Influence of climate change on thermal stresses in concrete box girders

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Abstract

The purpose of this study is to investigate the impact of climate change on the thermal and structural response of concrete box girders. An advanced finite element platform was used to model a concrete box girder and analyze the additional thermal stresses that result from climate change. Meteorological data for future climate scenarios in Toronto, Canada was used as input in a thermal model to simulate the temperature distribution within the bridge deck. The temperature distribution was then used as input in a structural model of the bridge, to determine the resulting thermal stresses. The results show increases in tensile and compressive stresses as well as increased bridge movements. This study highlights the importance of explicitly considering climate change to achieve more robust bridge codes, particularly when it comes to thermal effects.

Keywords: box girder; concrete; climate change; thermal effects; finite element analysis; bridge engineering; thermal gradients

1 Introduction

Climate change is defined as a change in climatic conditions which is attributed directly or indirectly to human activity [1]. Changes in atmospheric conditions influence the performance of existing and future bridge infrastructure by altering the frequency and magnitude of environmental loads as well as accelerating the degradation rate of building materials due to the cyclic reversals effected by the temporal cycles of climate extremes.

One load that is particularly impacted by the change in climatic conditions is the thermal load acting on the bridge. Prevalent bridge codes use historical climate data to provide extreme bridge design temperatures as well as the shape and magnitude of thermal gradients without considering the possibility of future changes in climatic conditions. The purpose of this study is to investigate the influence of climate change on the temperature distribution within the bridge deck and its resulting structural performance.

2 Background Information

2.1 Thermal effects

The temperature within a bridge deck changes as it interacts with the climatic conditions in its vicinity. This temperature change can lead to the expansion and contraction of the bridge materials and a commensurate change in the length of the bridge superstructure. In an instance where a member is restrained against movement, the resulting strains will cause cracking and internal stress redistribution.

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