New beam element for horizontally curved steel-concrete composite box girder bridges

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Abstract

Box girder cross-sections are typically used in the design of bridges in curved alignments due to their excellent torsional properties. However, beam elements available for the analysis of those bridges including torsion and distortion effects are scarce and limited to specific geometries. The intend of the new proposed finite element is to provide a tool for the analysis and design of any symmetrical steel-concrete composite box girder bridge in either straight or curved alignment including torsion and distortion effects.

Keywords: FEM, Curved, Bridges, Composite, Box-Girder, Cross-Frames, Warping, Distortion.

1 Introduction

Composite steel-concrete box girder bridges may be a competitive solution for a bridge when the span is greater than 90 m, when there is required a slender deck or, especially, when the curvature in the plan is important (Span/Radii>0.2) [1]. This is due to the lightness of this type of deck and its excellent torsional properties.

However, box-girder bridges tend to distort when they are subjected to eccentric loads or have a curvature in the plan. In the case of composite box-girders, the stresses caused by distortion may become important due to the high transverse flexibility of the cross-section. To prevent this phenomenon, intermediate cross-frames are typically placed along the deck.

Some codes have traditionally addressed the distortion providing some guidelines for the intermediate cross-frame design, avoiding distortion calculations. For instance, the AASHTO-9 [2] limit the maximum spacing of intermediate cross-frames in curved bridges, or, in Spain, the RPX-95 [3] also limit the maximum spacing and impose a minimum stiffness ratio between cross-frames and transverse section based on Nakai [4] research.

On the other hand, recent codes such as the Eurocode-3 [5] do not provide any guideline for intermediate cross-frame design. It is only stated that when maximum distortional stress exceeds 10% of the maximum stress due to compression and bending, effects of distortion shall be taken into consideration. Consequently, the evaluation of distortion for every composite box girder bridge designed according to Eurocodes is required, making necessary efficient tools for the calculation of this phenomena.

Finite Element models using shell elements are time demanding since they require lots of degrees of freedom and important post-processing time [6]. For this reason among others, tools based on the thin-walled theory have become popular for distortional stress evaluation.