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A REVIEW ON CORROSION AND CORROSION INHIBITORS IN VARIOUS FORMS OF STEEL COMPONENTS

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Abstract

Steel components plays a major role with respect to load carrying capacity of structures , but the major problem in the steel components is the corrosion. When the steel structure is subjected to corrosion which effectively reduces the weight and thickness of the components and also eventually the strength of the steel structural components. The Corrosion occurs when the steel component is exposedto the moisture environment, electrochemical reaction at the interface between the metal and electrolyte solution. In the environment the metals will be subjected to atmospheric corrosion, underground corrosion as well as water corrosion. Environmental factors like pH, moisture, temperature, weather changes, chemical composition, viscosity, and thermal conductivity, will adversely affect the corrosion process. The control of the corrosion is the key aspect for the design and maintenance of the existing buildings. Due to corrosion effects there would be crores of loss in an year. It is concluded that, the corrosion results in reduction of the metal thickness, weight and also mechanical strength. To decide the amount of corrosion in the specimen thickness loss and weightloss are considered. In the present paper corrosion causes and its effects are briefly reviewed.

***Index Terms*: Corrosion, Strength, Thickness loss, Weight loss**

I. INTRODUCTION

corrosion is a natural processes which causes deterioration of steel which leads to major loss and catastrophic failure like collapse by reducing load bearing capacity of the structure. Sometimes it leads to life frightening situations, as a result it has to be addressed for safety, economic and environmental reasons. As corrosion is a natural processes and most of the steel components in India are in front of these problems it has to be addressed properly to enhance their service life. As corrosion is a electrochemical processes leading to degradation of materials, mainly steel components which are exposed to highly polluted industrial environment and mainly marine atmosphere are subjected to corrosion. It is necessary to assess the level of damage caused to structure by visual inspection to evaluate the residual strength in steel components. For a compression member it is insufficient because the capacity is very sensitive to geometrical imperfections. Due to corrosion, the properties of steel such as yield strength, ultimate strength and failure strain are altered. In 1967 and in 1983 the for the failure of silver bridge and Mianus river bridge corrosion played a major role for the failure of bridge structures. These failure revealed that utmost importance has to be given for inspection of older bridges. Even galvanized has experienced the corrosion phenomenon. It is necessary and important to assess the strength parameters of important structure such as telecommunication towers and transmission towers to evaluate the residual strength which has undergone corrosion processes.

II. LITERATURE REVIEW

A.Cinitha , P. K. Umesha and Nagesh R. Iyer (2015)

In the present paper various issues connected to corrosions, types of corrosions, chemical reactions and electrochemistry over corrosion of steel structures, requirements to quantify corrosion and also study regarding experiments on corroded coupons and compression members made of angle and tubularsections are studied. Coupon test was conducted on 11 specimens to study the behaviour of steel specimen. Galvanostatic approach is adopted to corrode the steel specimen by keeping current as constant. Observations are taken and , Stress vs Strain graph extracted from Angular membersand tubular coupons were plotted. From the experimental study it was noticed that, corrosion leads to reduction in metal thickness along with weight loss and reduction in mechanical strength. From the compression test it has observed that the location and loss of metal due to corrosion have a significant

behaviour on structural behaviour. Considering steel angle sections, there is a reduction of ultimate load carrying capacity from 1.5 - 37.9 % and for hollow tubular sections it reduces to 10 - 25%.

Umeozokwere Anthony , Mbabuike Ikenna, Oreko Benjamin Ufuma, Ezemuo (2016)

In the present study, the rate of corrosion and the impact of corrosion on mild steel in different environmental circumstances like- 0.1M of Hydrochloric acid, Underground soil, Atmosphere , Salt water and Fresh water are studied. Steel specimens of similar sizes were subjected to various environmental conditions for a duration of six months with a weekly inspection by weighing the sample and re-immersing to various environments. The corrosion rate and weight loss were presented and it was observed that the rate of corrosion increased and indicated the following trend 0.1M Hydrochloric acid, Underground soil ,Salt water, Fresh water and Atmosphere. Few models were developed to predict and analyze the rate of corrosion in different environments. It was noticed that the laboratory method was considered to be the quickest and economical method to evaluate the rate of corrosion for different environmental condition.

A. Cinitha , P. K. Umesha , G. S. Palani , V. Sampath (2018)

In this paper, the behavior of structural steel members is analyzed by exposing to different degreesof corrosion and high temperature. Galvanostatic approach is used to cause corrosion in a structural steel component. The microstructural analysis was conducted to analyze the variation in mechanical and chemical properties in steel components. The average material properties were determined and Stressvs Strain graph was plotted.. The chemical analysis result of steel tubular members were tabulated. The static axial compression test under hydraulic load was conducted at elevatedtemperatures and results are tabulated. At elevated temperatures and at different degrees of corrosion seven compression test specimens were conducted up to the failure of specimen. The results are analyzed and graphs are plotted for Axial load vs Deflection and Strain. It was concluded that 21% reduction in strength was observed for a specimen corroded with 20% weight loss and 36% percent reduction in strength was observed for 40% weight loss compared to uncorroded samples.

Katalin Oszvald, Laszlo Dunai (2013)

In this paper, the stability behavior of corroded compression angle members by numerical study is carried out. Diversity in corrosion is considered by applying different corrosion patterns, reduction of thickness, extension and position of corrosion. The experimental study is carried out by considering 24 specimens. Centric compression is applied and the effects of uniform, pitting and local corrosion damages is noticed. The result of buckling test showed that the resistance on basis of maximum cross section reduction shows better approach when compared to the average cross section. Centric compression test were also conducted on shell and solid models. Test results were analyzed for horizontal displacement of specimen. Numerical study of GNB and GMNI analysis for corroded and non corroded steelstructural members are carried out.

Viktor Urbana , Vit Krivy , Katerina Kreislova (2015)

In the present paper, the corrosion tests were carried out on weathering steel bridges. Steel bridges components were exposed to atmosphere for about one year and results were analyzed. The tests wereconducted such that, the corrosion specimens were installed on 10 weathering Steel structures in Czech Republic. Towards end, there were 97 testing specimens mounted on it. The evaluation of specimens were carried out due to development of corrosion products on typical areas, and it was observed that the corrosion products was affected byleaking and corrosion losses. By conducting the tests, specification of analytical model for calculation of design values and corrosion losses were analyzed. Results shows that,corrosion losses are conditioned by location of exposed surfaces within the structure. From the tests, description of dependencies between two measured quantities for longer exposure is determined .

T. Kaita, J.M.R.S. Appuhamy, M. Ogha, K. Fujii (2012)

In the present study tension tests were carried out on 26 specimens for different corrosion circumstances for a width of 70-180mm and the accurate measurement of remaining strength was evaluated. By considering the corrosion conditions and minimum thickness ratio the tested specimens were categorized into three categories. The tensile effective thickness and yield effective thickness is determined by the empirical formula. The yield strength was estimated by considering the correlation between yield effective thickness and measurable statistical thickness parameters. The relation for average minimum thickness was found. Tensile strength has been estimated by considering correlation between tensile effective thickness, measurable statistical thickness parameters and minimum average thickness. The graph of tensile effective thickness vs minimum average thickness was found andresults were analyzed.

J.M.R.S. Appuhamy , M. Ohga , P. Chun , P.B.R. Dissanayake (2012)

Present paper describes that corrosion and fatigue cracking are the two main losses occurring in steel structures. The specimen used for testing was a steel girder bridge of Ananai River, Kochi in the shore of Pacific Ocean. The corroded 21 specimens were taken and tensile test was conducted.
Yield, tensile strength, failure surfaces and ultimate behavior of corroded members are evaluated by using non linear finite analysis. The Corroded materials was categorized into 3 types by taking corrosion conditions and minimum thickness ratio into consideration. To evaluate the initiation of ductile fracture as the function of multiaxial plastic strains and stresses, "Stress Modified Critical Strain Model (SMCS)" was proposed. The results were analyzed by the graph between Load vs Displacement. Two corrosion condition modelling (CCM) parameters were analyzed to model the corroded surface by taking material loss into consideration. Results were analyzed based on experimental and theoretical approach. Primary and Secondary Seismic analysis was carried out by considering load and displacement.

Ashutosh S. Trivedi, Arpit Singh Bhadoriya, Manoj Sharma (2018)

Present paper provides an overview of corrosion in reinforced steel structures and to examine water-cement ratio, concrete fluidity and alkalinity during placement. It is predicted that corrosion in the initial stage can be easily predicted by Acoustic Emission (AE) effectively. Mechanism of corrosion, factors effecting corrosion are discussed in the present paper. It is noticed that Calcium palmitate and its combination with calcium nitrite reduces the strength in concrete. It was noticed that W/C ratios had a major impact on the magnitude of macro cell current. The lower water-cement ratio could effectively inhibit the macro cell current by weakening the kinetics of cathodic and anodic reactions, thus the lower W/C ratio not only increases the macro cell polarization resistance of the cathode but also increase the microcell polarization resistance of the anode. From the experimental investigation it was observed that during corrosion processes more longitudinal cracks were observed in the constant current specimens than in the constant voltage specimens. Under tensile stress the rate of corrosion will be faster compared to compressive stresses. Different methods to evaluate corrosion such as Coulostatic technique, Galvanostatic pulse method, Half-Cell potential, Linear polarization resistance (LPR), Time domain reflectometry (TDR), Ultrasonic guided waves, X-ray diffraction, and atomic absorption are also discussed in this paper.

Sidhant Agarwala , Omprakash Netula (2017)

Present paper focuses on control of corrosion in underwater piles. Corrosion mechanism in sea water, corrosion management and methods adopted for corrosion protection and fiber- reinforced polymer composites are examined in this paper. As steel piling is used in water chemically charged areas (Anode) are intensively connected to lesser active chemical surface (Cathode) which leads to corrosion of anodic areas due to flow of electric current. Corrosion occurs in three stages. During stage 1 progress is carried out by programmatic assessment. In the second stage actual remediation and physical assessment is carried out and in the third phase repaired structure monitoring is carried out.
From the study it is noticed that corrosion protection is carried out by coating the metal surface with continuous non porous material which reduces the rate of corrosion (Protective coating). The coatings are categorized into different categories like metallic , organic and inorganic. Different types of coatings are used for underwater piles such as Inorganic zinc silicateprimers, Epoxy Coatings (High Build), Epoxy Primers (Zinc Rich), Aliphatic Polyurethane Topcoats, Non-Skid Deck Coating and Cathodic Protection (CP). Also in this, studies is carried out on Fiber Reinforced Polymer Composites which is widely used for the repair and rehabilitation for concrete structures by increasing tensile capacity by providing the lateral support. When FRP is provided along with concrete it protects the piles by preventing corrosion and it also protects from UV Radiation. The benefits such as chemical resistant, light weight ,high strength and high degree of flexibility are observed in FRP.

Marko Chigondo, Fidelis Chigondo (2016)

An overview of corrosion and the study on the recent natural corrosion inhibitors for mild steel is focused on this paper. From the study it is identified that the corrosion prevention measures such as, Synthetic Organic Corrosion Inhibitors, Some Active Ingredients in Green Corrosion Inhibitors for Mild Steel, and Plant Extracts as Corrosion Inhibitors can be used to prevent corrosion For Mild Steel. The types of corrosion such as Uniform Corrosion, Galvanic Corrosion, Pitting Corrosion, Stress Corrosion Cracking, Corrosion Fatigue, Intergranular Corrosion, Crevice Corrosion, Filiform Corrosion, Erosion Corrosion, Fretting Corrosion are reviewed in this paper. The prevention of corrosion can be done by cathodic protection and by the use of suitable inhibitor. cathodic protection is carried out by using a metal to work as a cathode in electrochemical cell. In aqueous environment corrosion inhibitors are most suitable technique to prevent corrosion. From the study the Synthetic organic corrosion inhibitors are the synthetic compounds containing multiple bonds which constitutes these inhibitors are expensive and toxic to human and the environment. But there aresome active ingredients such as Green Corrosion Inhibitors for Mild Steel and the the plant extracts have some potential to replace the synthetic Organic and Inorganic inhibitors which has been successful. The adsorption of natural corrosion inhibitors on metal surfaces is influenced by many factors includingnature, testing media, and chemical structure of inhibitor.

MA Quraishi, DK Nayak, R Kumar, V Kumar (2017)

Present paper focuses on the mechanism of corrosion and the control of corrosion in reinforced steel concrete. The parameters such as oxygen, humidity (Electrolyte) are essential to initiate the corrosion. Presence of moisture, humidity and oxygen acts as a catalyst to initiate the corrosion. One of the major reason behind corrosion is chloride attack. Water , aggregate, cement , admixtures, de-icing salts and seawater are the major source of chloride attack. From the Bureau of Indian Standards maximum chloride content in cement should be 0.1 percent. Soil encompasses sulphate in the form of gypsum. Solid sulphate is not effective in initiating corrosion but it reacts with hydrated products of cement to form calcium ettringite within the hydrated cement. Delayed ettringite formation (DEF) causes expansion of hardened concrete leading to cracks and damage in structure. In addition due to loss of bond between cement paste and aggregate reduction in strength is noticed. anodic inhibitors, cathodic inhibitors and mixed inhibitors are used to prevent corrosion. Protective oxide film is formed on the metallic surface which forces into passivation region. Whereas cathodic inhibitors are less effective than the anodic inhibitors. The mixed inhibitors are thecombination of both anodic and cathodic inhibitors.

Ahlstrom, Tidblad, Sandberg, Wadso (2015)

Present paper focuses on the study of Galvanic corrosion and its properties of steel in saturated concrete, to prevent the continuous corrosion in cooling water tunnels of a nuclear power station. In a reinforced concrete aluminum-based sacrificial anodes are used. Steel bars were also attached to the stainless steel water pipes. Consequently the rate of sacrificial anode depletion was more than expected. In pore water solution due to high pH steel is generally passive in concrete with low chloride concentrations. By using carbon steel composition of the alloy electrochemical experiment is conducted. A steel bars of 12mm diameter were cut into 150mm length. All steel bars were degreased with trichlorethylene before casting. A mixture containing Portland cement and 4 mm sand is used to cast a steel with a cover of 60mm with water cement ration 0.6. A cylindrical tube made of stainless steel was used as counter electrode and close to the concrete sample, an electrode was inserted. The electrodes were either an Ag/AgCl saturated, KCL electrode or a saturated calomel electrode. 3% Nacl is used to submerge an electrode. The surface of the test sample was cleaned at each potential, the sample was polarized and the results were recorded. Due to this measured potentials in the cooling water tunnels did not exceed 600 mV (SCE) on the side without sacrificial anodes. The potential on the side withanodes, the voltage was reduced to 700-800 mv. The chloride concentration in the cooling water was found to be the more than 0.7 by mass of cement. The Electrochemical experiment showed the risk of Galvanic corrosion of steel in the concrete when the potential is anodically polarized to above 200 mV.

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