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Rehabilitation Methods and Materials for Chloride Induced Corrosion of Offshore Structures

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ABSTRACT: Marine conditions are the most aggressive conditions exposed to reinforced concrete. To provide proper repairs and rehabilitation measures one needs to have a clear understanding of the distress mechanism in such environment and proper construction methods to be adopted. chloride induced corrosion is the primary cause for deterioration of concrete in sea structure. The paper presents some of the materials that can be used to counter this mechanism of distress. However, the method to be adopted will be influenced on extend to damage to structure.

KEYWORDS:Barrier coatings, cathodic protection, patch repairs, compatibility, polymers.

I. INTRODUCTION

The successful repair of any member subjected to marine exposure depends on two factors. The first is the ability of the material used in repair to defend the existing structure against external aggressive chemical attacks from the sea water, second is the advance construction methods and tools used for repair works.

The primary objective should be both to identify and understand the mechanism responsible for cause of distress. Understanding the distress mechanism will help identify the engineer the probable extend of damage, non-destructive tests to be conducted and design the repair that will combat this damage. The repairs should be designed in such a way that they will prevent the failure after the repair or the failure will be delayed for a considerable amount of time. The material used should be inert and compatible with the existing structure both electrochemically and dimensionally. The advance construction techniques and methods used will have a great impact on the quality of repair done.

Distress mechanism are physical, chemical and electrochemical in nature that occur between marine environment, concrete and steel. This paper outline some of the methods and materials that can be used for countering chloride induced corrosion.

A. Barrier Coatings.

II. **REPAIR METHODS AND MATERIALS**

Protective coatings or surface modifiers are used as a carbonated front or as a barrier to chloride penetration if the reinforcement is not passivated when the element is newly repaired. There are many cement and barrier coatings on the market under different brand names. The table was created with several materials tested for their ability to control the penetration of CO2 or chloride. When choosing a coating, it should be noted that the formation of water vapor can cause certain coatings to come off the concrete over time. Therefore, water vapor permeability should be considered as an important factor before choosing a barrier system.

Due to the large number of repair materials available, it is not always easy to select the right repair material for the right application. However, silane / siloxane has proven to be the best alternative in harsh coastal environments due to its



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high chloride diffusivity. However, some manufacturers do not manufacture silane products, but rather modified cement-based materials with low chloride diffusion resistance. When choosing the right protective material, you need to find one from different manufacturers. Finally, you can choose a manufacturer's product that resists the attack mechanism you are trying to counter

Туре	Classification	C02	H20 Vapor Trans-	Chloride
		Resistance	Diffusion	Diffusion
			mission	Resistance
Methacrylate	Coating	High	Moderate	High
Styrene Acrylate	Coating	High	Low/moderate	-
Ethylene Ter-	Coating	High	Moderate	High
polymers				
Vinyl co-	Coating	High	Moderate	-
polymers				
Urethane	Low build coat	Very high	Very low	Very high
Epoxy	Coating	Very high	Very low	Very high
Bitumen	High build coat	Very high	Very low	High
Emulsion	High build coat	moderate	High	Poor
Chlorinated	Coating	high	Very low	High
Rubber				
Alkyd	High build coat	moderate	High	-
Cementitious	Slurry coating	Low	High	Very low
Silane/siloxane	Surface enhancer	Very poor	Very high	Very high.

 $TABLE-RANGE\ OF\ BARRIER\ COATINGS.$

B. PATCH REPAIR OF DAMAGED AREAS.

The corrosion caused by chlorides is much more aggressive in nature and the corroded sites are well isolated, but usually there is a high rate of corrosion. The main danger is that this type of corrosion can corrode large areas of concrete without showing any visible signs of corrosion. If the surrounding concrete still contains chloride after repairing the patch, initial anodes may form on both sides of the patch. If this happens, there will be no corrosion adjacent to the patch, but the patch can fail in just two years. To repair the patch following are the steps involved.

1. Concrete removal and surface preparation.

The first step is to remove the surrounding concrete to expose all the corroded rebar. The purpose is to remove only the damaged concrete without damaging the remaining concrete. You can use a light power chisel with a hand hammer. When the chisel is complete, use a hand wire to remove the debris and then use compressed air to remove the loose particles. The surface should remain rough and clean to ensure good adhesion of the repair material to be applied later.

2. Steel Preparation.

When steel is exposed and begins to corrode, it is important to consider the condition of the steel. First, it must be evaluated for its structural function. Any steel that does not perform a structural function shall be cut from the structure and discarded. The remaining steel should be tested for corrosion. If the non-abrasive portion of the bar is too small to support the bar's design load, that portion should be removed and replaced with a new rod. Replacement bars can be welded or overlapped with existing bars. It is important to remove all corrosion products from partially corroded rods, as they contain corrosive substances which, if not removed, can cause further corrosion in repair or damage areas or change the bond between the repair material and the existing material used.

Steel can be cleaned by

• Sand blasting



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- Rotary wire brush mechanically driven
- Abrasive disc fitted to small angle grinder.
- Cleaning by Strips of emery cloth used by hand for surfaces not accessible.
- High pressure water jets



Figure 10: A typical patch repair

3. PATCH APPLICATION.

In terms of materials, repair mortar is used as an alternative to original concrete. It is usually a cement-based slurry containing fine aggregates or even microfiber reinforcement. Some of the materials that can be selected as patch repair material are

- Fibre reinforced polymer.
- Polymer impregnated concrete
- Polymer modified concrete.
- Polymer concrete.
- Ferrocement.
- Epoxy resin mortars
- 4. CURING AND SEALING.

Proper curing of repair concrete is very important, and curing can be accomplished using a waterproof membrane or polythene sheet that is bonded to the surface of the patch to prevent moisture loss.

C. CATHODIC PROTECTION.

Cathodic protection is a steel protection technique that has been widely used for many years to protect steel pipes and tanks from corrosion and has been applied in recent years to protect reinforcement in concrete. Since the development of conductive coatings, the effectiveness of cathodic protection has improved, it has become easier to install and is now applicable to many types of concrete structures. i.e. docks; harbor facilities; marine terminals; bridge substructures such as piers, pier caps and beams; parking garages; etc.

Corrosion of steel is caused by the formation of electrochemical cells. Because concrete acts as a coupling electrolyte, an anodic reaction occurs at some point on the steel surface, and the cathodic reaction consumes dissolved electrons in the rest of the steel surface. The presence of chloride ions causes local passivation. A small external current shifts the potential between steel and concrete to critical levels. Therefore, the electrons imprinted on the steel cause the steel to



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function as the cathode of the electrochemical cell. One method of cathodic protection is, for example, to apply a conductive overlay to the deck of the bridge and apply an applied current between the overlay and the rebar to effectively re-immobilize the steel. The potential shift caused by direct current is very important for cathodic protection. Due to the high resistivity of electrolytic concrete, it is necessary to evenly distribute the protection current throughout the structure.



Figure - working of cathodic protection

The main advantage of this system is that once activated, it can completely stop the corrosion process, providing a permanent solution even if more chloride can penetrate. In fact, the concrete on top is electrochemically highly conductive, so this concept works better in the presence of chlorides.

III. SELECTION OF REPAIR MATERIALS.

Compatibility- It can be defined as combination of properties and dimensions which ensures that interface bond strength is not exceeded and repair material carries its design load.

Figure various Compatibility factors to before selecting repair material

- Essential Parameters for repair materials.
- Low shrinkage properties
- Requisite setting / hardening properties
- Workability
- Good bond strength with existing sub-strata
- Compatible coefficient of thermal expansion
- Compatible mechanical properties and strength to that of the sub-strata
- Should allow relative movement, if expected, particularly in case of sealing of cracks or dealing with expansion joints.
- Minimal or no curing requirement
- Alkaline character



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- Low air and water permeability
- Aesthetics to match with surroundings
- Cost
- Durable, non-degradable or non-biodegradable due to various forms of energy, life, UV rays, heat, etc.
- Non-hazardous / non -polluting

Property	Relationship of repair mortar(R)toConcrete substrate(C)		
Strength in compression, tension and flexure	R>C		
Modulus in compression, tension and flexure	R~C		
Poisson's ratio	Dependent on modulus and type of repair		
Coefficient of thermal expansion	R~C		
Adhesion in tension and shear	R>C		
Curing and long-term shrinkage	R <c< td=""></c<>		
Strain capacity	R>C		
Creep/Fatigue performance	Dependent on whether creep causes desirable Or undesirable effects		
Chemical reactivity	R>C		
Electrochemical stability	Should not promote alkali aggregate reaction, Sulphate attack or corrosion of embedment in substrate		
	Dependent on permeability of patch material And Chloride ion content of substrate		

Table- General Requirements of Patch Repair Materials for Structural Compatibility

IV. CONCLUSION

As described above, some methods and materials are mentioned above to prevent chloride-induced corrosion for structures subject to marine environment. Before proceeding with restoration work, it is important to understand the underlying mechanism of failure in order to choose the right repair method. It also needs to be clear about the failure mechanism one is trying to combat as it will largely influence material selection and repair as well as the costs associated with restoration. In addition, before any new material is put into repair, it should be studied and tested for compatibility. Incompatible materials cause repairs to fail and can even accelerate the deterioration process. In addition, the material must provide a significantly extended service life to the structure

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