Transverse galloping at low Reynolds numbers

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1. Introduction

Among the broad variety of phenomena that flow can induce on structures, transverse galloping is well known to engineers (Simiu and Scanlan, 1978). This is an hydro/aeroelastic instability produced by the interaction of the lateral motion of the elastic body (structure) and the incident flow. Generally, transverse galloping can occur with long elastic bodies of aerodynamically bluff cross-section (non-circular) when the velocity of the incident flow exceeds a certain critical value. Then, the stabilizing effect of structural damping is overcome by the destabilizing effect of the fluid force and an oscillatory motion (normal to the wind flow) develops. This oscillatory motion increases in amplitude until the energy dissipated per cycle by structural damping balances the energy input per cycle from the flow. Sometimes, this amplitude can be many times the characteristic transverse dimension of the structure. Moreover, under certain conditions there is some oscillation hysteresis in the galloping behaviour for a range of flow velocities. This characteristic was observed for the first time by Parkinson (1961, 1964) in the course of laboratory experiments. When hysteresis takes place, multiple solutions for the amplitude of oscillation can appear for a range of flow velocities, depending on whether the flow velocity is increasing or decreasing. Most of the early interest in transverse galloping was directly related to the electrical lines and galloping oscillations sometimes observed when the ice accretion on the wires modified their initially almost circular sections. Thereafter, attention broadened to situations where the phenomenon has also been observed: marine pipelines (Simpson, 1972), traffic signs and signal supports (Johns and Dexter, 1998), gates with underflow (Nguyen and Naudascher, 1986), and some metallic structures (Mahrenholtz and Bardowicks, 1980).