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# DEVELOPMENT OF CEMENT BASED EPOXY RESIN USED AS ANTICORROSIVE REINFORCEMENT COATING: A REVIEW

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***Abstract*— This paper presents in brief, the development of cement based epoxy resin anticorrosive reinforcement coatings used so far to protect the steel embedded in concrete against corrosion. Epoxy resin has good adhesive properties and cement is used as binding agent. Reinforced concrete is one of the most versatile construction material which used for the construction of several strategic structures like long-span highway bridges, pavements, off-shore structures, multi-storied framed structures and many other mega- industrial structures. Engineers still believe that once the reinforced concrete structures are designed and built, it will remain durable and maintenance free and they can fulfil the intended purpose and function for the whole of its designed life, but the microstructural properties and permeability of concrete to various aggressive ions are responsible for corrosion of reinforcement in concrete. The present work involves the development of cement based epoxy resin reinforcement coatings.***

***Keywords*— Epoxy resin, Epoxy resin curing agent, Cement, Solvent, Anti corrosive coating.***

## I. INTRODUCTION

Lots of research and literature have been published on the testing and performance of epoxy coated reinforcement. Most laboratory and field trial research has shown epoxy-coating to be an effective corrosion protection system, (Tech 32) Epoxy resin was discovered in 1938 by Pierre Castan, a chemist in Switzerland. As of 1989, 137,000 tons of epoxy resin had been produced in Japan, and epoxy resin has been used in a wide range of fields, such as paints, electricity, civil engineering, and bonds. This is because epoxy resin has excellent bonding property, and also after curing, it has excellent properties on mechanical strength, chemical resistance, and electrical insulation. Durability of concrete structures mainly depends on corrosion rate of steel bars in concrete. In search of ways to extend service life of reinforcement bars in concrete structure is widely concerned by the civil engineering circles. Measures have been tried to inhibit corrosion of reinforcement bars for the past decades. One popular way is application of a coating on the reinforcement bars which can be effective in minimizing the rate of reinforcement corrosion in concrete structures. The most commonly used materials for protecting steel bars from corrosion were epoxy-resin-based coatings.

The use of epoxy-coated reinforcing steel was one of the techniques developed to extend the service life of newly constructed concrete structures. Epoxy coated reinforcing steel was first used in the construction of a bridge deck in Pennsylvania in 1973 under the Federal Highway Administration's National Experimental and Evaluation Program Project No. 16 (Kilareski, 1977). By 1976, 40 bridge decks had been constructed with Epoxy-coated Reinforcement in 18 states and the District of Columbia under this program. Currently, Epoxy Coated Reinforcement is the most used corrosion protection method for concrete bridges in the United States (Pyć, 1998).

## II. CORROSION OF REINFORCEMENT IN RCC STRUCTURES

Concrete is use as construction material in the form of plain or reinforced concrete throughout the world. The physical, chemical and environmental factors effects on the durability characteristics of concrete. The environmental changes due to pollution, lack of maintenance, poor quality of work and materials are affecting factors for corrosion of reinforcement. Various factors affecting the reinforcement concrete cement the atmosphere, water, salts are common factors responsible for reinforcement corrosion. The damage due to corrosion is a serious effect upon the structural properties of concrete structures. Once the corrosion of reinforcement starts due to effect of oxide and if the structure is under load, the stress acting on it increases. In such case the ultimate tensile stress exceeds and finally the structure fails.

The corrosion of reinforcement is the main problem which decreases the service life of building. Corrosion of reinforcement occur due to many reasons like water seepage from slab, improper covering during construction, lack of quality work like less compaction of concrete , low quality materials , bad water cement ratio etc.

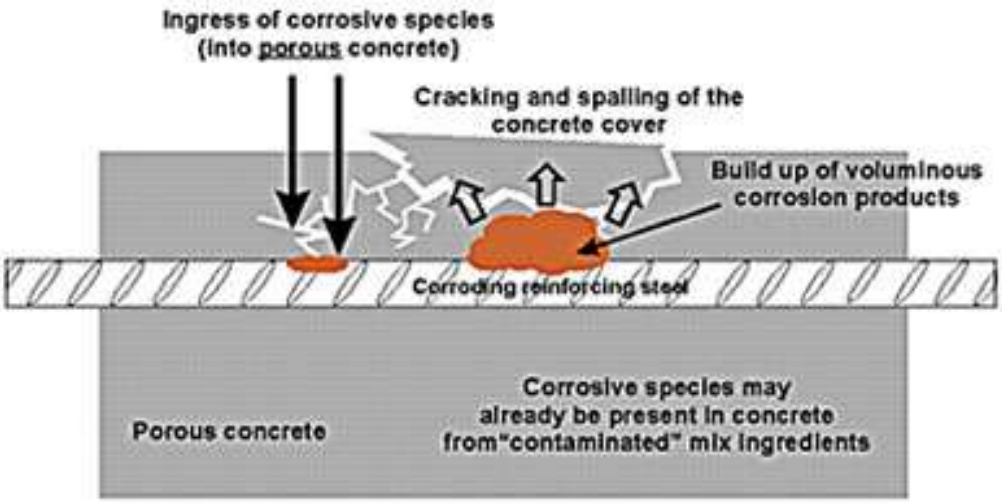


*Fig 1. Corrosion of Reinforcement*

## III. CORROSION PROCESS

Corrosion is a multifaceted phenomenon that adversely affects and causes deterioration in metals through oxidization. Millions of dollars of loss throughout the metal industry can be attributed to metal corrosion. When two metals having different potentials are coupled together and are contained in a conductive electrolyte, current will flow and corrosion will commence. Current will flow from the metal with the greater negative potential through the electrolyte to a metal that is more positive. Corrosion will occur at the point where the current leaves the metal surface. Corrosion of steel is an electrochemical reaction that requires the presence of water ($H_2O$), oxygen ($O_2$) and ions such as chloride ions ($Cl^-$), all of which exist in the atmosphere. Atmospheric chloride ions are in greatest abundance anywhere near the coastline. This electrochemical reaction starts when atmospheric oxygen oxidizes iron in the presence of water. In addition, the atmosphere also carries emissions from human activity, such as carbon dioxide ($CO_2$), carbon monoxide (CO), sulfur dioxide ($SO_2$), nitrous oxide ($NO_2$) and many other chemicals, which can also be significant in the corrosion process. Also, if any two dissimilar metals are in contact with each other, the more reactive metal will corrode in preference to the less reactive metal.

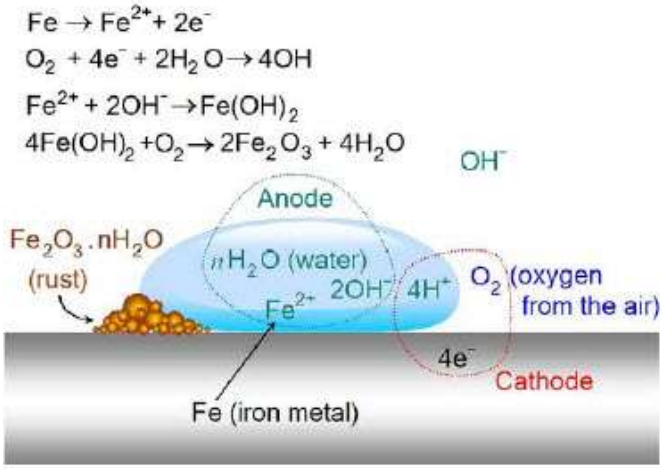


*Fig.2 Corrosion process*

## IV. EPOXY COATED REINFORCEMENT

Egyptians developed the art of paint-making with wider colour range considerably during the period Cirea 3000-600 B.C. The first synthetic pigment, known today as Egyptian Blue, was produced almost 5000 years ago. During this period, red lead was used in wood preservative paints, but was more extensively used by the Romans. First resins used were almost all naturally occurring gums and waxes. During 600 BC— AD 400, Greeks and Romans were known to preserve and decorate objects with paints. Varnishes incorporating drying oils were introduced during this period. By the late eighteenth century, owing to increased use of iron and steel by industrial revolution, all types of paints and coatings were developed for construction and engineering purposes. The use of turpentine as a paint solvent was first described in 1740. The basis of formaldehyde resin chemistry was laid down between 1850 and 1890, although it was not used in paints until the twentieth century. During 1877, the nitrocellulose was discovered and used safely by plasticizing it with camphor. In 1918, a new white pigment, Ti02, which was to replace white lead completely, was introduced.

During 1949-1951, epoxy resins were developed in Switzerland and 'in the United Kingdom (UK) and became available in the United States of America (USA). These resins could be applied in heavy coatings, from 75 to 500 microns per coat. By the end of 1950, usage of epoxy coatings had developed in volume, and various formulators were trying to correct some of the disadvantages of these coatings in several applications. As far as coatings on steel reinforcements in concrete are considered, most cases serve as a means of isolating the embedded steel from the surrounding environment. Thus, an intact coating shields the steel from various adverse conditions occurring at the concrete/steel interface which can cause corrosion of the steel and subsequent failure of the structure. More specifically, a coating on steel reinforcement is generally used to eliminate the effect of some anticipated factor which could promotes corrosion.

Epoxy-coated reinforcing steel is being used extensively in the United States for corrosion protection in concrete structures. The first full scale application of this material was in four-lane bridge in Pennsylvania in the year 1973. Since then, tens of thousands of structures have been constructed with this material. Epoxy-coated rebars have gained widespread acceptance as a means to extend the service life of parking garages, bridges, pavements and other reinforced concrete structures susceptible to corrosion.

Since its first use in 1973, the cost of epoxy-coated rebars has dropped significantly. As use and production grew, the cost decreased. For most structures, coating all the reinforcing steel will usually only increase the total structural cost by between 1% and 3%. Epoxy coatings to steel reinforcements are either applied by brushes or electrostatically using a biphenyl-amine epoxy powder over the hot, freshly sand blasted surface. Initial laboratory tests have suggested that the epoxy product could provide good corrosion protection. Corrosion performance over the long-term in bridge decks applications has been reported to be satisfactory. Many field studies have been conducted on bridges containing epoxy-coated bars. These studies have principally found to-date that structures containing epoxy-coated bars are more durable than those with black bars. The number of bridges containing epoxy coated reinforcing being evaluated is numerous.

Fig.3 *Epoxy Coated Bars*

## V. DEVELOPMENT OF CEMENT BASED EPOXY COATING

One Simple Solution for corrosion of reinforcement is to coat the reinforcement with a fusion bonded layer of epoxy resin. This provides a continuous barrier with low permeability to oxygen, water and chloride ions. Tests have shown that epoxy coatings on reinforcement can reduce the rate of deterioration of concrete specimens containing high levels of chloride. However, corrosion did develop at faults in the rebar coating. In practice, there will be some defects in epoxy-coated bridge reinforcement, i.e., pinholes in the coating when it leaves the factory, and damage during transport to the site, placement of the reinforcement, and pouring and vibrating the concrete. Such damage should be repaired, but locating all of the faults is difficult and very time consuming. The after-production cut-ends and damaged areas are coated with repair-epoxy rather than the fusion bonded material. In addition, bent bars, although visually undamaged might have lower corrosion resistance than straight bars.

The long term durability of structures employing epoxy-coated reinforcement will depend on the progress of corrosion at defects. If the number of defects is limited and corrosion does not spread beneath the coating, then long term performance should be possible. The Transport Research Laboratory in the United Kingdom set up an exposure test to study the effect of defects and potential areas of reduced corrosion resistance on the performance of epoxy-coated

reinforcement. The factors considered were repaired and unrepaired coating damage, and bent bars. The corrosion performance of epoxy-coated reinforcement with such defects was compared with uncoated reinforcement using test specimens exposed in an outdoor rural environment. To encourage corrosion salt was added to the concrete mix during casting of some specimens. Others were ponded with salt solution after exposure. The epoxy-coated reinforcement used was produced commercially and in compliance with the recently developed British Standard. Although epoxy-coated reinforcement has been used in bridges in North America since 1973, it has seen little use so far in bridges in the UK. The first UK manufacturer commenced production in 1987 which encouraged the development of the British Standard. This report deals with the results after the first 2 years of the exposure tests. Additional specimens remain on exposure for future examination.

## VI. CONCLUSIONS

So, it's proven that Epoxy Coating is the solution of corrosion of reinforcement in RCC structure but some problems are in that the solution is additives in coating while applying the coating. Some Research is done on silicon based Epoxy Coating, but cement as additive is new concept. Sika Chemicals Ltd. developed a cement based epoxy Coating in USA. Coating should be site applicable and easy to use. Development of cost effective solution with great results is cement based epoxy coated bars. Epoxy Resin, Epoxy Resin Curing agent and Cement are mixed in proportion of 1:0.5:5 and the solvent is used to reduce the viscosity of liquid which can create a most suitable Epoxy coating which is cement based. General Purpose Epoxy Resin, Hardner (Polymer redispersable liquid) and Solvent

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