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Objective-based equivalent static wind loads for long-span bridges

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1 Abstract

The process to arrive at design wind loads for long-span bridges involves experimental testing and analytical methods. Time domain simulations are becoming increasingly common and many available studies demonstrate results of buffeting response analysis in the time domain. However, there is significantly more to the process than the response analysis to derive wind loads that can be applied practically for design. The current study focuses on two key aspects required to derive design wind loads: prediction of the peak modal deflection and derivation of modal combination coefficients using objective functions.

Keywords: Long-span bridges; buffeting response analysis, equivalent static wind loads, objective functions, peak detection

2 Introduction

The design of flexible medium- and long-span bridges is often governed by wind stability and loading. Wind loads for flexible bridges have originally been derived based on combining wind tunnel test data with analytical methods based on quasi-steady theory [1]. However, neither the wind tunnel nor analytical methods directly yield the peak pressures required for design of the bridge and various methodologies are now employed to distribute the loads appropriately across the bridge [3, 8].

At present it remains more convenient for bridge designers to apply a collection of equivalent static wind load combinations as opposed to direct application of time series. Either way, as will be shown in the following sections, the application of too short or too few time series may lead to unconservative load prediction. In addition to the convenience to follow code recommended load combinations, one of the advantages of equivalent static wind load combinations is that each combination can be expressed statistically as the expected peak value as opposed to an instant in time.

The pressure in degree of freedom i that must be resisted by the bridge is

$$p_i(t) = p_{wind_i}(t) - \frac{M_{ij}}{A_i}\ddot{z}_j(t) \quad (1)$$

In Eq. (1), the buffeting pressure p_{wind} is given by

$$p_{wind_i}(t) = \frac{1}{A_i} q C_i\big(\alpha_w(t)\big) + p_{se_i}(t)$$
$$\alpha_w(t) = \frac{w'}{U + u'} \quad (2)$$

where p_{se_i} is the self-excited pressure, q is the reference pressure, C_i is a force or moment coefficient, U is the steady wind speed and u', w' are the turbulent fluctuations. The self-excited

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