Time delay-based mitigation design and nonlinear resonance of large amplitude vibration of the cable-stayed beam

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Abstract. This paper studies the nonlinear primary resonance in the vibration control of cable-stayed beam with time delay feedback. Considering the continuity conditions, the in-plane nonlinear motion equations of the cable stayed beam are obtained via the Hamilton principle. Then, utilizing the method of multiple scales, the modulation equations that govern the nonlinear dynamics of the cable-stayed beam are derived. Depending on the excitation amplitude and the commensurability of the delayed-response frequency to the excitation frequency, it can be demonstrated that appropriate choice for the feedback gain can greatly reduce the response amplitude of the primary resonance. Moreover, the mode energy and component energy are defined, and they are applied to investigate the energy transfer and distribution in the vibration controlled cable-stayed beam. And the energy transfer mechanism is discussed.

Introduction

Cable and beam are two kinds of structural units which form different engineering structure through certain connection modes. With the increase of span, the structure has considerable flexibility. Under the condition of a very large load, the energy of the entire structure system is distributed among different structural elements, which stimulates the large-scale vibration of the whole structure [1, 2, 3]. Then, the large amplitude vibration control of such structures has gradually become one of the key problems to be solved [4, 5]. On the other hand, time-delay feedback control has attracted the attention of scholars [6]. In this paper, the main objective is to design the time delay-based vibration mitigation technique and study the nonlinear primary resonance of the controlled cable-stayed beam, The schematic diagram of the model is shown in Fig. 1(a).

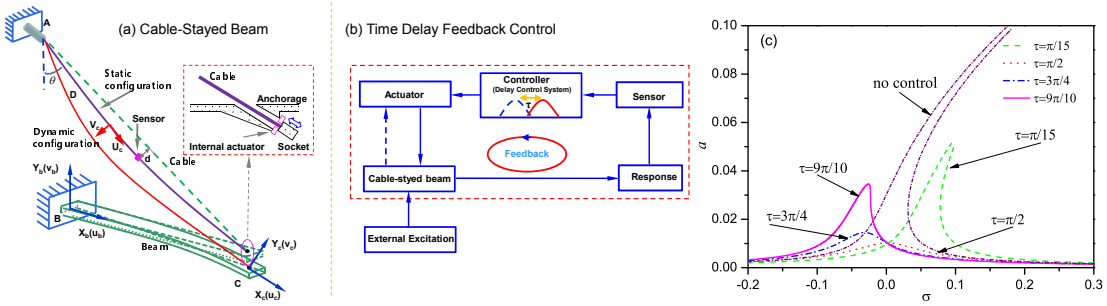

Figure 1: The configurations of the controlled model and amplitude-frequency response curves. (a) the controlled cable-stayed beam; (b) the flow chart of time delay feedback control; (c) The amplitude-frequency curves of the primary resonance response of cable-beam beam with time delay

Results and Discussion

By applying the Hamilton principle, the equations of motions with time delay feedback (as Fig. 1(b)) has been presented. The amplitude-frequency response equation of the nonlinear primary resonance response is obtained by solving the time-delay feedback control equation. Through theoretical and numerical analysis, as shown in Fig. 1(c), it is concluded that the time-delay feedback control can suppress the large vibration of the cable-stay beam and has a certain guiding significance for its vibration control.

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