Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 190 (2017) 603 – 610

Procedia Engineering

www.elsevier.com/locate/procedia

Structural and Physical Aspects of Construction Engineering

Influence Lines of Bridges with Box-Girder Cross-Section under Torsion and Distortion

Yvona Koleková[a], Michal Kováč[b], Ivan Baláž[b,]*

[a]*Department of Structural Mechanics, FCE, STU in Bratislava, Radlinského 11, 810 05 Bratislava, Slovak Republic*
[b]*Department of Metal and Timber Structures, FCE, STU in Bratislava, Radlinského 11, 810 05 Bratislava, Slovak Republic*

Abstract

Influence lines of torsion and distortion internal forces of large concrete and steel cable-stayed bridges with continuous box-girders. Application for real bridges: (i) steel SNP bridge over river Danube in Bratislava, Slovak Republic, (ii) concrete Harp bridge over pond Jordán near Tábor, Czech Republic.

Peer-review under responsibility of the organizing committee of SPACE 2016
Keywords: influence lines; steel bridges; concrete bridges; torsion; distortion

1. Introduction

General differential equation which describes a lot of problems in Structural mechanics may be written in the following form [1, 2, 3]:

$$v^{IV}(x,t) - \frac{\frac{N}{EI} + \frac{EI}{GA_v}\frac{k_f m\omega^2}{EI}}{1 + \frac{N}{EI}\frac{EI}{GA_v}} v^{II}(x,t) + \frac{\frac{k_f - m\omega^2}{EI}}{1 + \frac{N}{EI}\frac{EI}{GA_v}} v(x,t) = \frac{\frac{q(x)}{EI}}{1 + \frac{N}{EI}\frac{EI}{GA_v}} \qquad (1)$$

* Corresponding author. Tel.: +421902313786
E-mail address: ivan.balaz@stuba.sk

Peer-review under responsibility of the organizing committee of SPACE 2016
doi:10.1016/j.proeng.2017.05.386

Nomenclature

A_v	shear area [m^2]
B	torsional bimoment [kNm^2]
B_D	distortional bimoment [kNm^2]
E	Young modulus of elasticity [MPa]
EI_{R1}	cross-section frame rigidity at antisymmetrical distortion [kNm/m]
G	shear modulus [MPa]
I_t	torsion constant [m^4]
I_ω	warping constant of torsion [m^6]
$I_{\omega D1}$	warping constant of antisymmetrical distortion [m^6]
M	bending moment [kNm]
N	axial force nomenclature continues down the page inside the text box [kN]
Q	transverse force in direction perpendicular to un-deformed beam axis [kN]
T_t	St. Venant torsional moment [kNm]
T_{tot}	total torsional moment [kNm]
T_ω	warping torsional moment [kNm]
V	shear force in direction perpendicular to deflected beam axis [kN]
k_f	modulus of the foundation [kNm^{-2}]
m	mass per unit length [kg/m]
v	deflection [m]
ω	circular frequency of harmonic vibration [s^{-1}]
ω_M	relative bending moment [-]

After introducing non-dimensional quantities

$$\xi = \frac{x}{L}, \quad \varepsilon^2 = \frac{N}{EI} L^2, \quad \kappa = \frac{EI}{GA_v} \frac{1}{L^2}, \quad \rho^2 = \frac{k_f - m\omega^2}{EI} L^4, \quad \varsigma = \frac{1}{2} \frac{\varepsilon^2 + \kappa\rho^2}{1 + \kappa\varepsilon^2}, \quad \eta = \sqrt{\left| \frac{\rho^2}{1 + \kappa\varepsilon^2} \right|} \tag{2}$$

the equation (1) may be rewritten in the following form

$$v^{IV}(\xi,t) - \frac{\varepsilon^2 + \kappa\rho^2}{1 + \kappa\varepsilon^2} v^{II}(\xi,t) + \frac{\rho^2}{1 + \kappa\varepsilon^2} v(\xi,t) = \frac{1}{1 + \kappa\varepsilon^2} \frac{q(\xi)}{EI} L^4 \tag{3}$$

or in the form

$$v^{IV}(\xi,t) - 2\varsigma v^{II}(\xi,t) + sign(\rho^2)\eta^2 v(\xi,t) = \frac{1}{1 + \kappa\varepsilon^2} \frac{q(\xi)}{EI} L^4 \tag{4}$$

In this chapter two partial statics cases ($\omega^2 = 0$) of beam in bending will be investigated: (i) case A, and (ii) case B. Case A: $\rho^2 = 0$ ($k_f = 0$), $\varsigma > 0$ and $\kappa \geq 0$. This case describes the behaviour of the beam loaded by combination of transverse actions and tension force with taking into account influence of the shear ($\kappa > 0$) or without influence of shear ($A_v = \propto$, $\kappa = 0$). The analysis of 2nd order have to be used for this case. The solutions of this case for 61 cases with various types of loading and boundary conditions are presented in the graphical form and in the form of exact formulae in [3]. Special attention is given there to the limit case when $\varepsilon^2 = 0$. In [3] both possibilities were solved with influence of the shear $\kappa > 0$ and without influence of the shear $\kappa = 0$. If the influence of the shear is