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Reinforcement Bond In Concrete With Differet Types Of Bars And Corrosion Prevention By Using Epoxy Resin

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Abstract

Corrosion is a spontaneous process of returning metals to their natural state by oxidation reduction reactions. Corrosion of metals results in a loss of both structural integrity and attractive appearance. Corrosion of reinforcing steel in concrete is one of the major causes for deterioration of bridges, buildings and other concrete structures.

Several parameters, oxygen, moisture content, and chloride concentration, will influence the development and rate of corrosion of reinforcing steel in concrete. It is known that corrosion will take place only if there is enough oxygen and water available at the bar depth for the corrosion process to occur. The presence of chloride ions will initiate the corrosion of steel in concrete and the rate of corrosion increases with increasing chloride concentration.

Epoxy resins-based organic coatings are extensively used as a long-lasting corrosion resistant coating because of their excellent electrochemical and mechanical properties. Most epoxy resins are complex molecules, and they can be successfully employed as hydrophobic corrosion resistant coatings in all types of corrosive electrolytes, including saline solutions. Consequently, their macromolecular structure offers large surface coverage leading to efficient anti-corrosion performance.

INTRODUCTION

The deterioration of reinforced concrete due to corrosion is a serviceability problem worldwide. The cover zone plays an important role in the durability and serviceability of concrete and provides the initial barrier to aggressive species. Damage to the cover resulting from the accumulation of corrosion products is characterized by cracking, delaminating or spalling of the concrete.

Corrosion of embedded steel bars was a major problem for RC structures for it may affect their residual capacity and life through four aspects, including loss of concrete section as a result of longitudinal cracking and spalling, loss of reinforcement section, change of reinforcement mechanical properties (especially fatigue), and a reduction in bond between reinforcement and concrete. Highway bridges, railroad bridges, and crane girders are continuously subjected to alternate loads that may cause fatigue fracture of reinforcing steel bars. When the RC structure under repeated loads is corroded, its service life can be significantly reduced for the brittle fracture of reinforcing steel bars.

Protective coatings and sealers, and overlays are also used on concrete surfaces to prevent rapid chloride ingress into concrete. An important tool in corrosion protection is use of corrosion inhibitors admixed into concrete as well as protective coatings on reinforcing steel. Epoxy and zinc-galvanized coatings are currently the most popular protective coatings used on reinforcing steel.

In recent years, epoxies have been used in various industries due to their versatility and range of properties, epoxy resins can be customized to meet specific requirements of individual applications and have become a popular choice.Epoxy resins are primarily composed of bisphenol A, which is synthesized by reacting epichlorohydrin with bisphenol-A. The reaction between the epoxide groups and the curing agent forms a highly crosslinked polymer network Hence, ERs coatings have excellent mechanical strength, adhesive properties, heat, and chemical resistances.

LITERATUREREVIEW

Shamsad Ahmad (2009)

Corrosion of steel in concrete is a slow process. Due to the protective nature of concrete, it takes a reasonably long time for initiation and progress of reinforcement corrosion even in the case of severe corrosive exposure conditions.

In this paper, an attempt has been made to firstly describe the impressed current technique commonly used for accelerating reinforcement corrosion in small- as well as large sized concrete specimens in the light of state-of-theart information available in the literature. Then the procedure for calculating 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 is presented. The effectiveness of the applied current in inducing reinforcement corrosion, guidelines for effectively using the impressed current technique, and some of the alternative techniques for inducing accelerated corrosion of steel in concrete are also described in the paper.

Gerald G. Miller, Jennifer L. Kepler, and David Darwin (2003)

The effect of epoxy coating thickness on bond strength is evaluated reinforcing bars with coating thicknesses ranging from 160 to 510 mm (6.4 to 19.9 mils). Three deformation patterns are evaluated using epoxy meeting the requirements of ASTM A 775. The reduction in bond strength caused by epoxy coatings between 160 and 420 mm (6.4 and 16.5 mils) is largely independent of coating thickness. The reduction, however, becomes significant for coatings thicker than 420 mm (16.5 mils). When combined with earlier research on bars ranging in size the results demonstrate that an increase in the maximum allowable coating thickness, from 300 mm to 420 mm (12 to 16.5 mils), is justified and larger reinforcing bars in the ASTM standard.

P. C. S. Hayfield (1986)

The cathodic protection of steel reinforcing bars in concrete to prevent their corrosion, brought on principally by de-icing salts used on roadways, is at the interesting stage where technology is barely keeping pace with practical demand. It already seems likely that platinum and other noble metals, used in conjunction with titanium and niobium, will play a vital role in several of the protection systems that appear to be the forerunners in a rapidly developing industry.

There are now a number of competing impressed current cathodic protection systems for arresting the corrosion of rebars in concrete; some of these have been under trial for a number of years while others have only recently been introduced. Specifications are being updated continuously to ensure that the most updated technology is invoked in new systems. But just as it may take a number of years for salt corrosion of rebars to result in significant degradation of reinforced concrete, so it takes several years to prove not only the effectiveness of cathodic protection systems but also their long term durability in actual service.

Shibin Li, Weiping Zhang, XianglinGu and Cimian Zhu (2011)

Under badly environmental conditions as well as complex loads, corrosion of embedded reinforcing steel bars in concrete is common for reinforced concrete (RC) structures. Fatigue of corrosion reinforcing steel bars is a key problem for old RC bridges. To assess the residual fatigue life of aged existing RC bridges, the most new study information on fatigue of natural corrosion reinforcement is analyzed, and axial tensile fatigue tests are conducted on fifteen naturally carbonation-induced corrosion steel bars.

The fatigue test results indicate that the existence of corrosion pits reduces the fatigue life of steel bars significantly under the same fatigue stress; with the development of corrosion, the fatigue life of steel bars decays according to negative power exponent law approximately and the attenuation rate increases with stress level augment. For the complexity of fatigue and corrosion, further pertinent conclusions remain to be confirmed.

Methodology Material

Mild Steel

Mild Steel is one of the most common of all metals and one of the least expensive steels used. It is to be found in almost every product created from metal. It is weldable, very durable (although it rusts); it is relatively hard and is easily annealed. Mild steel has a maximum limit of 0.2% carbon. The proportions of manganese (1.65%), copper (0.6%) and silicon (0.6%) are approximately fixed, while the proportions of cobalt, chromium, niobium, molybdenum, titanium, nickel, tungsten, vanadium and zirconium are not. Because of its poor resistance to corrosion it must be protected by painting or otherwise sealed to prevent it from rusting. Being a softer metal it is easily welded. Its inherent properties allow electrical current to flow easily through it without upsetting its structural integrity. This mild variant of harder steel is thus far less brittle and can therefore give and flexible in its application where a harder more brittle material would simply crack and break.It has ferromagnetic properties, which make it ideal for manufacture of many products.Mild steel is the cheapest and most versatile form of steel and serves every application which requires a bulk amount of steel.

Fig 1: Mild steel bars

TMT Steel in Genaral

TMT stands for 'Thermo Mechanically Treated' bars hot rolled from steel billets. TMT bars have much high yield point. But the yield point is not well defined. The yield stress or characteristics stress is given by 0.2% proof stress. These bars possess ribs or deformations. Hence for Fe500 their surface with the result their bond characteristic is improved. They are available in the grade of Fe415 and Fe500.

These bars have following advantages: TMT bars have very good bond with concrete than mild steel, so that they may be placed without end hook and with much smaller anchorage length, resulting in further saving in steel. Because of the high yield strength the quantities of steel require in RC work is reduced.

Since the difference in its cost comparative to mild steel is marginal. So there is the reduction in the overall cost of RC construction.

These bars have following disadvantages:

With increase in stress level the cracking tendency increase. Hence for Fe550 or higher grade it becomes necessary to use high grade concrete.

Due to reduction in percentage in tension steel, the design strength of concrete reduced.

Fig 2: TMT steel rebars

Epoxy Resin

Epoxy coated rebar becomes a solution and is widely used for corrosion protection of steel rebar in reinforced concrete in marine environment. Various defects to epoxy coating are inevitable during the manufacture, handling, transportation and concrete cast process. The defects of epoxy coating make the steel substrate directly exposed to the aggressive environment, and very much affect the protective properties of epoxy coating on steel rebar in concrete. Epoxy coatings on rebar are designed to act as a physical barrier, isolating the steel from the three primary elements needed for corrosion to occur— oxygen, moisture, and chloride ions. The coating also serves as an electrical insulator for the steel and minimizes the flow of corrosion current. Though bars completely coated with epoxy won't rust, their performance depends on the quality and integrity of the coating. When coating defects, an damage occur, corrosion resistance decreases.

With the improvement in adhesion property, epoxy coated rebar become the most economical method of corrosion protection of concrete construction. The corrosion protection properties of epoxy coating are always present; its protection is available from the moment it is installed. It cannot wash off and protect the steel in corrosive environment whether or not the concrete is involved. Properly handled and placed epoxy coating will not degrade over time. Concrete structure built with epoxy coated rebar requires only monitoring and inspection resources required for any well thought out maintenance program.

Fig 3: Epoxy Coated rebars

A. Mix Design of Concrete

- Determine the Requirements. Start by understanding the specific requirements of your project.
- Select the Water-Cement Ratio.
- Choose the Cement Content.
- Select and Proportion Aggregates.
- Determine the Admixture Dosage.
- Calculate the Mix Proportions.
- Conduct Trial Mixes.
- Perform Quality Control Tests.

B. Casting the OPC specimens :

Take a sample of freshly mixed concrete – We take a sample of the concrete we want to test from our mobile batching unit, where it has been freshly mixed.Concrete cubes are typically made in moulds with dimensions of 150mm x 150mm x 150mm.

Pour the concrete into cube moulds – The sample concrete is poured into cube moulds. The concrete in each mould is then filled, levelled, compacted and tampered torequirements. Each cube is taken to our temperature-controlled lab, where it is kept for 24 hours, before being cracked and put into our water tanks to cure.Fill the concrete in each mould in three layers.

After each layer do proper compaction by applying 35 strokes using a tamping rod. After 3rd layer compaction, Finish the top surface using a flat trowel.

Let the concrete cubes cure – The cubes are kept in our temperature-controlled water tanks for 7 Days, 14 Days, and 28 Days.

C. Testing of the OPC specimens:

The Pullout test and Accelerated current test has been carried out on specimen to check bond strength and Corrosion Resistance due to epoxy coating.

CONCLUSION

The results show that, the accelerated corrosion test, the epoxy-coated bars show the lowest current readings during the whole period of the immersion time compared to the regular carbon steel bars. Epoxy coating provided excellent corrosion protection to the steel as long as the coating was not damaged and no corrosion of rebar in concrete takes place.

References

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Shiju Joseph, Shashank Bishnoi and Soumen Maity "Analysis that the production of LC3 will be commerically viable with respect to PPC "(2014)