CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The most common durability problem in reinforced concrete structures today is the corrosion of the embedded steel (Bentur et al. 1997). Corrosion of reinforcement in concrete can produce cosmetic flaws such as staining or cracking. Much more severe, however, is the structural damage it can produce. Delamination, spalling, exposure of the steel, and reduction of the reinforcement cross-section can lead to serious safety hazards (Bentur et al. 1997). Repair and/or replacement of these seriously damaged structures can be very costly. It is estimated that the cost to repair bridge decks in the US alone are somewhere between $50 and $200 million each year (Bentur et al. 1997). It is therefore apparent that any method of delaying or stopping the corrosion process would be greatly beneficial to the owners (departments of transportation) and civil engineering industry.

2.2 Causes of Corrosion

Although corrosion can occur in the absence of chlorides, chloride ions are the main cause for the corrosion of reinforcing steel in concrete (ACI 222R-96). It would seem obvious that to prevent corrosion, one could just produce concrete with no chlorides. Unfortunately, preventing corrosion is not as simple as eliminating all chlorides from the concrete mix. Although ACI 318-02 does specify maximum acceptable chloride contents under different conditions, it is often times impossible to fully eliminate chlorides altogether even in new construction. These ions can be found throughout nature. Even mix ingredients such as water and aggregate generally contain small amounts of chloride. Sometimes, chloride ions are intentionally added to the mix as a form of accelerant (ACI 222R-96). After casting, reinforced concrete can be further subjected to many forms of chloride invasion. Bridges and marine structures are especially vulnerable to chloride attack due to the use of deicing salts and salt laden air along the coastlines. When the chlorides are dissolved, they can migrate into the unprotected concrete just as pore water.

2.3 Mechanism of Corrosion

"The corrosion of steel in concrete is an electrochemical process in which both chemical reactions and flow of electrical current are involved" (Bentur et al. 1997). Four things must be present for corrosion to take place: an anode, a cathode, an electrical conductor, and an aqueous medium (ACI 222R-96). Electrons are produced at the anode by the anodic reaction and flow to the cathode where they are used in the cathodic reaction. This flow of electrons, along with the counter flow of ions in the external concrete pore solution make up the corrosion current (Bentur et al. 1997). Iron is oxidized to ferrous ions at the anode, i.e., the negative pole, as below:

$$\mathbf{Fe \rightleftharpoons Fe^{++} + 2e^{-}} \qquad \textbf{(2.1)}$$