Title

Development of Simulation Method for Crack Propagation and Corrosion Product Movement Due to Rebar Corrosion

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Introduction

The deterioration of reinforced concrete (RC) structures caused by corrosion of steel reinforcements is often characterized by concrete cracking as a result of volume expansion of the formed corrosion products. It is of great importance to understand the relationship between corrosion amount and crack development, since this relationship can help to quantify the level of corrosion from visible corrosion cracks, and to predict the residual service life of the damaged structures.

The development of corrosion cracks is affected by material properties of corrosion products, such as the expansion ratio, stiffness, and movement properties. There are a number of test results suggesting that part of corrosion products may penetrate to the concrete pores and cracks, which does not contribute to the expansion pressure. This experimental observation has been considered in several numerical modeling. Although these modeling techniques can simulate the effect of corrosion products movement on the crack development indirectly, the applied parameters may vary significantly. Especially, for simulating the crack propagation, the amount of the corrosion products that effectively contribute to concrete cracking was often determined with consideration of the crack volume. But many researches do not consider the effect of concrete volume directly, because continuum based method such as F.E.M can not consider crack width explicitly.

The aim of this paper is to develop the simulation method of the corrosion products movement through concrete pores and cracks and to clarify the influence of the corrosion products movement on the crack development in a quantitative manner. A numerical model is based on the Rigid Body Spring Method (RBSM) for structural analysis of concrete and the rebar based on stiffness equation, combined with the Truss Networks Model for mass transport analysis based on diffusion equation. The RBSM is one of discrete element methods and can simulate crack behavior explicitly. The moving process of corrosion product into concrete pores and cracks is highlighted in which the contribution of solid and liquid part of corrosion product is considered.

The developed simulation method is validated by comparison with the test results in terms of crack width and pattern. It is shown that the developed method can simulate internal and surface crack development dependent on time accurately