Advances in Concrete Construction, *Vol. 2, No. 1 (2014) 39-56*
DOI: http://dx.doi.org/10.12989/acc.2014.2.1.039

Chloride diffusion study in different types of concrete using finite element method (FEM)

Sajal K. Paul[1a], Subrata Chaudhuri[2b] and Sudhirkumar V. Barai[*1]

[1]Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur 721 302, India
[2]UltraTech Cement Ltd., Aditya Birla Group, Mumbai 400 093, India

(Received February 10, 2014, Revised March 5, 2014, Accepted March 7, 2014)

Abstract. Corrosion in RCC structures is one of the most important factors that affects the structure's durability and subsequently causes reduction of serviceability. The most severe cause of this corrosion is chloride attack. Hence, to prevent this to happen proper understanding of the chloride penetration into concrete structures is necessary. In this study, first the mechanism of this chloride attack is understood and various parameters affecting the process are identified. Then an FEM modelling is carried out for the chloride diffusion process. The effects of fly ash and slag on the diffusion coefficient and chloride penetration depth in various mixes of concretes are also analyzed through integrating Virtual RCPT Lab and FEM.

Keywords: concrete; chloride diffusion; rapid chloride permeability test; FEM simulation

1. Introduction

Corrosion of reinforcement has been established as the predominant factor causing widespread deterioration of concrete construction worldwide, especially of the structures located in the coastal marine environment. The most important reason of this kind of corrosion attack on concrete is chloride ingress. It causes corrosion in the steel reinforcements embedded in the concrete. The hydration products of cement provide a high alkaline environment in concrete which will activate a passivating film of iron oxide on the embedded steel bars. The passivating film can keep its chemical stability on the steel surface and protect the steel from being corroded. However, when the chloride concentration in concrete reaches a threshold value, the protective film on the steel bars is destroyed (at pH level below 11), and the reinforcement corrosion starts. As a result effective cross sectional area of reinforcements gets reduced and it is replaced with corrosion products. Hence, the ultimate strength of reinforcing bars gets reduced. Later due to over accumulation of corrosion product on the reinforcement surface tensile stress is generated in concrete, which causes cracking and premature loss of service life of concrete. So, chloride ion ingression and thereby induced reinforcement corrosion in steel-reinforced concretes have

[a]M. Tech. student, E-mail: sajalpaul.ce104@gmail.com
[b]Ph.D., E-mail: subrato.chowdhury@adityabirla.com
*Corresponding author, Professor, E-mail: skbarai@civil.iitkgp.ernet.in

http://www.techno-press.org/?journal=acc&subpage=7 ISSN:2287-5301(Print)2287-531X(Online)

3589.
Ishida, T., Prince, O.L. and Anh, H.T.L. (2009), “Modelling of chloride diffusivity coupledwith non-linear binding capacity in sound and cracked concrete”, *Cement Concrete Res.*, **39**, 913-923.
Ismail, M., Toumia, A., Françoisa, R. and Gagné, R. (2004), “Effect of crack opening on the local diffusion ofchloride in inert materials”, *Cement Concrete Res.*, **34**(4), 711-716.
Lina, K.T. and Yang, C.C. (2014), “A simplified method to determine the Chloride migration coefficient of concrete by the electric current in steady state”, *Comput. Concr.*, **13(**1), 117-133.
Dao, L.N., Dao, V.N., Kim, S.H. and Ann, K.Y. (2010), “Modelling steel corrosion in concrete structures”, *Int. J. Electrochem. Sci.*,**5**, 302-313.
Naik, T., Singh, S. and Hossain, M. (1996), “Permeability of high-strength concrete containing low Cement factor”, *J. Energy Eng.*, **122**(1), 21-39.
Namagga, C. and Atadero, R.A. (2009), *World of Coal Ash (WOCA) Conference* Lexington, KY, USA.
Sillanpää, M. (2010), “The effect of cracking on chloride diffusion in concrete, Master’s thesis submitted in partial fulfillment of the requirements for the degree of master of science in technology”, Department of Structural Engineering and Building Technology, Aalto University.
Stanish, K.D., Hooton, R.D. and Thomas, M.D.A. (2000), “Testing the chloride penetration resistance of concrete: A literature review”, Department of Civil Engineering, University of Toronto.
Suwito, C.X.C. and Xi, Y. (2006), *International Journal of Numerical analysis and Modeling*, **3**(4), 481-503.
Thomas, M.D.A. and Bamforth, P.B. (1999), “Modelling chloride diffusion in concrete effect of fly ash and slag”, *Cement Concrete Res.*, **29**, 487-495.
Wang, L. and Ueda, T. (2011), “Mesoscale modelling of the chloride diffusion in cracks and cracked concrete”, *J. Adv. Concrete Tech.*, **9**(3), 241-249.
Vagelis, G.P. (2013), “Service life prediction of a reinforced concrete bridge exposed to chloride induced deterioration”, *Adv. Concrete Construct.*, **1**(3), 201-213.
Yunping, X. and Zdeněk, P.B. (1999), “Modelling chloride penetration in saturated concrete”, *J. Mater. Civil Eng.*, **11**, 58-65.
Yang, C.C. and Weng, S.H. (2013), “A multi-phase model for predicting the effective chloride migration coefficient of ITZ in cement-based materials”, *Adv. Concrete Construct.*, **1**(3), 239-252.
Zeng, Y. (2007), “Modeling of chloride diffusion in hetero-structured concretes by finiteelement method”, *Cement Concrete Compos.*, **29**, 559-565.
Zichao, P., Xin, R. and Airong, C. (2014), “Chloride diffusivity of concrete: probabilistic characteristics at meso-scale”, *Comput. Concr.*, **13**(2), 187-207.

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