The effect of the mean wind force on the post-critical galloping response of shallow cables

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Abstract. The post-critical aeroelastic behavior of horizontal, suspended, shallow cables is analyzed via a continuous model. Perturbation methods are used to obtain bifurcation equations ruling the essential behavior of the cable close to the galloping conditions. Discussion on the post-critical dynamical evolution is given, after numerical validation of the asymptotic outcomes.

Introduction

Cables are largely used structural elements and represent a strategic asset in many engineering applications. A general characterization of statics and dynamics of cables is found in [1], whereas their response to wind, especially in cold regions, i.e. where an ice accretion may break the typical axial-symmetry of the cross-sections, is usually evaluated within the Den Hartog formulation [2]. In-plane galloping analysis was performed on a continuous model in [3]. The motivation of this paper comes from previous analysis on the critical behavior of horizontal, suspended, shallow cables given in [4]. There, the in-plane and out-of-plane aerodynamic response of cables was analyzed via a continuous model, also accounting for an internal damping contribution which simulates a viscous-elastic constitutive material. In particular, the effect on the galloping conditions of the swing of the plane on which the cable lays was analyzed, giving rise to occurrence of symmetric or anti-symmetric critical modes, independently on the sag-to-span ratio of the cable, but only related to the initial attitude of the cross-section to the wind. Here, starting from the same model proposed in [4], the formulation is extended to analyze the post-critical behavior, making use of perturbation methods and comparing the outcomes with those given by numeric integration after the application of the finite difference method.

Results and discussion

Two different initial attitudes to wind of the iced cross-section of the cable are considered, namely case 1 and case 2, keeping fixed all the other geometrical and mechanical characteristic. In particular, in case 1 the cable is more prone to galloping than case 2. In correspondence, it is found that the critical mode, which is complex, is anti-symmetric for case 1 and symmetric for case 2 (see Fig. 1), it being strongly dependent on the equilibrium configuration reached by the cable in proximity of the galloping condition. This equilibrium configuration, which defines the fundamental path, is attained on a rotated plane on which the cable lays, whose rotation angle with respect to the vertical plane depends on the mean wind velocity. Starting from this occurrence, the post-critical analysis is performed via the Multiple Scale Method on the continuous model, providing the relevant bifurcation equation which allows one to describe the evolution of the shape and amplitude of vibration of the cable for larger velocities.

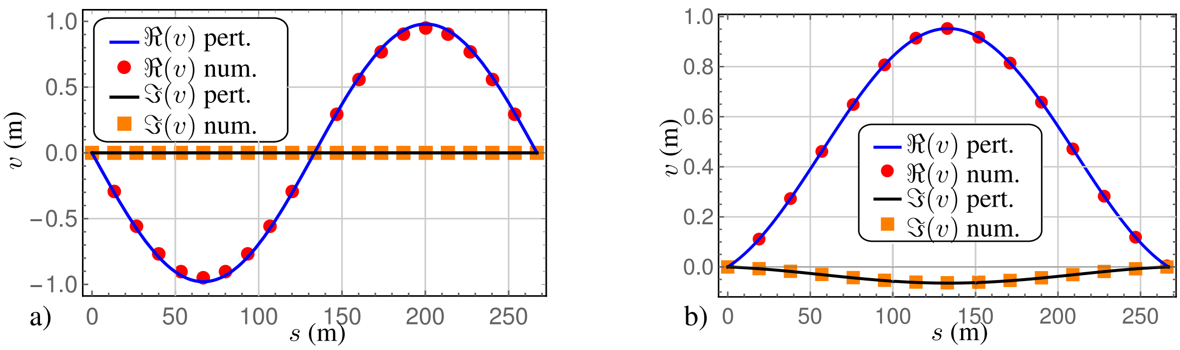

Figure 1: Critical mode of the cable for: a) case 1 ; b) case 2.

References

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