POWDER EPOXY COATING OF STEEL REBARS - STATE OF ART REPORT

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The various standards and specifications evolved for powder epoxy coating material, performance data, likely suppliers, etc., are discussed in detail. The cost benefit ratio based on durability factor and unit cost of material is also worked out. Considering the Indian scene, the various limitations coming in the way of large scale adoption are pointed out.

Key words: Powder epoxy, Reinforcing steel, Electrostatic coating system

COATING PROCESS

Powder epoxy coatings for steel rebars were developed in the early 70's in USA and since then have been widely used in forty states in that country [1]. The process of applying epoxy coatings onto the surface of reinforcement steel bars involves several steps [2]. Initially, the surface of the steel to be coated has to be cleaned. Reinforcing bars are cleaned by passing them through an abrasive blast cleaning machine. Inside the cleaning chamber of the machine, the bars are blasted with a combination of steel shot and grit. As the bars pass through the blast, they are mechanically rotated to assure that the entire surface area of the bar is subjected to the blast. The mill scale and rust have to be removed and a near white steel surface has to be obtained. The abrasive blast cleaning is advantageous in that it produces a moderately rough surface thereby enhancing the adhesion of the epoxy coating to the bar surface. The cleaned bars have to be coated before re-oxidation of the surface occurs.

The bars have to be heated to a temperature in the range 200-275°C after cleaning, in a non-contaminating and even heat source, before the epoxy powder is applied. This can be done in a gas-fired furnace or an electrically heated furnace. More commonly, induction heating has been employed. The bars can be allowed to pass into the coating chamber as soon as they are heated by the induction coils. This can be accomplished by controlling the rate at which the bars pass through the induction coils and coating chamber. It is important to maintain a constant even heat to assure the proper coating of the epoxy. This can be done by using heat sensors in suitable positions to monitor the bar temperature, before the bar enters the coating chamber.
APPENDIX I

SPECIFICATIONS

I AMERICAN:

Thickness of film

150-200 Microns

Mechanical Properties

Impact ASTM A775-81 A1.2.7
Pass 80 in. lb.,
No cracking
Direct and reverse.

Eriksen Indentation

8.0 mm [minimum]

Eriksen pencil hardness

Pass 2H

DIN 53-157 Sward rocker hardness

160 SEC

Taber abrasion resistance

Weight loss

ASTM A775-81 A1.2.6

less than

25mg/1000 cycles

Adhesion bend test

No cracking or

ASTM A775-81 A1.2.4.1

disbonding, 120°,

3 inch mandrel

Bond strength to concrete

Greater than 80%

ASTM A775-81

compared with

uncoated bar

Corrosion Resistance

Hot salt spray

2000 hr – passed

Humidity

2000 hr – passed

Film continuity 75 ± 5 V DC
detector

less than

2 holidays/ft

II BRITISH:

Same as ASTM A775-81

III JAPANESE:

Thickness of film

200 ± 50 microns

Impact strength

30 Kg. Cm.

Bend test

180°, inner bending radius is

2 to 2.5 times the diameter of

diameter of steel bar. Cracking and peeling must be less than 20%.

Bond strength

Greater than 80%

compared with

uncoated bar

Corrosion resistance

Average corroded

area less than 1%
PERFORMANCE

The performance of powder epoxy coated rebars have also been evaluated [5-8]. Some of the results are listed in appendix II. From the table, it can be seen that powder epoxy coatings of thickness 150 microns or greater offer excellent protection against corrosion as compared to the protection offered by liquid epoxy coatings. The bond strength with concrete of powder epoxy coated steel bars is also superior as compared with that of liquid epoxy coated rebars.

It can be seen from the table that as the thickness of the coating is increased to about 250 μ, the bond-strength decreases. In general, the powder epoxy coated rebars have been observed to perform better than other epoxy coated rebars.

APPENDIX II

PERFORMANCE OF POWDER EPOXY COATED REINFORCEMENT STEEL

<table>
<thead>
<tr>
<th>Material</th>
<th>Test</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder epoxy coated, 80 μ</td>
<td>Accelerated corrosion</td>
<td>Reddish brown rust in specific regions</td>
</tr>
<tr>
<td>150 μ</td>
<td></td>
<td>No rust</td>
</tr>
<tr>
<td>250 μ</td>
<td></td>
<td>No rust</td>
</tr>
<tr>
<td>Liquid epoxy coated, 150 μ</td>
<td>Accelerated corrosion</td>
<td>Corrosion observed extensively</td>
</tr>
<tr>
<td>250 μ</td>
<td></td>
<td>-do-</td>
</tr>
<tr>
<td>Plain steel</td>
<td>Bond strength</td>
<td>250 Kg/m²</td>
</tr>
<tr>
<td>Powder epoxy coated, 80 μ</td>
<td></td>
<td>224 Kg/m² [Good]</td>
</tr>
<tr>
<td>150 μ</td>
<td></td>
<td>208 Kg/m² [Good]</td>
</tr>
<tr>
<td>250 μ</td>
<td></td>
<td>150 Kg/m² [Poor]</td>
</tr>
<tr>
<td>Liquid epoxy coated, 150 μ</td>
<td></td>
<td>112 Kg/m² [Poor]</td>
</tr>
<tr>
<td>250 μ</td>
<td></td>
<td>110 Kg/m² [Poor]</td>
</tr>
<tr>
<td>Powder epoxy coated</td>
<td>Potential measured Field</td>
<td>-0.20V</td>
</tr>
<tr>
<td>after 720 days exposure Sea-water</td>
<td></td>
<td>-0.26 V</td>
</tr>
<tr>
<td>Powder epoxy coated</td>
<td>Corrosion of reinforcing steel in pre-crack</td>
<td>No corrosion</td>
</tr>
<tr>
<td>[crack widths]</td>
<td>0.05-0.08 mm</td>
<td>No corrosion</td>
</tr>
<tr>
<td>Powder epoxy coated</td>
<td>Corrosion of reinforcing concrete after 720 days</td>
<td>No corrosion</td>
</tr>
</tbody>
</table>

APPENDIX III

SUPPLIERS

<table>
<thead>
<tr>
<th>Epoxy powder</th>
<th>Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotchkote 202</td>
<td>Minnesota mining and manufacturing company, Inc.</td>
</tr>
<tr>
<td>213 and 214</td>
<td>El du pont de nemours company Inc.</td>
</tr>
<tr>
<td>Flint flex 531-6080</td>
<td>Cook paint and varnish company.</td>
</tr>
<tr>
<td>Epoxy powder 720-A-009</td>
<td>Polymer corporation.</td>
</tr>
<tr>
<td>Corvel ECA-1440-J- green-2779</td>
<td>Armstrong products company.</td>
</tr>
<tr>
<td>Epoxy plate 346 to 349</td>
<td>Mobil chemical company.</td>
</tr>
<tr>
<td>Mobiloxy 1004-R-2</td>
<td>Napcorporation.</td>
</tr>
<tr>
<td>Nap-Guard 7-2000</td>
<td>Fuller-o'brien corporation.</td>
</tr>
<tr>
<td>Oxyplast El-704-P-9</td>
<td>Dexter corporation.</td>
</tr>
<tr>
<td>Hy-Sol DK 23-0602</td>
<td></td>
</tr>
</tbody>
</table>

* All from USA

COST/BENEFIT RATIO

The cost of coating for employing powder epoxy coatings to steel rebars has been worked out (appendix IV). Two factors have been considered, one based on the material and the other from experience [7, 10]. Both calculations yield the cost of coating/m² in the same order.

So far, powder epoxy coated rebars have not been tested for their durability according to the Indian conditions. To evaluate the cost/benefit ratio for our application, the durability factor for powder epoxy coatings have to be evaluated, since cost/benefit ratio is given by, durability factor divided by cost of coating per m² of the rebar.
Coatings to our Indian conditions has to be thoroughly studied and evaluated before being employed in structures. Also, indigenous production of such promising powder epoxy materials, for coating reinforcing steels, has to be attempted.

ACKNOWLEDGEMENT

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REFERENCES


3 "Standard Specifications for epoxy coated reinforcing steel bars" ASTM A775/A775M-84

4 Recommendation for design and construction of concrete structures using epoxy – coated reinforcing steel bars, Japan Society of Civil Engineers, (1986)

5 JR Clifton, HF Beeghy and RG Mathey, "Corrosion of metals in concrete" Publication SP-49-10 American concrete Institute Michigan (1975) 115


10 "UK Corrosion 83", Harrogate, Institute of Corrosion Science and Technology, Britain (1985)

LIMITATIONS

Even though powder epoxy coatings have been observed to offer considerably good corrosion protection to steel rebars, there are several limitations associated with their application. First, as there is not a single manufacturer in India for powder epoxies that can be coated for steel rebars, the powder epoxy material has to be imported, presently. As the coating is a factory process and involves high temperature, the process control becomes vital, and extra costs arise due to transportation to factory and to site, power, equipment, etc. Handling the coated rebars also becomes crucial and has to be monitored. After coating the rebars, their performance in tropical (Indian) environments has to be studied and we have to establish standards for our application. Finally, the cost/benefit ratio has to be worked out for our Indian conditions before it is accepted for large scale utilisation.

CONCLUSIONS

In USA, UK and Japan, powder epoxy coatings for reinforcing steels have been successfully employed and have been found to offer excellent corrosion protection as compared to others. The suitability of powder epoxy