GOOD PRACTICES IN THE HANDLING OF FUSION BONDED EPOXY COATED BARS FOR REAPING MAXIMUM PROTECTION AGAINST CORROSION

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ABSTRACT

Corrosion of the reinforcing bars embedded in concrete can be caused by intrusion of chlorides, sulphates, sulphides and carbon dioxide which might cause premature deterioration of concrete structures. Structures located in highly saline environment, structures subjected to intermittent wetting and drying (Bridge Piers) and structures exposed to dampness (Roof Slab, Concrete Pavements) are highly susceptible to corrosion damage. Such kinds of corrosion causes serious durability problems and shortens the service life of structures. Epoxy coated bars can be a solution to afore mentioned problems. Corrosion led deterioration becomes a major maintenance issue for bridges, jetties, buildings in offshore and coastal area. A huge amount of public funds are drained in maintenance of those structures. For improved durability and reducing life cycle costs, the use of epoxy coated bars in lieu of conventional black bars can be a judicious choice. In the recent time, the use of epoxy bars has increased and its demand is on the rise. However, it needs special care in handling in order to reap maximum benefit out of this bar. This paper describes the various field handling techniques of epoxy bars during transporting, fabricating and concreting which can be useful for engineers and construction contractors.

Introduction

Corrosion is the chemical or electrochemical reaction between material and its surrounding environment that causes deterioration of the material (ASTM G15). Corrosion in embedded reinforcing steel in concrete is a prime cause of concrete durability related problems. Corrosion of rebar embedded in concrete can occur from chloride diffusion from saline environment due to carbonation process or by any other surrounding acidic environment. Structures at coastal regions, dams, bridge piers, abutments lie in immense risk of corrosion. The structures which are exposed to dampness and intermittent drying and wetting like top floor slabs also possess high risk of corrosion. Epoxy coating on the fusion bonded epoxy coated bars acts as a barrier from corrosion reactions and the rate of corrosion of epoxy bars are 40-50 times less than the uncoated bars (Efaz et al., 2016). As a result, the use of epoxy bar has increased in recent times. However, use of epoxy coated bar needs special care. ASTM A775, ASTM A934 and ASTM D3963 describes the basic requirements of epoxy coated bar.

Fusion Bonded Epoxy Coated Bars

Fusion bonded epoxy coated bars (FBECB) are reinforcing bars coated with thermosetting epoxy resins and other additives which are applied in the powder form on the surface of the reinforcing bars and fused to create a continuous coating (ASTM A775). The powder form additives are applied at a typical temperature of 225^0 C to 245^0 C through spraying it using suitable spray guns on to the hot blast cleaned rebars after it being fluidized (Efaz et al., 2016).

Basic Requirements for Epoxy Coated Bars

In order to reap the maximum benefit out of the epoxy coated bars must fulfill some basic requirements. The basic requirements according to ASTM A775 and ASTM A934 are:

i. Coating thickness
ii. Coating continuity
iii. Coating flexibility

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iv. Coating adhesion

Quality Control Issues of FBECB

Over the time ASTM requirements for fusion coated epoxy coated bars have become more and more stringent in order to ensure proper quality control. The chronology of changes made to ASTM A775 is shown in Table 1.

Table 1. Chronology of Changes Made to ASTM A775

Year	Changed Status	Provision of Prior Version
1981	First version approved	-
1989	Permissible damage reduced to 1%	2%
1989	Introduction of anchor profile of 1.5-4 mil	-
1990	Repair of all damage	Repair of damage > 0.1 in^2
1993	Coating thickness 7-12 mil	90 percent between 5 and 12 mil
1994	Increase bend test to 180^o	120^o
1995	Reduce allowable holidays to less than 1 per foot	2 per foot
1995	No coating deficiency allowed	0.5 percent
1995	Coat within 3-hours	8 hours
1997	Coating adhesion CD test	-
1997	Cover bars stored outside if longer than 2 months	-
2004	Coating thickness increased for larger diameter bars. 7-16 mil (Nos. 6-18)	7-12 for all bar sizes
2004	Clarified individual thickness measurements no single measurement <80% of minimum or >120% of maximum	-
2006	Clarification on thickness measurements added	-
2007	Added patching material requirements	-

Challenges for Fusion Bonded Epoxy Coated Bars

Fusion bonded epoxy coated bars (Epoxy coated bars) are used for its dielectric properties which protects rebar from corrosion and helps to increase the service life and durability of the structure. However, there are some critical issues in implementing this bar in construction industry. These are:

i. One of the main problems of epoxy bars are its bonding problem. In order to get better bonding more development length is to be provided (Xing et al., 2015). As a consequence, more amount of reinforcing bars are needed and this causes increase in the total cost.
ii. With the increase of the thickness of the coating on the bars the bond performance decreases (Anda et al., 2006). Increased thickness of the coating might be useful for better durability but it reduces the bonding among the materials. For this reason the coating thickness must be within the range of 7 to 16 mil (ASTM A775).
iii. Special care is a must to ensure protection against coating damage especially in transportation, field handling, storage, fabrication and casting (ASTM D3963).

Recommended Work Practices for Fusion Bonded Epoxy Coated Bar

The following precautions are necessary for reaping maximum protection against corrosion:

During Transportation, Handling and Stacking

- Coated bars should never be dragged
- Coated bars should be lifted in a way so that minimum sagging occurs.
- Unloading of the coated bars must be near the casting site in order to minimize handling.
- Bundles of coated bars should not be stored on the ground.

- If the coated bars are stored in outdoors, then it is necessary to cover it with opaque material. Because long exposure to sunlight (ultra violet rays) would damage the coating and effectiveness of corrosion protection.
- Coated and uncoated bars should not be stored in a same place

Storing process is further illustrated in Figure 1.

Figure 1. Precautions taken during storage of coated bar

During Cutting, Banding and Welding

- Coated bars should be placed where no corrosive metallic substance are present.
- Coated tie wires should be used for the purpose of tie.
- Coated bars should not be flame cut rather than it should be cut using power shears and chop saws.
- Cut ends, damaged spots, welded areas should be repaired with special epoxy which is compatible with the coating material. If mechanical splices are used if should also be epoxy coated.
- Mandrel should be nylon/Teflon collared while bending

Precaution process during fabrication is demonstrated in Figure 2.

(a) (b) (c)

Figure 2. Precautions taken during fabrication. a) Cut ends being repaired with epoxy, b) Coated tie wires and c) Nylon collared mandrel.

During Concreting

- Extra care is necessary during concrete placing.
- Compaction should be done by using plastic headed vibrators instead of metallic nozzle.
- Free fall of concrete during placing should be avoided.
- If partial concreting is made then special measures should be taken for ensuring protection against UV rays for the uncovered parts.

The necessary precaution during concreting is illustrated in Figure 3.

Figure 3. Precautions taken during concreting.

Conclusions

Corrosion of the embedded rebar is one of the main obstacles for ensuring durability of concrete structures. Fusion bonded epoxy coated bars not only reduces the corrosion probability but also improves the durability of structures and hence it prolongs the service life of a structure. The effective corrosion protection with the use of epoxy coated bar would require stringent field handling and compliance to be met. Without special care for transporting and handling of epoxy coated bars, protection from corrosion initiated problems cannot be reaped. Poor performance of epoxy coated bars has been attributed to improve field handling practices in project like Florida Keys (Bridge).Both field engineers and field workers must be made aware of the standard requirements (ASTM A775, ASTM A934 and ASTM D3963) during manufacturing, transportation, fabrication and concreting. Moreover, the necessary work practices must be included in the country's codes and standards.

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