Influence of aerodynamic characteristics of "H" beams on galloping stability.

Fernando GANDIA
Aeronautical Engineer
Universidad Politécnica de Madrid, Spain.
fernando.gandia@upm.es

Assistant Professor of Mechanics of Fluids and Aerodynamics.

Jose MESEGUER
Aeronautical Engineer
IDR/UPM. Madrid, Spain.
j.meseguer@upm.es

Professor of Aerospace Engineering

Angel SANZ
Aeronautical Engineer
IDR/UPM. Madrid, Spain.
angel.sanz.andres@upm.es

Professor of Aerospace Engineering

Summary

This paper presents the experimental study developed on a prismatic beam with “H” section, sometimes used in bridges as suspenders, vertical bars or decks.

The purpose of this study is to understand the physical behavior of the air around this type of section, in order to reduce the aerodynamic loads, the onset speed of galloping and even to avoid it. To achieve this, a study of the influence of all geometric parameters that define the section has been developed. Previously, the most interesting configurations have been selected using a smoke flow visualization technique in the wind-tunnel, then the corresponding static aerodynamic loads were measured, completed with dynamic tests and, finally, the parameters governing the phenomenon of galloping determined.

Keywords: Translational galloping instability, bluff bodies, wind tunnel, dynamic tests.

1. Introduction

It is well known that two-dimensional bluff bodies in cross-flow are subject to typical aeroelastic phenomena like vortex shedding, translational and torsional galloping, and even flutter. Galloping is a typical instability of flexible, lightly damped structures. Under certain conditions these structures may have large amplitude, normal to wind oscillations, at much lower frequencies than those of vortex shedding found in the Kármán vortex street.

Theoretical foundations of galloping are well established and can be easily understood through an extremely simple theory like the one due to Den Hartog [1], which, in a first attempt, is enough to elucidate if a given two-dimensional body can gallop or not. According to Den Hartog, galloping can be explained by taking into account that, even if the incident wind velocity U_∞ is uniform and constant, in a body reference frame the lateral oscillation of the body can cause that the total velocity experiences changes both in its magnitude and direction with time. Therefore, the body angle of attack also changes with time, hence the aerodynamic forces acting on it (figure 1).

Concerning the stability analysis, it is based on the simplest model of galloping (one degree of freedom) it is assumed that a two-dimensional body, whose mass per unit length is m, is elastically mounted on a support with a damping coefficient ζ and a stiffness $m\omega^2$ (where ω is the angular natural frequency). Within this approximation, if the aerodynamic force (proportional in this case to dz/dt) is considered as a contribution to the total damping of the system, the total damping coefficient is:

$$\zeta_T = \zeta + \frac{\rho U_\infty b}{4m\omega}\left(\frac{\mathrm{d}c_l}{\mathrm{d}\alpha} + c_d\right) \quad (1)$$

where U_∞ stands for the upstream flow velocity, and b for a transversal characteristic length of the body (figure 2).

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