Climate Change and Its Influences on Spatial Time-Dependent Reliability of Pretensioned Prestressed Concrete Bridge Girder Subject to Carbonation-induced Corrosion

Jianxin PENG
Lecturer, PhD
School of Civil Engineering and Architecture, Changsha of University of Science and Technology
Changsha, Hunan, China
pengjianxin2008@gmail.com

Jianxin Peng, born 1978, received his PhD degree in civil engineering from the Hunan Univ., China. His main area of research is related to reliability-based condition assessment, climate change and its effects on concrete structures.

Jianren ZHANG
Professor, PhD
School of Civil Engineering and Architecture, Changsha University of Science and Technology
Changsha, Hunan, China
jianrenz@hotmail.com

Jianren Zhang, born 1958, received her PhD degree in civil engineering from the Tsinghua Univ., China. His main area of research is related to durability assessment of reinforced concrete structures.

Lei WANG
Lecturer, PhD
School of Civil Engineering and Architecture, Changsha of University of Science and Technology
Changsha, Hunan, China
Leiwlei@hotmail.com

Lei Wang, born 1979, received his civil engineering degree from the Changsha Univ. of Science & Technology.

Summary

The paper will assess how increases in CO_2 levels will affect carbonation-induced damage and safety loss to prestressed concrete structures. Probabilistic methods are used as there is significant spatial uncertainty and variability of deterioration mechanisms, material properties, dimensions, strength and load modelling and environments. The spatial time-dependent structural reliability analysis will predict the probability of corrosion initiation and the probability of failure (collapse) of a typical prestressed concrete AASHTO bridge girder over the next 100 years. Results are presented for a range of future CO_2 emissions scenarios. For the worst case scenario the probability of corrosion initiation is 340% higher than the best mitigation scenario. There is thus a significant likelihood of corrosion damage that will need costly and disruptive repairs during the service life of many concrete structures. For the worst case scenario the probability of failure is 15% higher than that for the best mitigation scenario. For the worst case scenario the probability of failure corresponding to spatial effects is 18% higher than that for non-spatial analysis.

Keywords: pretensioned prestressed concrete; climate change; carbonation-induced corrosion; emission scenarios; spatial time-dependent reliability.

1. Introduction

The durability of Prestressed Concrete (PSC) structures is adversely affected by environmental stressors. A common and serious stressor is carbon dioxide (CO_2) which can cause depassivation of the protective film of steel reinforcement (known as carbonation). Carbon dioxide is always present in the atmosphere and its concentration is higher in the vicinity of its sources – in industrial and densely populated regions which tend to have the highest proportion of built infrastructure. For example, Stewart et al. (2002)[1] found that high CO_2 concentrations were recorded in industrial areas in the Czech Republic, and then assessed the effect this would have on carbonation depths by considering time-dependent increase in CO_2 levels during the 21st century.

Pitting corrosion is non-homogeneous along a prestressing steel, in fact it is highly spatially variable due to the spatial variability of concrete and steel material properties, environment, moisture, concrete cover, surface cracking. Recently, spatial variability of corrosion damage has been studied. Stewart (2009)[2] modelled the spatial effect of pitting corrosion on the structural

https://doi.org/10.2749/222137810796012162
Distributed by structurae