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Modeling the interaction between non-uniform corrosion of rebar and corrosion-induced cover cracking

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1 Abstract

Circumferential non-uniform corrosion of rebars in concrete normally occurs in marine environment, and has an adverse impact on corrosion-induced cover cracking which may conversely change the circumferential corrosion profile. This paper investigates the interaction between chloride-induced non-uniform corrosion and corrosion-induced cover cracking. A chloride penetration model is introduced to predict the distribution of chloride content in concrete, which can determine the corrosion initiation time around the circumferential surface of a rebar. Subsequently, the time-dependent corrosion rate around the rebar surface can be calculated based on electrochemical theory, and then the corrosion profile at different time can be deduced. With the cross-sectional corrosion profile as an input, a mechanical model for corrosion-induced cover cracking can be utilized to simulate the development of surface crack, which has a significant influence on the diffusion of chloride ions and oxygen and may change the corrosion process. The derived model is verified with experimental results, and then a case study is conducted to demonstrate the time-varying non-uniform corrosion profile. Numerical simulation results indicate that, compared with uniform corrosion, non-uniform corrosion can lead to earlier cover cracking and faster development of surface crack width.

Keywords: Marine environment, reinforced concrete, concrete cover cracking, non-uniform corrosion

2 Introduction

Steel corrosion has become a primary factor for structural performance deterioration of reinforced concrete structures [1]. As reinforcement corrosion initiates and continues, the volumetric expansion of corrosion products gradually exerts internal pressure on the surrounding concrete, which may lead to longitudinal cracking and even spalling of concrete cover.

During the past decades, considerable research has been conducted on numerical simulation and experimental investigation of the corrosion-induced concrete cover cracking [2]. Most of these researches are based on the assumption of circumferential uniform corrosion, which may only apply to accelerated corrosion experiments in laboratory. Actually, both carbonation and chloride penetration are a time-consuming and gradual process, and normally induces circumferential non-uniform corrosion of rebars in a natural environment. Field investigations also show that the corrosion process normally starts around the rebar circumference facing concrete surface for the easy access to chloride ions.

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