Effect of Cracking on the Torsional Stiffness of the Taiwan High Speed Train Box Girder Bridge

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Summary

The effect of cracking on the torsional stiffness of box girder bridges is investigated using a typical 30 m long girder of the Taiwan High Speed Rail project. Linear elastic as well as nonlinear analyses considering cracking are performed. For the linear elastic analysis, the effects of the modelling, the method used for applying the rotation and the diaphragm walls on the torsional stiffness are investigated. The effect of cracking is considered in the non-linear analysis. A parametric study is performed to investigate the effect of the material parameters and the modelling of the bearings on the torsional stiffness. The results are compared with the torsional rigidity according to the classical Saint Venant's Theory. It is shown that the way the rotation is applied to the system has a considerable effect on the torsional rigidity. In addition, cracking reduces the torsional rigidity by up to 70% depending on the level of loading. are preparing your contribution.

Keywords: analysis; box girder; cracking; finite elements; stiffness; torsion.

1. Introduction

The torsional stiffness of box girder bridges may be determined for the design in a simplified manner using the classical “Saint Venant´s Torsion Theory” or by a more sophisticated finite element analysis. The assumptions for the validity of the classical “Saint Venant´s Torsion Theory” can be summarized as: 1. the axis of the beam is straight, the beam is uniform, homogeneous and isotropic, 2. the material behaviour is linear elastic, 3. the twisting moments are applied at each end, 4. all cross sections rotate as a rigid body, i.e., there is no distortion of cross section shape, thus, no deformations perpendicular to torsion axis exist, 5. the rate of twist is constant along the torsion axis, and 6. cross sections are free to warp along its torsion axis but the warping is the same for all cross sections. Many of these assumptions are not fulfilled in a real structure. For example, in bridge design the distortion of the box girder has to be considered and additional reinforcement in the transverse direction to cover the bending moments caused by the distortion have to be placed. In addition, the way how torque is applied in reality cannot be considered in the classical Saint Venant´s Torsion Theory. Thus, the transverse shear deformations that occur in webs of box girders at the bearing zones cannot be taken into account.

A more sophisticated 3-D finite element modelling of the bridge results in a more accurate presentation of the torsional behaviour. However, normally a linear elastic analysis is performed ignoring the fundamental cracking behaviour of concrete resulting in a high torsional stiffness. In regions of high seismic activities, this high stiffness results in high values of earthquake loading. Cracking of the concrete softens the cross section and thereby reduces the torsional stiffness and as a result the earthquake loading is reduced. The effect of cracking on the torsional stiffness of box girder bridges is investigated here using a typical 30 m long girder of the Taiwan High Speed Rail project. The cross section of the bridge is shown in Fig. 1. In this specific project the elastic analysis

https://doi.org/10.2749/weimar.2007.0231