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CONTROL OF CORROSION ON UNDERWATER PILES

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ABSTRACT

Structures that are used for the transfer of loads from the superstructure to the sub surface strata are known as Foundation. And Piles are a type of foundation. For a hydraulic structure such as bridges, dams, etc. or for surfaces having high water content, the piles are driven into the ground and under the water strata. Piles normally used in underwater structures are subjected to corrosion. Corrosion reduces the structures stability and longevity. There is absolutely no method for elimination of corrosion; but corrosion protection measures can be employed for controlling the effects of corrosion. Corrosion protection can be done in different ways, depending on the environment and other atmospheric and hydrological factors. Types of corrosion protection include – treatment of surfaces, utilization of inhibitors, use of coatings and sealants, cathodic and anodic protection.

Keywords: Longevity, Protection Measures, Stability, Types of Protection.

I.INTRODUCTION

Corrosion is the destruction of metals and alloys by the chemical reaction with the environment. During corrosion the metals are converted to metallic compounds at the surface and these compounds wears away as corrosion product. Hence corrosion may be regarded as the reverse process of extraction of metals from ore.
Corrosion and in particular corrosion of metal structures, is a problem that must regularly be addressed in a wide variety of areas, for example, in the automotive industry, metal parts are often plated or coated to protect them from road salt and moisture in hopes of increasing their longevity. Indeed, many traditional metal parts are currently being used with polymeric components, which are not only lighter but also more cost effective to produce. But these are generally impervious to electrochemical corrosion often experienced by metals. Even with the proper selection of base metals and well-designed systems or structures, there is no absolute way to eliminate all corrosion. Therefore, corrosion protection methods are used to additionally mitigate and control the effects of corrosion. Corrosion protection can be in a number of different forms/strategies with perhaps multiple methods applied in severe environments.

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1.1Mechanism of Corrosion of Steel in Sea Water

On the account that steel piling in carried out in seawater, the more chemically active (charged) surface areas (anodes) are metallically coupled to the less chemically active surface areas (cathodes), which result in electricity flow and corrosion of the anodic areas. Roughening of the surface occurs when the local anodic and cathodic areas consistently shift during the corrosion process. There are times that there is no shifting of these active local areas from their position end, and there is a localized attack on the metal and pitting occurs. Generally, depth of pitting = ratio of the anodic sites / area of cathodic site [in contact with the electrolyte (seawater)]. As the anode area reduces in relation to the cathode area, the deeper is the pitting.

1.2 Zones of Corrosion of Steel Piles

Examination of corroded marine piles reveals several distinct areas of attack. It is convenient to divide these areas into four zones, each having a characteristic corrosion rate as shown in Fig 1.1

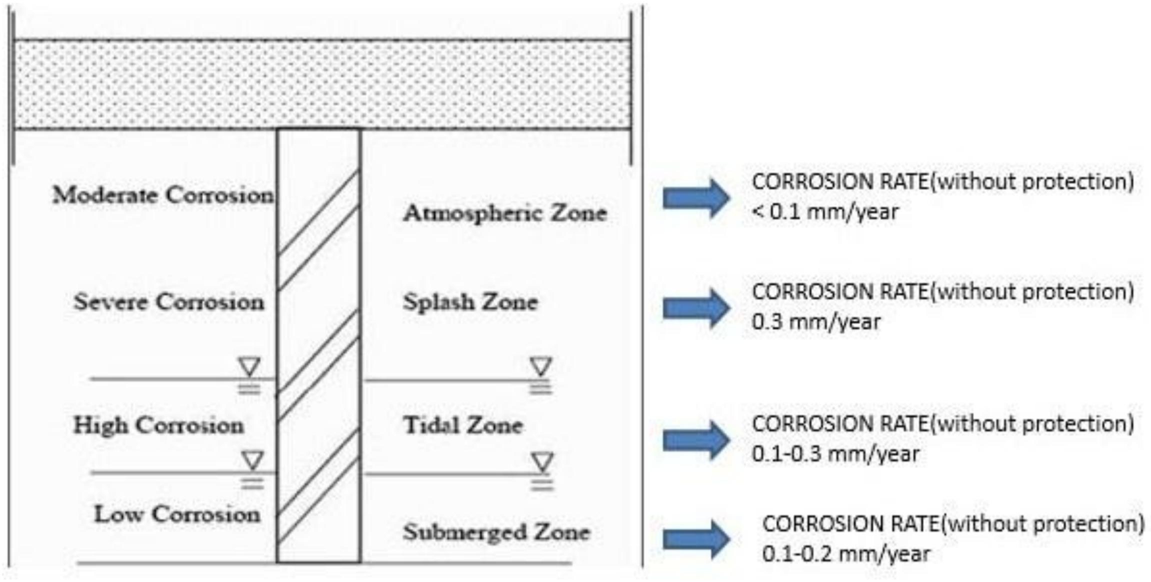

Fig.1 Zones of corrosion of steel piles

II.Corrosion Management

Conceptual and feasibility studies of the corrosion control method are done. It is categorized into three major phases. Phase 1 – In this phase, the programmatic assessment of the project is done.

Phase 2 – In this phase, the physical assessment and actual remediation work is done. Inspection of corrosion is also is carried out.

Phase 3 – In this phase, future monitoring of the repaired structure is done.

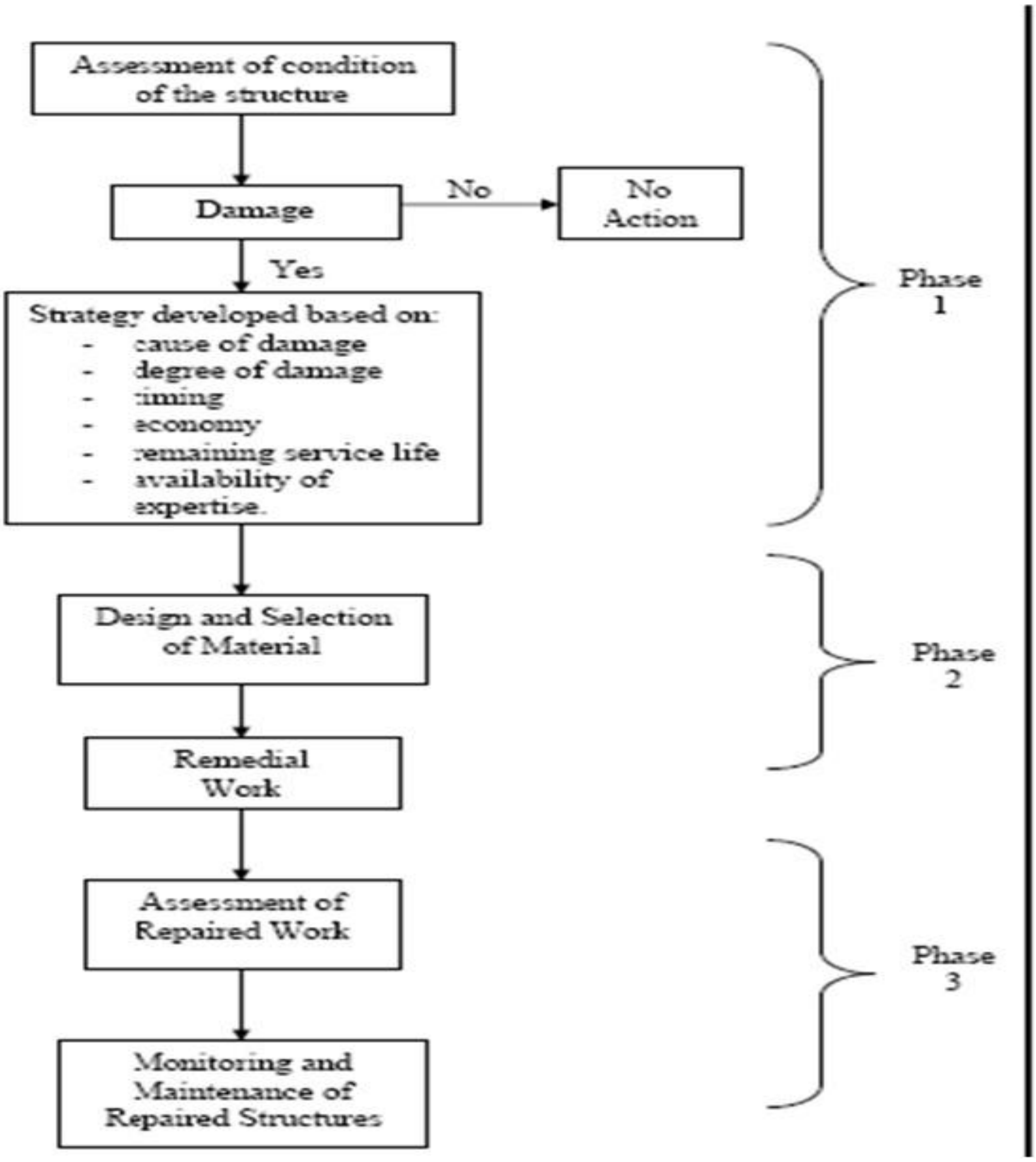

Fig.2.The Overall flowchart for an effective corrosion management program

III. CORROSION PROTECTION METHODS

3.1 Protective Coating

In order to protect metals from corrosion, the contact between the metal and the corrosive environment is to be cut off. This is done by coating the surface of metals with a continuous non-porous material inert to the corrosive atmosphere.

Surface coatings are broadly classified into three a). Metallic coatings

b). Inorganic Coatings

c). Organic Coatings

Individual coatings are formulated to perform specific functions and must be selected to become components of a total system designed for optimum results considering the environment and service expectations.

The different types of coatings used for under water piles are:

3.1.1 Inorganic Zinc Silicates Primers

Steel structures that are permanently immersed in sea water, such as jackets in the area below the Splash Zone, are typically not coated for various reasons and protected solely by cathodic protection systems consisting of sacrificial anodes or impressed current arrays, which can be maintained as required by underwater contractors. Various anticorrosive pigmented primers are available, some that passivate the steel but the most effective are inorganic zinc silicate primers which essentially become anodic to the steel in a corrosion cycle. The primary advantage of this type of coating is that it will arrest rust creep, or undercutting of the coatings surrounding the damaged area, and confine corrosion to the point of the damage. These coatings also provide a high degree of resistance to heat and chemical spills.

3.1.2 High Build Epoxy Coatings

Epoxies are generally more abrasion and chemical resistant than primers and topcoats and in this case protect not only the substrate itself, but the zinc primer as well from all of these detrimental factors. However, one drawback with epoxy coatings is very poor resistance to ultra violet from sunlight and most will chalk and fade rapidly. This leads to an erosion of the coatings' film thickness, reducing the barrier protection of the system.

3.1.3 Aliphatic Polyurethane Topcoats

Polyurethane finish coats are generally acknowledged as providing optimum resistance to UV and high degrees of flexibility and chemical resistance. They also help to maintain a very high level of cosmetic gloss and color retention and can be cleaned very easily, generally with low pH detergents and fresh water pressure washing. Although polyurethane finishes offer no real anticorrosive or barrier protection to the substrate they do provide a high level of protection to the integrity of the coatings system.

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3.1.4 Zinc Rich Epoxy Primers

Zinc modified epoxy anticorrosives will provide a high level of service and are more tolerant to compromised surface preparation and ambient weather conditions provided the zinc loading of the formula is sufficient. Zinc rich epoxy is also most effective in maintaining damaged areas and breakdown of the coatings systems applied at new construction as it is compatible with alternate methods of surface preparation such as power tool cleaning and UHP Hydro Blasting.

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3.1.5 Non-Skid Deck Coatings

Coatings specifically designed with anti-slip properties normally incorporate very course aggregates for an exaggerated profile. They are applied in very high film builds and normally without a zinc rich primer. When primers are required they are usually epoxy types.

3.2 Cathodic Protection

The preferred technique for mitigating marine corrosion, based on historical performance and measurable results, is cathodic protection (CP) - the practice of using electrochemical reactions to prevent the corrosion of steel structures. The reason for increased acceptance: cathodic protection prevents corrosion on underwater structures.

In theory and practice, the implementation of a CP system is quite simple. Assuming you already have corroding steel in seawater, all you need is an anode, a power supply, and engineering talent. A protective circuit is accomplished between the anode, steel (cathode), power supply and electrolyte (seawater).

3.3Application of Fibre Reinforced Polymer Composites

Fibre reinforced polymers (FRP) are mostly used for the repair and rehabilitation of concrete structural elements. The composites are very light in weight, are resistant to chemicals, have high strength and in fabric form have high degree of flexibility. The FRP composite when mixed with wet concrete makes it economical to conduct repairs on sub structure parts. When the FRP is used, then the corroded part of the structure element is carefully removed and the FRP composite induced concrete is applied. The FRP provides the lost tensile capacity and it also provides the steel with lateral support. When the FRP is applied with concrete, the spreading of corrosion to other piles is protected and it also ensures protection from UV radiation.

3.4 A Typical Anode Delivery System

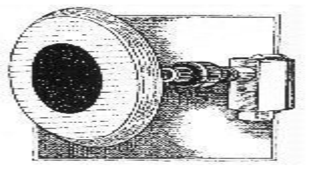

Fig. 3.4 Pile mounted anode

Pile mounted anodes are designed for efficient current distribution in and around pilings where the complex geometry of the facility precludes remote placement of the anodes. These delivery systems are suitable for direct attachment to pilings. The Flat Back Pile Mounted Anode was designed specifically for H-Piles, and can also be configured for installation on sheet piling.

3.4.1 Pile Mounted Anodes

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3.4.2 Disk Anode

The disk anode was designed in conjunction with the U.S. Army Construction Engineering Research Lab for use on navigational locks and dam gates. This anode system is also suitable for use on seawater intake structures, vessel internals, and sheet piling when shore side access is possible.

3.4.3 Retractable Mount

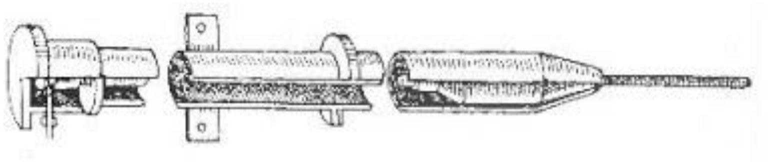

Fig. 3.4.3 Retractable mount

For installations where it is deemed necessary to access the anode for periodic maintenance, or when current is only required on a periodic basis, the retractable anode allows the user to easily retrieve the anode. The above illustration is rotated by 90 degrees.

3.4.4 Sled Anode

Anodes mounted on the sea bed typically afford the best spread of protection on a marine structure. Sled anodes can be designed for operation in either seawater or buried in the mud. The Post Tension Sled was developed to insure anode operation out of the mud when resting in silty and soft sea beds. By adjusting the height of the concrete sled, the mesh anode sled can also be designed for operation out of the mud. The advantage of this type of sled is its low profile, thereby limiting the potential for, damage by anchors fishing nets, etc.

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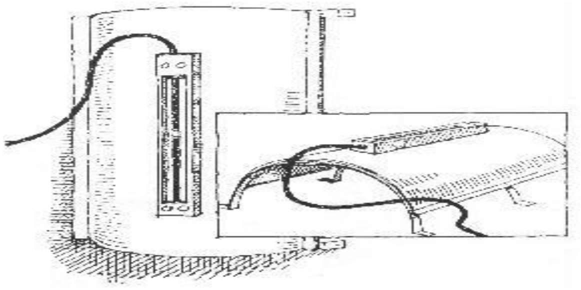

Fig. 3.4.4 Sled anode

3.4.5 Suspension Anodes

Suspension Anode Delivery Systems allow for strategic placement of anodes in and around a marine facility, providing optimum distribution of current. Many suspended anode systems are also suitable for mounting on pilings, or other structural steel.

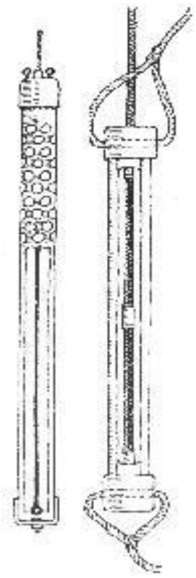

Fig 3.4.5 Suspension anode

3.4.6 Rod Anode

Although incorporated into a variety of anode delivery systems, the rod anode is most commonly used for the cathodic protection of seawater intake structures and vessel internals.

IV.STANDARDS AND CODES

There are no Indian standards codes as such for the control of corrosion. The latest editions of the following organizations' standards, codes, and guidelines shall be used for the design of corrosion control systems:

• NACE International (formerly The National Association of Corrosion Engineers)
• RP0169 – Control of External Corrosion on Underground or Submerged Metallic Piping Systems
• American Society for Testing and Materials (ASTM)
• ASTM D512 – Standard Test Methods for Chloride Ion in Water
• ASTM D516 – Standard Test Method for Sulfate Ion in Water
• ASTM G51 – Standard Test Method for measuring pH of Soil for Use in Corrosion Testing
• American Railway Engineering and Maintenance-of-Way Association (AREMA)
• Federal Highway Administration (FHWA)
• Publication FHWA-NHI-00-044 – Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes

V. CONCLUSION

Though there is no absolute way to eliminate all corrosion on under water piles, there are some effective measures to control them. The cathodic protection is found to be quite simple to employ and mostly used in marine conditions. The protective coatings are used in vast and expensive structures. The FRP composites have many advantages over conventional methods such that they are light weight, possess high strength and chemical resistance and moreover have incomparable flexibility.

Of the various ways of wrapping of FRP composites, transverse wrapping is found to be the easiest as otherwise, the longitudinal pieces are awkward to handle and difficult to position. Bi-directional material is the best option. Scaffolding measures during the application of materials ensures safety and simplifies installation. Out of the two system of FRP application, the pre-preg system is easier to use. On-site FRP saturation can be problematic. High winds and high tides should be avoided during the process.

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