IN-VENTO 2018
XV Conference of the Italian Association for Wind Engineering
9-12 September 2018, Napoli, Italy

A critical database for the Strouhal number of bridge decks

Bernardo Nicese[1], Claudio Mannini[1], Antonino Maria Marra[1] and Gianni Bartoli[1]

[1]Department of Civil and Environmental Engineering, University of Florence, Italy
Corresponding author: Bernardo Nicese, bernardo.nicese@unifi.it

Abstract

This paper represents a first step towards a prenormative study on the Strouhal number of bridge decks. The main goal of the work is to identify, where possible, a range of values of this important parameter for the most common typologies of deck cross sections to be used for the preliminary design of bridge structures. With this aim in mind, data available in the literature are critically reviewed, collected and classified.

1 Introduction

In the last decades, the construction of slender bridge structures characterized by limited mass per unit length and low frequencies of oscillation has become more and more common. As a consequence, the study of vortex-induced vibration (VIV) of bridge decks due to the wind action is a crucial design issue. In particular, the Strouhal number (*St*) is a parameter of utmost engineering importance, as it allows the estimation of the VIV critical wind speed.

It is well known that the Strouhal number depends on several factors: geometry of bridge deck cross section, angle of attack of the air flow, incoming flow turbulence characteristics, and Reynolds number. In particular, concerning the cross section geometry, a key role is played by the presence of lateral barriers, screens and other non-structural details. As a result, the estimation of the Strouhal number without specific wind tunnel tests is a complicated task. Indeed, presently the available codes do not allow any accurate enough prediction of this parameter for the preliminary design of bridge structures.

This paper reports a few results of an ongoing prenormative study about the Strouhal number for several typologies of bridge deck cross sections (Fig. 1). As a first step, a large number of data available in the scientific literature have been collected and categorized on the basis of some selected key influencing factors.

A synthetic example of the resulting database is reported in Table 1. Therein, both the results of experiments (either in the wind tunnel or at full scale) and computational fluid dynamics (CFD) calculations can be found. All of the values of the Strouhal number reported are made homogeneous considering the height *D* of the deck without non-structural details (barriers, screens, etc.) as reference dimension.

umber for the various bridge deck typologies seems viable. Nevertheless, the need of extending the data collection and of considering additional parameters in the classification is also apparent, in order to make smaller the range of Strouhal number values to consider in a preliminary VIV analysis of bridge decks.

Table 1. Strouhal number data for various bridge deck cross sections. *B* and *D* denote respectively the width and the height of the bridge deck. The Strouhal numbers have been determined through full-scale tests (FULL), wind tunnel experiments (WT), or numerical simulations (CFD). α is the angle of attack of the air flow (positive nose up).

Cross section	Bridge	B/D	Method	α	Configuration	St
Quasi-streamlined box girder (Fig. 1a)	Storebælt East Bridge (Brusiani et al., 2013; Fradsen et al., 2001)	7.75	FULL	-	-	0.08-0.15
			WT	0°	Bare	0.11
			CFD	0°	Bare	0.14
Single box girder (Fig. 1b)	Storebælt East Bridge approach spans (Larose et al., 2006; Schewe et al., 1998)	3.69	FULL	-	-	0.22
			WT	0°	Bare	0.16-0.22
	Ikara Bridge (Larose et al., 2006)	5.50	FULL	-	-	0.20
			WT	0°	Bare	0.16
Twin-box girder (Fig. 1c)	Xihoumen Bridge (Li et al., 2011)	11.04	FULL	-	-	0.094-0.107
	Stonecutters Bridge (Larose et al., 2003)	13.63	WT	0°	Bare	0.20
	General twin-box study (Laima et al., 2013)	10.28	WT	0°	Bare	0.15
	General twin-box study (Matsuda et al., 2001)	10	WT	-5°	Bare	0.17-0.21
				0°	Bare	0.20
				+3°	Bare	0.20-0.22
				+5°	Bare	0.21-0.24
Trapezoidal box girder with lateral cantilevers (Fig. 1d)	Sunshine Skyway Bridge (Ricciardelli et al., 2001)	6.73	WT	-4°	Bare	0.15
					Barriers	0.12
				0°	Bare	0.14
					Barriers	0.11
				+4°	Bare	0.09
					Barriers	0.09
	CRIACIV section inspired by Sunshine Skyway Bridge (Mannini et al., 2010)	6.43	WT	-5°	Bare	0.24
				0°	Bare	0.21
				+5°	Bare	0.24
			CFD	0°	Bare	0.154-0.211
	Volgograd Bridge (Corriols et al., 2010)	2.06	CFD	0°	Bare	0.133
			CFD	0°	Barriers	0.116

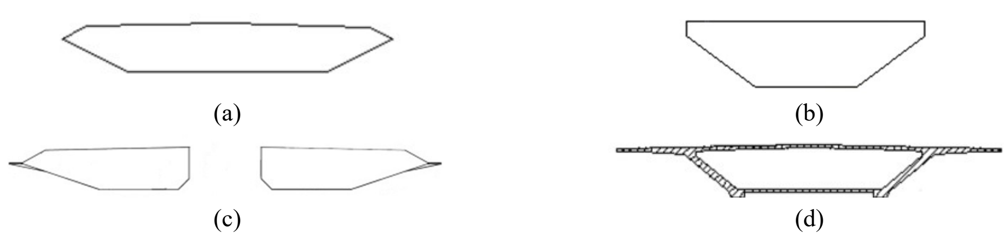

Figure 1. Schematics of the bridge deck section geometries that have been considered.