

Coupled Point Defect Theory and Artificial Neural Network Studying Dynamic Behaviors of Rebar Corrosion

Yakun Zhu^{1,2}, Digby D. Macdonald², Mirna Urquidi-Macdonald³, George R. Engelhardt⁴

¹ *University of Science and Technology Beijing, Beijing, China*

² *University of California at Berkeley, Berkeley, CA, USA*

³ *Pennsylvania State University, University Park, PA, USA*

⁴ *OLI Systems, Inc., 2 Gatehall Dr. Parsippany, NJ, USA*

Yakun.zhu@ustb.edu.cn

Abstract The degradation of reinforced concrete structures remains a serious issue in infrastructural systems, such as buildings, highways, and bridges. The problem is caused by the presence of chloride, either from being present in the concrete mix (e.g., from the use of brackish water or the addition of CaCl_2 as a “setting agent”) or by ingress from the external environment (e.g., road salt or marine environments). A metric known as the chloride threshold (CT) has been developed to describe the susceptibility of the steel to chloride-induced passivity breakdown. Despite the widespread use of CT as a metric for describing the impact of chloride on rebar corrosion, a theoretical basis for this metric does not appear to have been established. In addition, the CT is a highly distributed parameter, reflecting the practical difficulty in controlling or measuring various environmental parameters in concrete and in reliably detecting passivity breakdown. Therefore, we have conducted several tasks to theoretically and practically understand how rebar corrosion is dependent on CT. We have established a rich database of CT and its associated primary and secondary influencing factors. Statistical analyses reveal that CT is lognormally distributed whereas potential parameters are normally distributed. We also demonstrated that it is possible to calculate CT in pure, empirical manner using Artificial Intelligence (AI) techniques, in accordance with point defect theory prediction, through trained artificial neural network. However, a significant amount of work remains to be completed in the future in developing an understanding of steel corrosion in concrete. Our knowledge of underlying factors that control the CT is still very poor due to the paucity of accurate data in the literature, and it is ultimately insufficient to provide a more accurate estimate of CT than that obtained by either the ANN prediction or point defect theory analysis at this stage.

Keywords Rebar corrosion, chloride threshold, point defect theory, artificial intelligence