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Corrosion Monitoring of Reinforced Concrete Structure

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Abstract: Concrete is used as construction material in the form of plain or reinforced concrete the world. It has to withstand the physical, chemical and environmental effects for fulfilling the durability characteristics. The environmental changes due to pollution, lack of maintenance, poor quality of work, lack of supervision, use of defective materials etc have also taken a heavy toll of concrete structures. Among various factors affecting the reinforced concrete structures the atmosphere, water, salts are most common factors which play a key role for corrosion. Handling with PCC is no problem but dealing with RC is one of the great work. Proper handling and monitoring is essential for RC as it contains reinforced steel which may corrode and lead to corrosion. Corrosion of steel is worldwide problem. It is causing cr. of rupees of loss through repair and maintenance so as to keep the facilities functional. The risks of corrosion in structure are quite unpredictable and unavoidable. For prevention of corrosion problems various Non-Destructive Techniques are used.

Keywords: Corrosion, Concrete, Steel Monitoring, Electrochemical techniques.

Introduction: Concrete is a complex material of construction that enables the high compressive strength of natural stone to be used in any configuration. This is accomplished by breaking natural stone to suitable sizes and mixing the aggregates so formed with suitable proportions of water and cement. This mixture can then be moulded into any required shape while still fluid. The water and cement react chemically, forming a glue that bonds the pieces of stone aggregate together into a structural member, which becomes rigid and strong in compression when the chemical re- action is completed (i.e. the concrete is cured). In tension, however, concrete can be no stronger than the bond between the cured cement and the surfaces of the aggregate. This is generally much lower than the compressive strength of the concrete.

Causes Of Corrosion

Corrosion is a destruction of material because of its reaction with the environmental conditions the most predominant among various factors of corrosion is the atmospheric corrosion which causing the rusting of steel. Appreciable corrosion only starts when the relative humidity of the air exceeds around 65 percent of water there is no danger of the corrosion. Corrosion may be defined as the involuntary destruction of substances such as metals and mineral building materials by surrounding media.

Factors Affecting Corrosion

1. Quality of Concrete
2. Cover Thickness of Concrete over Reinforcement
3. Condition of Reinforcement

4. Effect of Environment and Other Chemicals
5. Porosity of Concrete
6. Effect of High Thermal Stresses

Literature Review

A significant amount of research work on various aspects of Corrosion Monitoring of Reinforced Concrete Structures has been published by many investigators.

Kumar Sanjay and Kumar Virendra (2001) studied that the damage due to corrosion is a serious effect upon the mechanical properties of concrete structures. Once the corrosion of reinforcement starts due to formation of oxide and if the structure is under load, the stress acting on it increases. In such case the ultimate tensile stress (UTS) exceeds and finally the structure fails. The present paper also highlights the corrosion of reinforced concrete structures, factors influencing corrosion of reinforcement, and its remedial measures to some extent. Further they arrived at following conclusions:

1. Due to corrosion of reinforcement, cracks in concrete structures is commonly appear on face of the concrete surface. This can be eliminated by using proper concrete grade, curing and compacting.
2. Due to reinforcement corrosion, the cross-sectional area of steel is reduced and it will fail under designed load as its cross-sectional area becomes less than calculated for design.

Ha-won Song and Velu Saraswathy (2007) stated various methods for Corrosion Monitoring Reinforced Concrete Structures. This paper 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. The Review was published in International Journal of ELECTROCHEMICAL SCIENCE. The paper review concluded:

1. A number of electrochemical rebar corrosion measurement techniques available presently are reviewed. Each technique is reviewed to possess with certain advantages and limitations. To obtain maximum information about the corrosion state of rebar in a particular structure, a combination of measuring techniques is recommended. Although the electrochemical corrosion measurements are usually qualitative and also semi quantitative, significant benefits can be derived from them.
2. Corrosion monitoring can be a vital part of planned maintenance and life prediction by giving quantitative information about the development of corrosion as aggressive conditions develop in the concrete due to chloride ingress or carbonation. It can also be used to assess the effectiveness of rehabilitation systems such as coatings or corrosion inhibitors. Installations have been carried out on new structures with long life requirements for planned maintenance and to prevent premature repair requirements.

Jamal RHAZI (2009) described an experimental investigation on a reinforced concrete bridge deck to compare half-cell potential measurements carried out from the underside to those obtained from the upper side of the deck. It was noted that the results are similar but are not identical. This particular situation is caused by the physical conditions of the upper-side and lower-side of the decks which, sometimes, can be similar. This article presents the results of an investigation carried out on a concrete bridge deck to determine the possible correlations between the HCP (Half-cell Potential) measurements collected from the lower-side to those collected from the upper-side of the decks. His experimental investigations report shows that the HCP values collected from the lower-side of a concrete bridge deck can be similar to those collected from the upper side when the physical conditions of the lower and the upper sides of the deck are similar.

Steven F. Daily (2005) stated that for the corrosion to occur there are four basic elements:

a)Anode b)Cathode c)Electrolyte d)Metallic Path. Normally concrete exhibits a pH above 12 because of presence of potassium hydroxide, calcium hydroxide, sodium hydroxide. There are two major situation in which the corrosion of reinforcing steel-

1)Carbonation 2)Chloride Contamination.

S.M.Morsy and I.Z.Selim (1995) described the Electrochemical techniques of the corrosion measurements of reinforcing steel in concrete. These techniques include half-potential measurements, impressed voltage method, impressed current method and potentiostatic polarization technique. They investigated the corrosion behaviour of the steel in both.

V. Kumar and Ramesh Singh (2013) stated that Literature on reinforcement corrosion in concrete structures, its mechanism and factors affecting corrosion of steel in concrete are available. Extensive research work has been devoted to develop models that predicts the time for corrosion initiation. The study reveals that though Calcium palmitate and its combination with calcium nitrite reduces the concrete strength but inhibition to the corrosion of the rebar increases the service life of the Reinforced concrete by 8 to ten times.

Guangling Song and Ahmad Shayan (1998) written a report on "Corrosion for steel: Causes, Detection and Prediction". In this report, achievements in area of measurement and prediction of corrosion of steel in concrete as well as, the factors affecting corrosion behaviour of steel reinforcement are summarized. It also deals with prevention and rehabilitation of corrosion damage reinforced concrete structures.

Sanjeev Kumar Verma presented paper on "Monitoring Corrosion of Steel Bars in RC structure". This paper attempts to present the importance of monitoring reinforcement corrosion and describe the different methods for evaluating corrosion state of RC structure. This paper also present few techniques to protect concrete from corrosion.

Shin-Ichi presented paper on steel corrosion induced by chloride or carbonation in mortar with bending cracks or joints. The objective of this study is to experimentally investigate comprehensively the pattern of corrosion cell formation as well as the corrosion rate using mortar specimen with defects simulating cracks & joints.

C. Andrade (2009) presented paper on "Reinforcement Corrosion: Research Needs". The paper reviews some of the subject, although not all related to the fundamental of the corrosion, the management of service life and repair techniques. The task to summarize all important aspect is to wide and much further basic work is needed in the area.

Dubravka Bjegovic describes electro potential mapping method and measuring technique with Gecor 6 device. Their application based on our own experiences and interpretetion of the measurement results. The main investigation is detection and measuring of defects is the initial stage of corrosion process.

Fernanda Giannotti's paper described that OCP is most typical procedure for routine inspection of reinforced concrete structure and gives an approximately idea of the corrosion process based on this technique. This study is related to the steel corrosion in high performance concrete with sillica fume and sillica from rice husk.

Facundo Almeraya presented paper on Advance Materials Research Center (CIMAV), 31109 Chihuahua CHIH, Mexico. The paper reviews some interesting Non-destructive ultrasonic method to determine the penetration extent of the concrete degradation by exposure of acid solution.

M.F. Montemor and Simoes (2003) studied that one of the most important cause for reinforcing steel corrosion is the present of chloride ions. They cause localised breakdown of the passive film that initially forms on steel as a result of the alkaline nature of the pore solution in concrete.

Conclusions: From the above literature review it is concluded that there are so many research work on corrosion monitoring by using electrochemical techniques that have been done. All the methods have some

limitations and disadvantages, so this project fulfill these gap. We hope that this documents will provide up to date collection of information in the field, and will help to engineers to under-stand the causes of corrosion and techniques of monitoring. Following are the conclusion of this literature survey-

1. Due to corrosion of reinforcement, cracks in concrete structures is commonly appear on face of the concrete surface. This can be eliminated by using proper concrete grade, curing and compacting.

2. A number of electrochemical rebar corrosion measurement techniques available presently are reviewed. Each technique is reviewed to possess with certain advantages and limitations. To obtain maximum information about the corrosion state of rebar in a particular structure, a combination of measuring techniques is recommended. Although the electrochemical corrosion measurements are usually qualitative and also semi quantitative, significant benefits can be derived from them.

3. Half cell potential of the steel in concrete has been found to be a fast indicator of corrosion activity. The change in potential occurs when the corrosion inducing agent diffuses to the steel surface through concrete and initiate the corrosion.

4. The use of Calcium Palmitate reduces the compressive strength of the concrete but inhances the inhibition capacity of reinforced concrete considerably increasing the service life of RC structure almost ten times.

5. The composition of the passive film formed on reinforcing steel and the mechanism of its breakdown by chlorides can be explained by more than one model. However it can be assumed that chloride ion form soluble complexes with iron leading to localised acidification and consequent pit growth. Chlorides can bind with concrete, being partially immobilised in the matrix. In spite of this, bound chloride may participate in the corrosion process.

6. Due to reinforcement corrosion, the cross-sectional area of steel is reduced and it will fail under designed load as its cross-sectional area becomes less than calculated for design.

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