CHLORIDE INGRESS IN UNSATURATED CONCRETE-DEVELOPMENT OF A MODEL, DETERMINATION OF TRANSPORT COEFFICIENTS

By

M. NAGESH

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Dedicated To My Mother

Source of my Strength and Inspiration
in the Pursuit of Knowledge

CERTIFICATE

This is to certify that the thesis entitled, "**Chloride Ingress in Unsaturated Concrete – Development of A Model, Determination of Transport Coefficients**", being submitted by Mr. M. Nagesh to Indian Institute of Technology, Delhi, for award of the degree of **Doctor of Philosophy** in Civil Engineering is a record of original bonafide research work carried out by him. Mr. M. Nagesh has worked under my guidance and supervision.

To the best of my knowledge, the thesis has reached the requisite standard. The material contained in this thesis has not been submitted, in part or in full to any other University or Institute for the award of any degree or diploma

BBhattacharjee

(Dr.B.Bhattacharjee)
Associate Professor
Dept. of Civil Engineering
Indian Institute of Technology
Hauz Khas, New Delhi-110016
India

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(M.NAGESH)

ABSTRACT

Concrete structures are designed not only for the strength and stability. but are also designed for their durability in a given exposure condition. Most concrete deterioration problems involve the penetration of external ions into the structure of the material. Given the increasing importance of durability problems, ion transport, mechanisms in cement- based materials have been the subject of a great deal of research in the past decade. Chloride induced corrosion of reinforced concrete is well known as a serious durability problem, caused by the rapid penetration of chloride ion into concrete. An investigation of appropriate chloride transport processes should, therefore, necessarily constitute an essential part of any study on chloride induced corrosion.

Chloride permeation is a complex phenomenon, involving various factors such as diffusion of chloride ions and movement of chlorides due to permeation of water. The predominant transport process is primarily dependent on the moisture condition of the concrete. A significant amount of research has been reported in the past. on the subject of chloride movement in saturated concrete under electrically assisted condition. Whereas in case of unsaturated/submerged concrete, the dominant phenomena are the capillary suction assisted chloride movement along with the diffusion. The past literature is deficit of such studies taking the capillary suction assisted chloride movement.

In the present research work, firstly, general model that takes care of chloride transport through unsaturated concrete considering the dominant mechanism involved (capillary suction in addition to diffusion) has been presented together with a simple experimental set-up. Also a finite difference calculation procedure has been presented

through which the transport coefficients in unsaturated as well as saturated concrete can be estimated.

Chloride transport properties are governed mainly by the porosity and pore size distribution. The porosity and pore size distribution again are governed by the mix parameters. For investigating the effect of concrete mix parameters on the transport coefficients, 9 mixes with 3 cement content and 3 water-cement ratio have been adopted. Triplicate specimens have been used in all cases. Two periods of curing have been adopted.

Solutions of different concentrations have been adopted to study the effect of concentration of the penetrating solution on the transport coefficient. NaCl and $CaCl_2$ solutions have been used to study the effect of cation type. Two initial specimen conditioning regimen has been adopted. As the characteristics of concrete depends on the pore structure of concrete. It is necessary to know the variation of chloride transport with concrete pore structure (i.e., porosity and pore size distribution of concrete). A limited micro-structural study has been carried out, using Mercury Intrusion Porosimeter to study the variability of the transport coefficients with the microstructure of concrete and also a model has been presented with pore size distribution data as input to determine the transport coefficients.

The relevant conclusions drawn include utility of the model and the experimental method, conclusions regarding the dependence of transport coefficients with the concentration inside the concrete, the dependence of transport coefficients on the microstructure of concrete.

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