Estimation of Extreme Climatic Thermal Actions in Concrete Structures

Oskar LARSSON
PhD-Student
Lund University
Lund, Sweden
Oskar.Larsson@kstr.lth.se

Oskar Larsson, born 1983, received his civil engineering degree from Lund University, Sweden. He continued upon graduating as a PhD-student at the same university. His main area of research is related to thermal actions.

Summary

The temperature distribution in concrete structures varies due to annual and daily climate variations. Solar radiation, air temperature, wind speed and long-wave radiation affect the temperature in the structure and may cause longitudinal and transversal movements. If these movements are restrained, stresses and strains can be induced which may contribute to cracking. To be able to predict the long-term effects and extreme thermal actions a finite element model has been developed. The model is used with global meteorological data to predict annual maxima of temperature gradients. The results show that the values in the Eurocode concerning the investigated region are underestimated for positive linear gradients. Values with a return period of 5 years are above the design values from Eurocode with a 50 year return period. The type of paving used has a significant effect on the results

Keywords: thermal actions, concrete, FE-model, solar radiation, climate

1. Introduction

Thermal actions due to variations in the surrounding climate can cause problems in concrete bridges. Daily and seasonal fluctuations in air temperature, solar radiation, cloud cover and wind speed will cause temperature variations in both space and time in a structure, which in turn will cause movements. Lengthwise movements, such as elongation of a bridge, are mainly affected by seasonal variations in air temperature, while transversal movements, such as curvature, are mainly affected by daily variations in solar radiation and long-wave heat radiation. If these movements are restrained, stresses may be induced in the structure. The temperature profile in the concrete also depends on material parameters such as density, conductivity, heat capacity, solar radiation absorptivity and the convective heat transfer coefficient, a factor mainly affected by wind speed. Given the complexity of these effects and the possible severity of the problems they cause, it is important to develop methods able to capture the relevant temperature variations and the induced stresses. Such methods are needed both for assessments of existing bridges, where thermal effects have a large impact, and for new bridges with special design conditions.

Several studies of thermal effects have been performed during the latest 30 years [1]-[5]. The main reason for these studies is that problems due to thermal effects have been reported in a large number of concrete bridges constructed during this period. The problems are mainly caused by a reduced use of bearings and movement joints due to durability concerns and more advanced analysis methods. The previous studies of thermal effects for different situations and geographical areas show that it is possible to simulate the temperature variations accurately.

Unfortunately, existing models use climate data with low resolution. In most cases only daily total values of climatic factors are used as input data, for example the daily total radiation [5]-[7]. If instead hourly values for solar radiation and long wave radiation are used, it is possible to capture

https://doi.org/10.2749/222137810796024448