INTERNATIONAL JOURNAL
FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

www.ijraset.com

Call: ⓒ08813907089 | E-mail ID: ijraset@gmail.com

A Study on Novel Approaches to Measurement of Corrosion of Reinforcement in Concrete Structures

B. Abhilash[1], B. Pavan Kumar[2], Ch. Naveen Kumar[3]
[1, 2, 3]UG students, Dept. of Civil Engineering, VNR VJIET, Hyderabad, India.

Abstract: Concrete and steel are widely used in the field of Construction of buildings, super structures and water tanks. A passive film is formed on the surface of the steel inside the concrete which protects the steel from corrosion. The passive film in concrete is protected by high alkalinity. However, when the chloride concentration at the region of steel exceeds the chloride threshold level, the passive film breakdown occurs. As concrete is weak in tension, steel reinforcement is provided in concrete structural elements to strengthen the structure against tension, but structures do fail due to corrosion attack on steel. The corrosion of steel reduces its durability which results in the failure of the structure. Corrosion is a process which results in the destruction or deterioration of a material when exposed to various environmental conditions. In the field of structural engineering, steel corrosion in concrete is of great concern. However, accurate method for the quantitative analysis of corrosion has not been discovered yet. In the past years, many reinforced concrete structures in the world have been suffered from rapid deterioration. Durability of structures especially which are exposed to environment is our main concern. A few deteriorations causes and factors have been explored. Reinforcement corrosion in concrete structures was found to be major deterioration problems. This paper mainly concentrates on the importance of corrosion of reinforcement and explains few methods for determination of corrosion state in reinforced concrete structures and also presents few methods like Half-cell potential method, Resistivity meter, Electrochemical sensors on how reinforcement can be protected from corrosion in reinforced concrete structures. Thus, more researches should be done to develop the preventive methods of corrosion of steel that are durable, economical, environment-friendly and do not cause any adverse effect on the structural behavior of concrete and steel
Keywords: Concrete, Steel, Reinforcement, Corrosion, Durable, Structural performance

I. INTRODUCTION

Reinforced concrete structure durability is influenced by many environmental factors. Corrosive agents like de-icing or seawater salts are the major factors causing deterioration in structures. In the alkaline environment, the reinforcement that is embedded is protected by a passive layer. Loss of alkalinity because of chloride attack on concrete or carbonation of concrete can break the steel passivity; this process results in corrosion of reinforcement. The concrete and the steel reinforcement both are damaged because of corrosion. When corrosion occurs in steel reinforcement, the original shape of corroded bars will be lost and the deformed reinforcement bars ribs will be diminished. Major changes in reinforced concrete members are because of the physio-chemical reaction of corrosion. For example, rust materials produced by corrosion of steel bars will occupy small volume than the original steel. Hence the volume expansion leads to cracking created by splitting stresses acting on the concrete. Consequently, the cracks may result in concrete cover spalling. Ultimately, such damage might increase the rate of corrosion. The cross-sectional area of the steel reinforcement bars will reduce its mechanical properties; cover cracking and spalling will affect on the mechanism of bond. Load-carrying capacity and ductility in the ultimate state, together with stiffness distribution and deflection in the service state will be affected due to the effects of corrosion on the bond mechanism.

II. METHODOLOGY TO MEASURE THE CORROSION OF STEEL IN REINFORCED CONCRETE STRUCTURES:

1) The corrosion of steel cannot be analyzed visually until a crack or strips are formed.
2) The corrosion of steel can be treated using some electrochemical techniques.
   Ex: The half-cell potential measurement method.

A. *Half-cell Potential Measurement Technique*
1) This technique is used with few other techniques in combustion.
2) Methodology for measuring the corrosion in concrete structures is assessed by combination of half-cell potential method with concrete resistivity method.
3) Sample of 750mm x 750mm x 200mm RC Slab were investigated.
4) Their results indicates that the above technique can be used to measure the corrosion of steel.

B. Polarization Resistance Technique
1) Polarization resistance technique (non-destructive) is expressed in gA/cm^2.
2) The values of corrosion can be assumed by the rate of deterioration of concrete structures affected by corrosion of steel.
3) They do not provide information on the actual loss in steel cross-section. This device uses Connect-ion less Electrical Pulse Response Analysis (CEPRA) system to operate.

C. Resistivity Meter
1) It is an electro-chemical method which generates a current flow.
2) The resistivity of concrete influences the current flow. Lower is the electric resistance more easily current flows through the concrete and greater will be the probability of corrosion.

III. CAUSES OF CORROSION

Attack of sulphate, acid attack, chloride attack, carbonation required presence of water because this chemicals are present in external environment for them carried in to the concrete a liquid medium is necessary to enter in to the concrete.

A. Carbonation Corrosion
Day by day the CO2 emission increases which is become more concern topic. The emission of CO_2 from vehicles, construction industry, burning of waste, industries etc. The urban structures present in other than coastal areas are more prone to CO2 attack. Structures in coastal areas also do attacked by carbonation. carbonation in reinforced concrete structure destroy the passive layer of steel by reduction of alkalinity of the concrete this leads to initiation of corrosion of concrete. Figure 3 compares the carbonation effect through a typical sheltered and unsheltered

Fig 1: shows effect of carbonation in sheltered and unsheltered (open to sun)

Structures. The Sheltered structures are more prone to carbonation attack than that of unsheltered structures since the fact is that humid environment more prone to carbonation corrosion than dry environment similarly sheltered structures environment will be like humid therefore it favors carbonation corrosion whereas unsheltered structures which are open to sun therefore dry environment are less prone to carbonation corrosion .

Fig 2: shows the a real bridge structure which is prone to carbonation attack.

Similar to the sheltered and unsheltered concept the inner part structure is more prone to carbonation corrosion since humid environment than that of part of the structure which is expose to atmosphere.

IV. CAUSES AFFECTING CORROSION OF STEEL

A. Effect of inside moisture
B. Leakage/Dampness
C. Inadequacy of Concrete cover
D. Carbonation
E. Impurities of water
F. $CaCl_2$ as accelerator
G. Electrolysis
H. Alkali-aggregate reaction
I. Grade of concrete
J. Age of Concrete structure
K. Environmental Influences

V. MONITORING SYSTEMS TO MEASURE THE CORROSION IN STEEL BARS

A. Half-cell potential method
B. Resistivity meter
C. Electrochemical sensors

VI. SERVICE LIFE PREDICTION OF REINFORCED CONCRETE STRUCTURES:

Service life of a structure is the time period during which the structure satisfying its design requirement for which it is designed without unexpected costs or disruption due to maintenance and repair. The service life of a structure can be understood by two different stages. The first stage called as initiation phase(corrosion-free) during this stage there will not be any corrosion but chloride, CO2, and other chemical agents starts enter in to the concrete which reduce the PH of concrete when PH decreases to approximately 9 then corrosion starts show its effect on reinforcement. The second stage called as propagation phase where the protective passive layer of reinforcement starts de-passivating and thereby the probability of failure of structure, cracking, load carrying capacity and durability problems increases. The corroded reinforcement loss its cross sectional area and increases its volume (2 to 3 times that of initial) therefore cracks will be developed which leads to more corrosion and consequently staining will starts. i.e., from here onwards repair phase starts .

The chloride diffusion, carbonation, inadequacy of concrete cover, penetration of sea water in to pores of concrete, sulphates attack, etc. are the some most damaging factors which cause for corrosion.
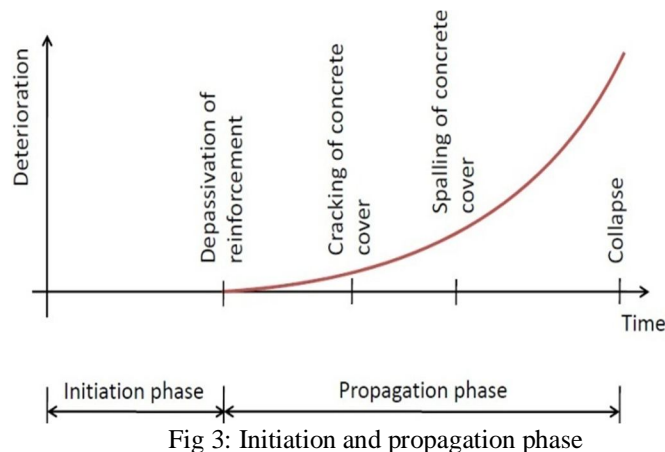

Fig 3: Initiation and propagation phase

Initiation of crack of concrete cover because of corrosion determines the final service functional life where restoration or substitution is required for corroded reinforcement. Some Studies have been conducted to estimate the crack propagation patterns and the time using a thermal analogy defined in 3D non-linear finite element models. This models explain the crack initiation and propagation for both uniform corrosion and non-uniform corrosion. Assuming uniform corrosion might lead to estimation of non-conservative functional service life.

VII. CHALLENGES TO IDENTIFY THE CORROSION OF REINFORCEMENT

Electrochemical techniques are widely used techniques for the analysis and study of corrosion of reinforcement which includes Electrochemical Impedance Spectroscopy (EIS). EIS is a type of technique used for evaluating a wide range of electrochemical systems in determining the contribution of electrode or electrolytic processes.

Reinforcement corrosion is widely reported in recent decades in the literature. The main causes of reinforcement corrosion are concrete carbonation or acidic gases penetration into the concrete. Besides these, there are few other factors, some of them related to the quality of concrete such as water/cement ratio, cement content, impurities in the ingredients, surface cracks, etc. Some other reasons related to the external environment such as temperature, oxygen, moisture, humidity, stray currents, bacterial attack, etc. The analysis of these causes and extent of corrosion are being carried out by using various electrochemical techniques.

VIII. CONCLUSION

The major problem for failure of reinforced concrete structures is because of corrosion of embedded steel bars. In this paper, we focused on the different non-destructive techniques for analyzing the corrosion condition of reinforced concrete structures like Polarization resistance technique, half-cell potential measurement technique and Resistivity meter technique.

Crack initiation determines the service life where restoration or substitution is required for corroded reinforcement. Continuous monitoring of concrete cover and steel might be able to predict more statistics about the present and future performance of the structure.

REFERENCES

[1] Analysis of Half-cell potential measurement for corrosion of reinforced concrete by VeerachaiLeelalerkeit, Je-Woon Kyung, MasayasuOhtsu and Masaru Yokota.

[2] Corrosion Monitoring of Reinforced Concrete Structures – A Review by SaraswathyVelu and Ha-Won Song.

[3] Test methods for on-site corrosion rate measurement of steel reinforcement in concrete by means of the polarization resistance method by Carmen Andrade and C. Alonso.

[4] Methodology for assessing the probability of corrosion in concrete structures on the basis of half-cell potential and concrete resistivity measurements by Lukasz Sadowski.

[5] Lee, H. S., Saraswathy, V., Kwon, S. J., &Karthick, S. (2018). Corrosion inhibitors for reinforced concrete: A review. Corrosion inhibitors, principles and recent applications, 95.

[6] Quraishi, M. A., Nayak, D. K., Kumar, R., & Kumar, V. (2017). Corrosion of reinforced steel in concrete and its control: An overview. Journal of Steel Structures and Construction, 3(1).

[7] Tawfik, T. A., El-Yamani, M. A., Abd El-Aleem, S., Gabr, A. S., &Abd El-Hafez, G. M. (2019). Effect of nano-silica and nano-waste material on durability and corrosion rate of steel reinforcement embedded in high-performance concrete. Asian Journal of Civil Engineering, 20(1), 135-147.

[8] Abreu, G. B. D., Costa, S. M. M., Gumieri, A. G., Calixto, J. M. F., França, F. C., Silva, C., &Quinõnes, A. D. (2017). Mechanical properties and microstructure of high performance concrete containing stabilized nano-silica. Matéria (Rio de Janeiro), 22(2).

INTERNATIONAL JOURNAL
FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089   (24*7 Support on Whatsapp)