KSCE Journal of Civil Engineering
DOI 10.1007/s12205-022-1601-4

pISSN 1226-7988, eISSN 1976-3808
www.springer.com/12205

Structural Engineering

Prediction of Equivalent Chloride Ion Diffusion Coefficient in Cracked Concrete of the in-Service RC Element

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ARTICLE HISTORY

Received 3 September 2021
Accepted 21 December 2021
Published Online 22 February 2022

KEYWORDS

In-service RC element
Equivalent chloride diffusion coefficient
Crack width
Crack spacing
Crack extending length

ABSTRACT

Considering the influence of the visible load-induced transverse cracks on chloride ion diffusion in cracked concrete of the in-service reinforced concrete (RC) elements under marine environment, a typical concrete volume with one transverse crack was taken to establish the governing equation. Assuming the crack widths at the outer lateral and bottom surfaces were equal, a model to predict the equivalent chloride diffusion coefficient in cracked concrete was put forward to consider the influence of the average transverse crack width, crack spacing and crack extending lengths in beam height and width directions on chloride diffusion. Results show that the proposed model can better reflect the variation trend of the equivalent chloride diffusion coefficient with different crack widths in in-service RC elements under marine environment.

1. Introduction

Chloride penetration in the in-service reinforced concrete (RC) elements is the main cause of the corrosion of the reinforcing bar in concrete in marine environment (Lei et al., 2020; Kiesse et al., 2020; Pasupathy et al., 2021a; Pasupathy et al., 2021b). Under the service-loads, the transverse cracks of different widths and depths in the concrete of the in-service RC elements provide a fast channel for chloride and other harmful ions to enter the concrete, which has a negative effect on the performance of those RC elements (Şahmaran, 2007; Şahmaran and Yaman, 2008; Ramezanianpour et al., 2018). For instance, crack widths higher than 135 μm may reduce the initiation period of corrosion process in RC elements (Şahmaran, 2007; Şahmaran and Yaman, 2008); the increased corrosion of reinforcement resulting from the increment of the crack widths may result in the increased probability of degradation of RC beams (Ramezanianpour et al., 2018). It is very important to understand the process of chloride transport in cracked concrete and determine the chloride ion diffusion coefficient in it, helping to predict the service life of the RC structures.

In the past years, experimental research on the permeability and diffusion of chloride ions in cracked concrete had been conducted (Rodriguez, 2001; Şahmaran, 2007; Şahmaran and Yaman, 2008; Djerbi et al., 2008; Granger et al., 2009; Marsavina et al., 2009; Picandeta et al., 2009; Wang et al., 2009; Jang et al., 2011; Al-Kutti et al., 2014; Wang et al., 2016; Wang, 2017; Ramezanianpour et al., 2018; Du et al., 2019; Wang and Zheng 2019; Zhu et al., 2020; Xu et al., 2020b; Zhou et al., 2020; Russo et al., 2020; Al-Ameeri et al., 2021; Lai et al., 2020; Wu et al., 2020; Wu et al., 2021). Among those experimental studies, cylindrical concrete specimens were used by Rodriguez (2001), Djerbi et al. (2008), Marsavina et al. (2009), Picandeta et al. (2009), Wang et al. (2009), Jang et al. (2011) and Wang (2017); concrete cubic specimens were used by Wang et al. (2016); concrete prism specimens were used by Şahmaran (2007), Şahmaran and Yaman (2008), Granger et al. (2009), Xu et al. (2020b), Zhou et al. (2020) and Russo et al. (2020); RC beam specimens were used by Al-Kutti et al. (2014), Ramezanianpour et al. (2018), Du et al. (2019), Wang and Zheng (2019), Zhu et al. (2020), Al-Ameeri et al. (2021), Lai et al. (2020), Wu et al. (2020) and Wu et al. (2021). Although artificial cracks were created in the concrete specimens (Rodriguez, 2001; Marsavina et al., 2009; Du et al., 2019) occasionally, most concrete or RC test specimens were loaded to crack (Şahmaran, 2007; Şahmaran and Yamanm, 2008; Djerbi et al., 2008; Granger et al., 2009; Wang

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