SS 2009-2010, No. DISAL-IP11 Project Summary

System Identification of Mechanical Parameters for a 2D Bridge Section Model

Maria Boberg

Professor : *Alcherio Martinoli*

The importance of considering of wind effects on structures became evident when the Tacoma Narrows Bridge collapsed in the 1940's in the United States. In order to avoid such catastrophes in the future engineers have developed many solutions (streamlining the bridge deck, increasing the structural damping, etc) that provide safe bridge performance under heavy wind loads. However, these passive constructions are essentially a static solution for controlling the response of a dynamic system to a variable and uncertain perturbation and as such it brings with it a number of limitations. In contrast to a passive solution, an active provides more efficient vibration mitigation since it can adapt to different wind conditions. Therefore, active solutions reduce the aerodynamic requirements on the cross- section, thus enabling a more rational and economical bridge design and new opportunities for improving bridge aesthetic.

This report is a part of the "SmartBridge project", a project investigating an innovative, distributed attenuation strategy for wind-induced vibrations based on active control of the bridge's aerodynamic profile. The principle of the suggested active solution is to have an array of adjustable flaps (winglets) installed along both edges of the girder and to have their angular position controlled as a function of the current dynamic state of the structure and/or local wind field measurements. The characteristics of the interaction between the wind field and the underlying structure (non-linear, spatially heterogeneous, time-variant, and noisy) with the additional degrees of freedom introduced by the flap system result in complex mathematical models and associated control strategies.

Until now the project has focused on verifying the analytical model of a passive bridge deck (no flaps installed), by conducting experiments on a physical bridge section model in a wind tunnel. This report concentrates on the theory and results from the first phase of the project: mechanical parameter identification of the experimental set-up and verification of the model's theoretical formulation.

The estimated natural frequencies are consistent over all set-points, thus the natural frequencies are not amplitude-dependent. Furthermore, the vertical step responses confirmed the validity of estimating the heaving mode natural frequency from a mixed step response. In conclusion, the 2D model represents the system very well in regard to the oscillations. However, the estimated decay rates are not as consistent. The results indicate that the decay rates are amplitude dependent. The question whether this is amplitude-dependence is necessary to include in the model remains.

The next step of the SmartBridge project is to estimate the aeroelastic system parameters. The state of the art is to employ the simple (amplitude-independent) 2D model for such an endeavor. Therefore, either our experimental set-up is not good enough, or the amplitude dependence is simply negligible. One indication that the latter is the case is that other reports show amplitude-dependence on the same scale and ignores it for the estimation of the aeroelastic parameters. Therefore, it is deemed plausible that the amplitude-dependent damping can be ignored and it will be attempted to estimate the flutter derivatives without adjusting the damping model.

In conclusion, the results are satisfying enough to proceed with aerodynamic system identification. However, if inconsistencies with theory become even graver for the estimate of flutter derivatives, the damping model should be revised.