Corrosion Performance of Electroless Nickel-Plated Steel

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ABSTRACT

The results showed excellent corrosion resistance for electroless nickel-plated steel embedded in concrete specimen exposed to outdoor or seawater. The chloride contents of concrete specimens increase as the days of immersing time in seawater pool increase during 500 days. Another steel bond strength test revealed that the electroless nickel-plated steel has similar performance as the conventional one. This means that the electroplating has no significant impact on steel bond strength. In most cases, the reinforcing steel bar which was coated with an electroless nickel-plated film showed a reduced corrosion probability.

KEY WORDS: corrosion resistance; freeze-thaw; durability; steel bond strength.

INTRODUCTION

In recent years, more and more incidences of problems with corrosion of reinforcing steel in concrete structures have been reported throughout the world. While there are several different theories on how steel corrodes in concrete, the problem is known to be associated with high concentration of chloride ions in the concrete and is especially severe in marine environments, coastal regions or where deicing salts are used. Steel embedded in concrete is normally protected from corrosion by an alkaline environment provided by the concrete cover. However, when chloride ions penetrate into the concrete, the PH of the concrete is reduced and this protective environment can be destroyed (Lee and Lee 1998).

Corrosion protection for rebar has been provided usually by coating the rebar with an epoxy. It has been assumed generally that epoxy coated rebar is immune to corrosion. However, performance of concrete structures using epoxy coated rebar has pointed to the contrary. Among a great number of examples of failures is the Long Key Bridge in Southern Florida, which showed severe signs of corrosion-related spalls within seven years after construction. Numerous additional spalls developed in other parts of the bridge substructure during subsequent years (Sagues 1994).

In addition, corrosion spalls began to appear also in the substructure of other Keys bridges built with epoxy-coated rebar at about the same time as the Long Key Bridge. These incidents included observations at the Seven Mile and the Niles Channel Bridges in 1987, at the Indian Key Bridge in 1990, and in the Channel Five Bridge in 1993 (Sagues 1994). The corrosion problem is believed to be associated with localized breakage of epoxy coating during construction, making the rebar even more susceptible to corrosion (Elleithy et al 1998). Virtually almost epoxy-coated rebar structures examined showed dramatic reduction of the adhesion bond between the epoxy coating and the underlying rebar. There is a need to specify a more reliable protection system for the rebar (Emmons 1995 and Swamy 1992). One of the feasible and reliable methods is to find a very promising technology of surface coating on rebar used for steel concrete structures. For example, fusion-bonded epoxy coating is extensively used to enhance the corrosion resistance of reinforcing steel. The bond strength between these bars and the concrete is expected to be less than that of the uncoated bars and it may be further impaired due to prolonged exposure to thermal variations. The results from Elleithy et al 1998 indicated a reduction in the critical bond strength between concrete and the fusion-bonded coated bars. Furthermore, the difference between the critical bond strength in the coated and uncoated bars decreased with increasing thermal cycles, indicating that thermal variation has a greater effect on bond strength than the coating thickness.

Electroless nickel-plated has been known to produce a thin film as one of the chemical electroplates. By producing the thin film with remarkable surface hardness, wear resistance, corrosion resistance as well as good adhesion that make it a very promising method of surface coating on steel used for construction (Huang 2006). However, studies on this Electroless nickel-plate method are still very limited and not yet widely explored. Accordingly, to further improve the process to increase the economic benefits of its applications is a critical subject to be studied.

The main aim of the work presented here is to assess the performance of steel coated with a nickel phosphorous alloy, and to evaluate corrosion resistance and durability of its bond to existing reinforced concrete.

EXPERIMENTS

Two kinds of severe environment testing on coated steel specimens were carried out to evaluate their corrosion resistance and durability of bond to existing concrete. One environment testing was done at Tai-Chung Harbor to test the corrosion resistance under rich chlorine environment near the sea shore. The other was a freeze-thaw cycling environment testing, which