Numerical and experimental dynamic analysis and control of a cable stayed bridge under parametric excitation

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Abstract

In cable-stayed bridges, the occurrence of parametric excitation is very probable due to the presence of many low frequencies in the deck or tower and in the stay cables. When a local (cable) and a global (structure) mode are coupled, even very small motion of the deck or tower may cause dynamic instability and extremely large vibration amplitudes of the stay cables. This paper presents a nonlinear dynamic study of a three dimensional cable stayed bridge in construction phase under parametric excitation. A nonlinear inclined cable with small sag which takes into account the quadratic and cubic nonlinear couplings between in-plane and out-of-plane motion, is coupled with a finite element model of a cable stayed bridge. Active damping is successfully added to the structure using collocated displacement actuator–force sensor pairs located on each cable and a robust control strategy based on decentralized collocated Integral Force Feedback. The effect of the amplitude of excitation as well as the added active damping on the steady state response of the stay cable under parametric excitation is studied numerically and experimentally. A phenomenon of energy transfer between the cable and the deck is observed. The experimental results are qualitatively in good agreement with the numerical ones.

Highlights

► The parametric excitation of a cable stayed bridge is studied numerically and experimentally. ► The effect of amplitude of excitation and active damping on the cable motion is investigated. ► An energy transfer phenomenon between the cable and the deck is observed. ► The threshold amplitude of excitation increases by increasing the active damping. ► The experimental results are qualitatively in good agreement with the numerical ones.

Keywords

Cable-stayed bridge; Nonlinear; Parametric excitation; Energy transfer; Active control

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