Assessing climate impact on reinforced concrete durability with a multi-physics model

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Abstract

A framework for performance-based durability engineering can incorporate climate impacts in its assessment of the lifetime sustainability of built infrastructure. Most performance-based durability and climate impact assessments have used simplified deterioration models, which are insensitive to shorter-term fluctuations in boundary conditions and therefore may underestimate climate change impacts. A highly sensitive fully-coupled, validated, multi-physics model for heat, moisture and ion transport and corrosion was used to assess a reinforced concrete structure located in coastal Norfolk, Virginia. Deterioration was predicted using tidal exposure conditions obtained from statistically downscaled global climate model output under two emissions scenarios. Deterioration, repair, and decision metrics under the emissions scenarios were compared using the performance-based framework to assess the influence of climate change.

Keywords: durability; performance-based; reinforced concrete; corrosion; climate change; hygrothermal; chlorides.

1 Introduction

Climate change has long been expected to increase the rate of damage accumulation of built infrastructure, both through more severe deterioration and through increased damage during extreme events such as hurricanes. As a globally favoured building material, any change in the rate of deterioration in reinforced concrete (RC) structures would be expected to result in significant impacts. RC is particularly susceptible to chloride-induced corrosion, which can lead to both serviceability and safety issues. Chloride-induced corrosion is a highly complex, coupled stochastic process; combining the stochastic nature of corrosion with the high uncertainty associated with both global and local climate change makes quantifying potential climate impacts challenging. It is a further challenge to link changing deterioration rates to more tangible decision-making information such as costs, as would be needed to support adaptation.

Several researchers have developed probabilistic approaches for assessing climate impacts on durability of structures exposed to chlorides. Previous studies have indicated a potential decrease in time to failure by <1% to >30% [1–3]. However, these studies have generally used deterioration models that are not particularly sensitive to changes in boundary conditions, e.g.,

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