

CHAPTER 1: INTRODUCTION

Chloride ion induced corrosion of reinforcing steel in concrete bridge decks has become a major problem in the United States. Steel will spontaneously corrode in the earth's moist, oxygen-rich environment. However, the high-alkaline environment of concrete forms a passive layer around the steel. This in turn reduces the spontaneous corrosion activity of the steel to nil. The problem arises from chloride ions that are present in seawater and deicer salts. Chloride ions that reach the concrete-steel surface begin to destroy the passive layer around the steel and allow the corrosion process to begin. These chloride ions reach the concrete-steel surface either by diffusing through the concrete pore water or through cracks in the concrete. Once the steel has started corroding it can cause cracks, spalling and delaminations on the bridge deck.

Latex modified concrete (LMC), low slump dense concrete (LSDC) and hot-mix asphalt membrane (HMAM) overlays are currently some of the most used rehabilitation methods. One of the limitations of these systems is that the chloride contaminated concrete is left-in-place. The corrosion activity still occurs at a reduced rate. Because the corrosion activity does still occur in these systems, it reduces concrete service life. The service lives of LMC and LSDC rehabilitation overlays and HMAM rehabilitation overlays are 22-26 years and 10-15 years, respectively¹. The current bridge design life is 75-100 years, thus making the service lives of these rehabilitation overlays unacceptable.

Epoxy coated reinforcing steel (ECR) was developed and promoted as a long term corrosion protection method for newly constructed bridge decks by the Federal Highway Administration (FHWA). It was estimated by FHWA that a less than specification quality coating, according to ASTM A 775, Standard Specification for Epoxy-Coated Reinforcing Steel Bars, would provide 46 years of corrosion free protection. As a result of this, ECR is the most widely used corrosion protection system today². However, recent evidence has suggested that ECR will not provide adequate long term corrosion protection. Some service life extension estimates are 5-7 years if the coating has not debonded from or is in the process of debonding

from the bar when chloride ions arrive at the depth of the steel². In cases where the concrete pore water has debonded the coating from the steel, the service life extension is nil.

To date, extensive efforts have been directed towards improving basic concrete properties and the protection of reinforcing steel for long term corrosion protection. However, little effort has been directed towards the development and use of corrosion durable materials such as aluminum or composites.

The Reynolds Metals Company has developed an aluminum bridge deck system. This system is proposed as an alternative to conventional reinforced steel bridge deck systems. The system consists of an aluminum substrate with a polymer concrete overlay. The substrate is an aluminum alloy 6063-T6 extruded bar stock. The overlay consists of an epoxy binder and silica sand aggregate. Reynolds Metals conducted research on this system, with the main focus being placed on the bond between the polymer concrete overlay and the aluminum substrate. Specimens were prepared both with and without pretreating the aluminum substrate surface prior to applying the polymer concrete overlay. As aluminum is exposed to air, an oxide layer forms on the surface. Chemical pretreatment can be used convert the reactive aluminum oxide to more inert species³. Thus, enhancing the bond between the polymer concrete overlay and the aluminum substrate. Specimens were subjected to various environmental conditionings that included a salt spray exposure, ultraviolet light exposure and freezing and thawing cycles. Pullout strength tests and fatigue tests were performed on the specimens after environmental aging. Reynolds was able to conclude from its test results that a surface pretreatment is essential to a good bond between the aluminum substrate and the polymer concrete overlay. It was found that if properly prepared, the composite system is durable after environmental exposure and fatigue⁴. A comparison between Reynolds tests results and the test results of this investigation will be presented in Chapter five.

There are some advantages to using an aluminum bridge deck system compared to a conventional reinforced concrete deck system. One is that the aluminum bridge deck systems

are a prefabricated modular design. This helps to reduce the time needed to install the system, it also reduces the need for formwork and site concrete. Another advantage is that the aluminum bridge deck system has a lower dead weight (22 pounds/square foot) than the concrete bridge deck system (100 pounds/square foot). And lastly, the aluminum bridge deck system has a potential for a longer service life because of its ability to resist the effects of deicer salts.

One of the major issues associated with the use of an aluminum bridge deck system is the ability of the polymer concrete overlay to provide an acceptable skid and wear resistance on the riding surface. Skid resistance is a measure of frictional characteristics of a surface, wear is the deterioration of a surface due to traffic use and/or the environment⁵. Another major issue of concern is the life of the bond between the polymer concrete overlay and the aluminum substrate when subjected to environmental factors and the fatigue effects of passing traffic. If debonding occurs, the traffic riding surface becomes the aluminum which offers little to no skid resistance.