

Original Article

Role of Epoxy Resin in Corrosion Protection of HYSD Bars in Reinforced Concrete Structures

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Abstract: Corrosion of steel reinforcement is one of the major causes of deterioration in reinforced concrete structures, especially in aggressive environments such as coastal regions and industrial areas. This study investigates the role of epoxy resin coating in enhancing the corrosion resistance of High Yield Strength Deformed (HYSD) bars used in reinforced concrete. Epoxy coating acts as a protective barrier that prevents the ingress of moisture, oxygen, and chloride ions, which are the primary causes of corrosion. Experimental analysis was carried out by comparing coated and uncoated steel bars embedded in concrete specimens under controlled conditions. Parameters such as corrosion rate, bond strength, and durability were evaluated. The results indicate that epoxy-coated bars significantly reduce corrosion activity and improve the service life of structures. The study concludes that epoxy resin coating is an effective, economical, and practical solution for corrosion protection in reinforced concrete structures.

Keywords: Epoxy coating, HYSD bars, corrosion protection, reinforced concrete, durability.

I. INTRODUCTION

The Reinforced concrete is one of the most widely used construction materials in civil engineering due to its high compressive strength, durability, and versatility. It combines concrete, which is strong in compression, with steel reinforcement, which is strong in tension, making it suitable for various structural applications such as buildings, bridges, and marine structures. However, despite its advantages, reinforced concrete structures are highly susceptible to deterioration over time, primarily due to the corrosion of embedded steel reinforcement.

Corrosion of steel reinforcement is a major durability concern and is considered one of the leading causes of structural failure worldwide. The process of corrosion is mainly initiated by the ingress of aggressive agents such as moisture, oxygen, carbon dioxide, and chloride ions into the concrete. These elements penetrate through pores and micro-cracks in the concrete and reach the steel surface, leading to electrochemical reactions that result in rust formation. The formation of rust causes an increase in volume, which induces internal stresses, leading to cracking, spalling, and eventual weakening of the structure.

HYSD (High Yield Strength Deformed) bars are commonly used as reinforcement in modern construction due to their superior strength and better bonding characteristics with concrete. However, even HYSD bars are not immune to corrosion, especially in harsh environmental conditions such as coastal regions, industrial areas, and zones with high humidity. In coastal regions, chloride ions from seawater accelerate corrosion, while in industrial environments, exposure to chemicals and pollutants further increases the rate of deterioration.

To enhance the durability and service life of reinforced concrete structures, various corrosion protection techniques have been developed. Among these, epoxy resin coating has emerged as an effective and widely adopted method. Epoxy coating acts as a protective barrier that isolates the steel surface from corrosive elements, thereby preventing direct contact with moisture and aggressive ions. This significantly reduces the rate of corrosion and enhances the performance of reinforcement in adverse conditions.

II. LITERATURE STUDY

Corrosion of steel reinforcement in reinforced concrete structures has been widely studied due to its significant impact on structural durability and service life. Several researchers have investigated different methods to control corrosion, among which epoxy coating has gained considerable attention. A.M. Neville (1995) explained that corrosion in reinforced concrete is mainly caused by the penetration of chloride ions and carbonation, which destroy the passive layer protecting the steel. His work emphasized the importance of durability design in concrete structures.

Mehta and Monteiro (2006) discussed the fundamental mechanisms of corrosion and highlighted that permeability of concrete plays a key role in allowing aggressive agents to reach the reinforcement.

They suggested that protective coatings can effectively reduce corrosion.

Mangat and Elgarf (1999) conducted experimental studies on epoxy-coated reinforcement and found that epoxy coating significantly reduces chloride-induced corrosion. Their results showed that coated bars exhibited better performance compared to uncoated bars in aggressive environments.

Clear (1992) studied the performance of epoxy-coated reinforcing bars in bridge decks and concluded that epoxy coating improves the service life of structures exposed to de-icing salts and marine conditions.

Koch et al. (2002) analyzed the economic impact of corrosion and highlighted that corrosion-related damage leads to huge maintenance costs. The study recommended preventive measures such as protective coatings to reduce long-term expenses.

FHWA (Federal Highway Administration, 2010) reported that epoxy-coated reinforcement is one of the most effective methods for corrosion protection in highway structures. The study confirmed that proper coating application increases durability.

Darwin et al. (2004) investigated the bond strength of epoxy-coated bars and observed a slight reduction in bond strength compared to uncoated bars. However, this reduction can be compensated by proper design considerations.

Singh and Sharma (2015) studied corrosion behavior of coated and uncoated reinforcement in marine environments and concluded that epoxy-coated bars significantly delay corrosion initiation.

Zhang and Li (2018) evaluated the durability of epoxy-coated steel in chloride-rich environments and found that coating thickness and quality play a crucial role in performance.

From the above studies, it is evident that corrosion of reinforcement is a major issue affecting concrete structures, especially in aggressive environments. Epoxy coating has been proven to be an effective method for reducing corrosion and enhancing durability. However, proper application, coating thickness, and quality control are essential to achieve optimal performance.

III. MATERIALS USED

A. Surface cleaning of steel bars

Surface cleaning of steel bars is a critical step before the application of epoxy coating, as it ensures proper adhesion and long-term performance of the coating. Any impurities present on the steel surface, such as rust, oil, grease, dust, or mill scale, can significantly reduce the effectiveness of the epoxy layer and lead to premature coating failure.



Figure 1: Epoxy coated bars

B. Application of epoxy resin coating

The application of epoxy resin coating is a crucial step in providing effective corrosion protection to HYSD steel bars. After proper surface cleaning, the epoxy coating is applied uniformly over the steel surface to form a protective barrier against moisture, oxygen, and chloride ions.

The coating process is generally carried out using methods such as spray coating or brush application. In industrial practice,

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electrostatic spray coating is commonly used to ensure uniform thickness and better adhesion. The epoxy resin is applied in a controlled environment to avoid contamination and ensure consistency in coating quality.

The thickness of the epoxy coating plays an important role in its performance. A uniform coating thickness is maintained throughout the surface of the steel bars to prevent weak spots or defects. Care is taken to avoid damage

C. Drying and curing of coated bars

After the application of epoxy resin, the coated steel bars are subjected to drying and curing processes to achieve the desired mechanical and protective properties of the coating. This stage is essential for the hardening of the epoxy layer and ensuring its long-term performance.

Drying is carried out under controlled temperature conditions to allow the solvent in the epoxy coating to evaporate. Following this, curing is performed either at ambient temperature or by heat treatment, depending on the type of epoxy used. Heat curing accelerates the polymerization process and improves the strength and adhesion of the coating.

Proper curing results in the formation of a hard, durable, and chemically resistant layer over the steel surface. It also enhances the coating's resistance to cracking, peeling, and environmental degradation.

If the curing process is not carried out properly, it may lead to weak bonding, reduced durability, and failure of the coating under service conditions. Therefore, adequate drying and curing are essential to ensure the effectiveness of epoxy-coated HYSD bars in corrosion protection.

IV. EXPERIMENTAL INVESTIGATION

Concrete specimens were prepared to evaluate the performance of epoxy-coated and uncoated HYSD bars under controlled conditions. Two sets of specimens were cast: one with uncoated HYSD bars, which served as the control samples, and another with epoxy-coated HYSD bars, which served as the test samples.

The concrete mix was designed using standard proportions, and proper care was taken during mixing, placing, and compaction to ensure uniformity in all specimens. The reinforcement bars were centrally placed within the mounds to maintain consistent cover thickness. After casting, the specimens were allowed to cure under normal conditions for a specified period to achieve the required strength.

To simulate real environmental conditions that cause corrosion, the specimens were exposed to aggressive environments. These included continuous moisture conditions and saltwater exposure to replicate chloride attack commonly found in coastal regions. The saltwater solution was periodically applied or specimens were partially immersed to accelerate the corrosion process.

After a predetermined exposure duration, the specimens were removed and tested to evaluate their performance. Various tests such as corrosion assessment, compressive strength, and bond strength were conducted to compare the behavior of epoxy-coated and uncoated reinforcement.

The experimental setup was designed to clearly demonstrate the effectiveness of epoxy resin coating in reducing corrosion and improving the durability of reinforced concrete structures.

V. RESULT AND DISCUSSION

Experimental investigation on epoxy-coated HYSD bars embedded in concrete with varying air void contents revealed significant insights into corrosion behavior and durability performance. The results indicate that as the percentage of air voids in concrete increases, the permeability of the concrete also increases, allowing easier ingress of moisture, oxygen, and chloride ions. This directly accelerates the corrosion process of embedded reinforcement. However, the application of epoxy coating on HYSD bars showed a considerable reduction in corrosion rate compared to uncoated bars, even in highly porous concrete conditions.

VI. CONCLUSION

This study evaluates the effectiveness of epoxy resin coating in protecting HYSD bars from corrosion in reinforced concrete structures. The results show that epoxy-coated bars perform significantly better than uncoated bars in resisting corrosion. The coating acts

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as a barrier against moisture and chloride ions, thereby reducing deterioration. The use of epoxy-coated reinforcement enhances durability, reduces maintenance costs, and increases the service life of structures.

Hence, epoxy coating is recommended for construction in aggressive environmental conditions.

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