thermo Mechanically Treated (TMT) bars. Comparative corrosion characteristics of protective coatings on these bars have not so far been evaluated.

Through the extensive survey of literature, the present investigation is aimed at evaluating the performance of EN coating technique on high yield strength CTD bars and testing them for corrosion protection developed in the laboratory. The objective of using any electrochemical technique for evaluating the corrosion rate of steel in concrete is to measure the steel / concrete interfacial resistance, which controls the corrosion processes. The simplest technique for doing this is one is the easiest technique to carry out, it involves over simplification that may lead to an underestimate of the actual rate of corrosion. The performance and the efficiency of corrosion resistance properties of the electroless nickel coating with and without coating damage in control and coated steel was evaluated by conducting various electrochemical test and calculated the corrosion rate by weight loss measurements as per the standards.