Long-term monitoring of temperatures in steel box girders

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Summary

During a period of several years, temperature variations have been monitored at several points of a cross section of the Vilvoorde Viaduct, which is one of the most important steel box girders of the Belgian highway network. Analysis of the monitoring data indicates that substantial temperature variations exist, during a 24-hour cycle of heating and cooling. Values of more than 30 degrees or more are found to be quite common. In addition temperature gradients have been measured of more than 20 degrees between both sides of the steel box girder, which could result in additional displacements and warping of the cross section.

Although thermal loads are not often considered during the first design steps of steel box girders, their influence can be quite substantial. When the thermal loads and more specifically the thermal gradients within the steel box girders reach considerable values, a number of other effects are influenced. High thermal gradients will reduce the cohesion of waterproofing layers and wearing courses, thus reducing the composite behaviour of these layers with the deck plate.

Hence, the quantification of the thermal loads working on steel box girders becomes quite important. While this was previously done using detailed finite element models, including solar radiation, cooling, convective airflow, etc. this research paper will give tangible design values for thermal gradients in steel box girders, based on actual measurements, which are in some cases higher than those values given by the current design codes, especially when looking at the temperature difference between two points of the same cross-section.

Keywords: steel box girder, temperature load, monitoring

1. Introduction

Steel box girders, equipped with an orthotropic bridge deck and constructed using stiffened plates are one of the most frequently used concepts for road bridges and flyovers spanning between 80 and 160 m. Similar sections are often applied for arch cross-sections of bridges spanning 200 m or more. They are a very economical solution and are easy to build thanks to the modern construction techniques. A new problem has arisen in recent international research, that was not taken into account for the design until now, which can heavily influence the behaviour of the bridge.

During a 24-hour cycle, a closed box girder is susceptible to heating, caused mainly by the radiant heat of the sun, but also by heat transfer by convection in the air inside the box girder and by the good thermal conductivity of the steel. The radiant heat of the sun, which acts primarily on the surface of the bridge, is captured by the surfacing and transmitted to the supporting steel structure. Once the steel section of the box girder heats up by thermal conduction, it will then on its turn start to heat up the air inside of the box girder, which will result in an internal heat convection system in the girder. The natural ventilation because of the manholes in these types of girders can never be influential enough to create a cooling airflow substantial enough to countermand this effect, taking in mind the typical dimensions of such a structure. As soon as the external heating source of the surfacing and the effects of the radiant heat decrease, the surface layers will start cooling. The interior of the box however, will nevertheless keep heating the surface layers for a considerable

https://doi.org/10.2749/222137810796024583
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