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Chloride Ingress Into Flexural Cracked Concrete

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ABSTRACT

The presence of cracks is shown to have a significant impact on chloride penetration into concrete. In this paper, the influence of flexural cracks on chloride ion penetration into reinforced concrete beams has been investigated experimentally and a theoretical model is developed. The size of the reinforced concrete beams tested is 200 x 250 x 2200 mm with 20 mm concrete cover. The beams were pre-cracked using a compression test machine and the crack widths induced varied between 0.1 mm to 0.5 mm. The chloride profile was determined after 1 month and 1 year of immersion in 3.0% NaCl solution. Chloride concentration varied with depth of crack at crack planes. A two-dimensional model using finite element analysis is developed to evaluate the chloride penetration into cracked concrete. This model was used to verify the chloride penetration data which is obtained from the experimental results. The prediction of chloride ingress, using the two dimensional model agrees well with the long term profiles.

***Key words**: durability, flexural cracks, chloride penetration, diffusion, cracked concrete.*

I. INTRODUCTION

It has been recognized that penetration of chlorides through the concrete cover is the basic mechanism that controls the corrosion process in a marine environment and corrosion of the reinforcing steel is one of the most important mechanisms of concrete deterioration that affects the durability of marine concrete structures. Corrosion of reinforcement can be initiated when the critical chloride concentration, known as critical threshold value is reached at the steel-concrete interface. Corrosion can also commence due to carbonation attack. In many cases, however, the penetration of chlorides through the concrete cover is considered to be the primary cause of steel corrosion for reinforced concrete structures in a marine environment.

Because of its critical role in causing corrosion of reinforcing bar, the mechanism of chloride transport into concrete has become the focus of considerable research. The development of a reliable prediction model for the ingress of chlorides into concrete should consider the complex combination of several transport mechanisms that include diffusion, capillary sorption and permeation[3]. For most cases, however, diffusion is assumed to be the governing mechanism for the ingress of chlorides into concrete and a model based on one-dimensional Fick's second law of diffusion has been widely used to estimate the chloride penetration into concrete.

For uncracked concrete, prediction using one dimensional Fick's second law, result in quite realistic estimation of chloride content in concrete. Once cracking has occurred, however, the diffusion of chlorides may occur both in the direction of the depth and in the direction lateral to its depth, therefore for cracked concrete a two-dimensional chlorides diffusion process should be assumed[5].

II. EXPERIMENTAL PROCEDURE

2.1 Materials

Normal strength concrete mixes were designed using locally available sand and crushed gravel as fine and coarse aggregate, respectively. Concrete Grade 20 is used throughout the present study. The water absorption and specific gravity on SSD basis of these aggregates are summarized in **Table 1**. Ordinary Portland cement similar to ASTM Type I is used.

Table 1
Aggregate Properties

Aggregate	Specific gravity	Water absorption
Coarse aggregate	2.56	4.60%
Fine aggregate	2.46	3.95%

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