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Couplings in parametrically excited inclined cables systems

G. Michon  
Université de Toulouse, ISAE, 10 Avenue Edouard Belin  
F31055 Toulouse Cedex 4 - France

A. Berlioz  
Université de Toulouse, LGMT, 135 Avenue de Rangueil  
F31077 Toulouse Cedex 4- France

C.H. Lamarque  
Université de Lyon, ENTPE, Laboratoire GéoMatériaux  
DGCB – URA CNRS 1652 , 3 rue Maurice Audin  
F69518 Vaulx-En-Velin Cedex- France

Email: guilhem.michon@isae.fr  
Email: berlioz@cict.fr  
Email: claude.lamarque@entpe.fr

Cables in stayed bridges are subjected to important dynamic solicitations for which dynamic model are now well established. Due to their design, such structures highlight resonance phenomena and instabilities frequently observed [1-4]. Nevertheless, some structures exhibit important vibration amplitudes that cannot be explained simply. Measurement recently performed on a bridge point a coupling of the cable with the deck or the pillar [5].

The present paper suggests to consider the deck flexibility coupled to the nonlinear dynamic of the inclined cable. Results of previous study [6-9] are used.

The retained nonlinear model of the cable include two degrees of freedom for the in-plane motion. Considering the bridge mass and deck rigidity adds one DOF, assumed linear in a first approach. The excitation is created on the deck, which produce an external force (such as the wind or the car traffic for example). An experimental set-up uses a specific device in order to highlight expected coupling phenomena on the parametric instabilities, see Figure 1. It is composed of a flexible blade which represents the deck, and an inclined cable. Both elements are linked to a mass forced to move vertically, and which represent the anchor point and the equivalent mass of a section of the deck. Therefore, the cable has a given initial static tension. An electrodynamic shaker applies a force close to blade clumping. The transmitted force from the shaker to the structure is measured thanks to a piezo-electric sensor. The instantaneous cable tension is measured via a S-shape force sensor. And a high resolution laser sensor captures without contact the in-plane motion of the cable. All these values are recorded by a LMS-Pimento front-end.

Figure 1: Experimental set-up
Analytically, the multiple scales method is applied to solve the nonlinear equations of motion. In-plane vibration of the cable and stability in the vicinity of the primary resonance $\omega_1$ and sub-harmonic resonance $2\omega_1$ are computed. The competition between the behaviour at $2\omega_1$ and $\omega_2$ are of particular interest, as it is observed experimentally on Figure 2.

Figure 2: Experimental results: reduced displacement vs reduced frequency. $\times : \omega_2$ response - $\circ : 2\omega_1$ response.

REFERENCES


