Flutter Analysis Using Quasi-Steady Time-Domain Flutter Derivatives

Sébastien Maheux
Ph.D. Candidate
University of Western Ontario
London, ON, Canada
smaheux@uwo.ca

Structural engineering graduate student focused on the design of long-span bridges (B.Eng. 2014, M.A.Sc. 2016 from the Université de Sherbrooke)

Sébastien Langlois
Assistant Professor
Université de Sherbrooke
Sherbrooke, QC, Canada
sebastien.langlois@usherbrooke.ca

Active researcher in the field of transmission line structures, cable mechanics and response of structures under wind action

Frédéric Légeron
Vice President
Parsons
Abu Dhabi, United Arab Emirates
frederic.legeron@parsons.com

Infrastructure Design Director specialized in large scale and complex bridge projects

Contact: smaheux@uwo.ca

1 Abstract

To be able to perform nonlinear flutter analyses for bridges, time-domain approaches should be used instead of Scanlan's formulation of self-excited forces. Thus, this paper addresses the development and validation of a modified quasi-steady time-domain model similar to Scanlan's approach that is based on the velocity and acceleration of the bridge deck. In this formulation, quasi-steady time-domain flutter derivatives measured in the wind tunnel through forced-vibration tests at absolute constant velocity and acceleration are used. For this, a unique test rig, which can be used either for free- or forced-vibration tests, was utilized. By measuring the time-domain flutter derivatives of the Great Belt Bridge, their nondimensionalization with respect to the bridge-deck width, velocity and acceleration of the deck is validated. Then, time-domain flutter analyses are performed using this new model. They agree with the experimental critical speed and the prediction using Scanlan's model.

Keywords: bridge aeroelasticity; flutter; flutter derivatives; wind tunnel; forced-vibration tests.

2 Introduction

Flutter analysis requires the assessment of self-excited forces, i.e., forces resulting from deck motions. The most common formulation of self-excited forces is the one proposed by Scanlan [1]. This force model relies on flutter derivatives and is limited to linear analysis.

However, cable-supported bridges are nonlinear structures since structural nonlinearities could be encountered under severe wind. To account for them, it would be interesting to use a time-domain formulation of self-excited forces. The quasi-steady approach is the simplest time-domain analysis framework, but it is not satisfactory for flutter analysis as unsteady effects are neglected [2]. Hence, convolution schemes were proposed to include these effects [3]. Other advanced approaches for flutter have also been developed (e.g. [4]).

Therefore, this paper addresses the development of a new time-domain model of self-excited forces similar to Scanlan's formulation and based on time-domain coefficients identified directly through wind tunnel tests. It aims at facilitating the realization of time-domain flutter predictions. The proposed model is validated using forced-vibration tests conducted for three section models of the Great Belt Bridge.

3 Quasi-Steady Time-Domain Flutter Derivatives

3.1 Mathematical model

The proposed model extends the approach in [5] to full-scale flutter prediction. The model is similar to

https://doi.org/10.2749/newyork.2019.2664
Distributed by Structurae