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INFLUENCE OF TEMPERATURE EFFECTS IN STEEL BOX GIRDERS

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ABSTRACT

This paper shows the results of the detailed monitoring program verifying the design and behaviour of the newly built steel superstructure.
The 523 m long historic viaduct crossing the Pede valley in Belgium consists of 16 three-hinged reinforced concrete arches with a span of 32 m each and a maximum height of 20 m, as shown in *Fig.1*. [1]
As part of a large-scale project in order to improve the accessibility of the Belgian capital by train, the existing railway line between Brussels and Ghent is expanded from 2 to 4 railway tracks over a length of more than 25 km.
Thermal sensors were installed on the steel bridge deck to analyze the temperature during long-term strain gauge monitoring in order to study the effects of temperature gradients on the closed steel box girders of the steel fly-overs.
The background of the monitoring project is a number of recent measurement projects on steel box girders in Belgium, which have indicated that daily temperature variations and their uneven distribution over the bridge can be an important load condition, the resulting behavior is not always included in the design loads according to the codes. [2]

Fig. 1. Front view of the new steel super structure.

The measured temperatures are introduced into a detailed finite element model, stresses resulting from this model are compared with measured stresses and stresses based on calculation using the same model but based on design load combinations. While the size of the temperature variations is more or less as was expected the resulting behaviour is more complex and less homogeneous than is generally assumed. A finite element model has been developed for the modelling of the added lateral steel box girders with variable sections of the bridge. The height of the box section is about 1.985 m, while the width of the upper surface is about 4.140 m. The longitudinal open stiffeners

which are present in the real bridge are not represented in the finite element model but they have been taken in account by modifying the thickness of the corresponding steel plates accordingly. This ensures that the thermal behavior in terms of conduction and thermal capacity of the model is comparable to the real bridge. The steel plates are modeled as shell elements with different thicknesses and material proprieties, and the concrete as volume elements with linear elastic proprieties. The thicknesses vary between 45 mm for the sides, 35 mm for the diaphragms, 95 mm for the bottom plate and 65 mm for the top plate, the span length is 32.100 m.

Nineteen variable cross-sections are used to give the bridge its peculiar shape. On the top of the steel box, a concrete structure is installed which is not contributing significantly to the thermal behavior. The two different materials are assumed to be perfectly connected over their entire connection area. Two different types of finite element analyses were performed: a steady state thermal analysis, followed by a structural implicitly non-linear analyses.

The thermal analysis is used to determine the actual the surface temperatures on all points of the steel box during a fictional 24h day. To do this, 8 different sinusoidal temperature functions were applied on the faces of the steel model. These functions are based on the real temperatures which are registered using the sensors. The temperatures in the thermal analysis vary over time and is simulating simulate the real solar irradiation during a longer period. For this thermal analysis, the thermal functions are actually acting the constraints of the steel box girder.

The structural implicit non-linear analysis leads to a static structural behavior along the same time used on the thermal analysis using the thermal loads obtained on the previous analysis as structural load; the time steps is of 1 second the thermal conductivity has been assigned to the model so it can deform under the thermal load applied, a reference temperature of zero degrees is also assigned to the model; in the 4 bottom sides of model 4 supports are used as fixed points for apply constraints.

This paper shows the monitoring results of the temperature variations and strains of the newly built superstructure.

CONCLUSIONS

A number of recent monitoring projects of steel box girders in Belgium have indicated that daily temperature variations can be an important load condition. The resulting behavior is not always included in the design loads according to the codes. While the size of temperature variations is more or less as can be expected, the resulting behavior is more complex and less homogeneous than is generally assumed.

REFERENCES

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