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Prediction of Time to Crack Reinforced Concrete by Chloride Induced Corrosion

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Abstract : In this paper, a review of different mathematical models which can be used as prediction tools to assess the time to crack reinforced concrete (RC) due to corrosion is investigated. This investigation leads to an experimental study to validate a selected prediction model. Most of these mathematical models depend upon the mechanical behaviors, chemical behaviors, electrochemical behaviors or geometric aspects of the RC members during a corrosion process. The experimental program is designed to verify the accuracy of a well-selected mathematical model from a rigorous literature study. Fundamentally, the experimental program exemplifies both one-dimensional chloride diffusion using RC squared slab elements of 500 mm by 500 mm and two-dimensional chloride diffusion using RC squared column elements of 225 mm by 225 mm by 500 mm. Each set consists of three water-to-cement ratios (w/c); 0.4, 0.5, 0.6 and two cover depths; 25 mm and 50 mm. 12 mm bars are used for column elements and 16 mm bars are used for slab elements. All the samples are subjected to accelerated chloride corrosion in a chloride bath of 5% (w/w) sodium chloride (NaCl) solution. Based on a pre-screening of different models, it is clear that the well-selected mathematical model had included mechanical properties, chemical and electrochemical properties, nature of corrosion whether it is accelerated or natural, and the amount of porous area that rust products can accommodate before exerting expansive pressure on the surrounding concrete. The experimental results have shown that the selected model for both one-dimensional and two-dimensional chloride diffusion had ±20% and ±10% respective accuracies compared to the experimental output. The half-cell potential readings are also used to see the corrosion probability, and experimental results have shown that the mass loss is proportional to the negative half-cell potential readings that are obtained. Additionally, a statistical analysis is carried out in order to determine the most influential factor that affects the time to corrode the reinforcement in the concrete due to chloride diffusion. The factors considered for this analysis are w/c, bar diameter, and cover depth. The analysis is accomplished by using Minitab statistical software, and it showed that cover depth is the significant effect on the time to crack the concrete from chloride induced corrosion than other factors considered. Thus, the time predictions can be illustrated through the selected mathematical model as it covers a wide range of factors affecting the corrosion process, and it can be used to predetermine the durability concern of RC structures that are vulnerable to chloride exposure. And eventually, it is further concluded that cover thickness plays a vital role in durability in terms of chloride diffusion.

Keywords : accelerated corrosion, chloride diffusion, corrosion cracks, passivation layer, reinforcement corrosion
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