Simulation of Thermal Load Distribution in Portal Frame Bridges

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Abstract

Uneven exposure to e.g. solar radiation can cause temperature differences between various structural parts of a bridge, which leads to tensile stresses if the parts cannot move freely. In this study, thermal simulations and stress calculations on a model of a portal frame bridge are performed with the aim of evaluating the temperature difference between the bridge parts. It is shown that the temperature difference between parts which is proposed by Eurocode 1 is overestimated, thus the resulting stress distribution being unrealistic. Using the design method proposed by Eurocode 1 is therefore likely to exaggerate the required reinforcement in crack width limit design, which in turn would lead to unnecessary costs and environmental impacts. Further studies are needed in order to determine proper thermal load values and temperature distributions.

Keywords: Thermal load, portal frame bridge, restraint stresses, thermal simulations, Eurocode.

1 Introduction

Changing weather conditions lead to temperature variations in bridges both over time and space. The temperature variations are caused by e.g. varying air temperature, temperature of adjacent soil, short wave radiation, wind speed, and long wave radiation from the ground and the sky. The air temperature has a large impact on the structural temperature, but impacts the bridge temperature relatively slowly. Increased wind speed makes the structure adjust its temperature faster due to convection. Soil temperature is more constant than the air temperature, and therefore levels out temperature variations in adjacent parts of the structure. Short wave radiation which originates from the sun can heat exposed surfaces significantly, contributing to rapid changes in temperature. Long wave radiation heat transfer to or from the sky can affect temperatures in a similar manner.

Due to these different thermal factors, the temperature in a bridge can at a certain time vary in different ways. One possible way is by temperature gradients over cross sections, investigated by i.e. Larsson [1] and Peiretti et al. [2]. Another type of temperature variation is the temperature differences between structural parts, which might appear e.g. between the flange and the web in a box-section bridge, the beam and the bridge deck in a girder bridge, or between deck and abutment in a portal frame bridge. The temperature variations cause the volume of structural parts to vary, and in structural members prevented from changing their shape, e.g. by

https://doi.org/10.2749/stockholm.2016.0009
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