

Vibration suppression of a cable-stayed beam with external excitations by a nonlinear energy sink

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Abstract. In this study, the influence of a nonlinear energy sink (NES) on the vibration of a cable-stayed beam structure under the excitation of external harmonic loads is studied. First, a theoretical model consisting of cable, beam and NES is established, as shown in Figure 1. By considering the interaction between the cable and the beam, the nonlinear dynamic equation of the cable-beam-NES coupled system is given. Then, the partial differential equations of the cable and beam are discretized into a set of ordinary differential equations using the Galerkin method. The incremental harmonic balance (IHB) method is used to solve the system of ordinary differential equations. Finally, the effect of the NES on the structural response of the cable-stayed beam is investigated. Meantime, the effect of the cable-beam coupling vibration on the vibration reduction effect of the NES attached to the cable was analyzed. The results show that the NES has a good suppression effect on the vibration of both the cable and the beam. In addition, the cable-beam coupling vibration reduces the vibration reduction effect of the NES attached to the cable.

Introduction

With the increase of the span of the cable-stayed bridge, the corresponding cable length becomes longer and longer, which makes the nonlinear problem of the cable-stayed bridge more prominent [1, 2]. At present, the commonly used vibration reduction measure is to add a damping device to the cable [3, 4]. However, although NES has been widely used in various engineering fields, there is no relevant research on the vibration control of cable-stayed beams by NES. In addition, the cable-beam coupling vibration of cable-stayed bridges is very easy to occur under the excitation of external loads. Does the cable-beam coupling vibration affect the vibration reduction effect of NES attached to the cable? This is a real-world engineering problem that is well worth studying.

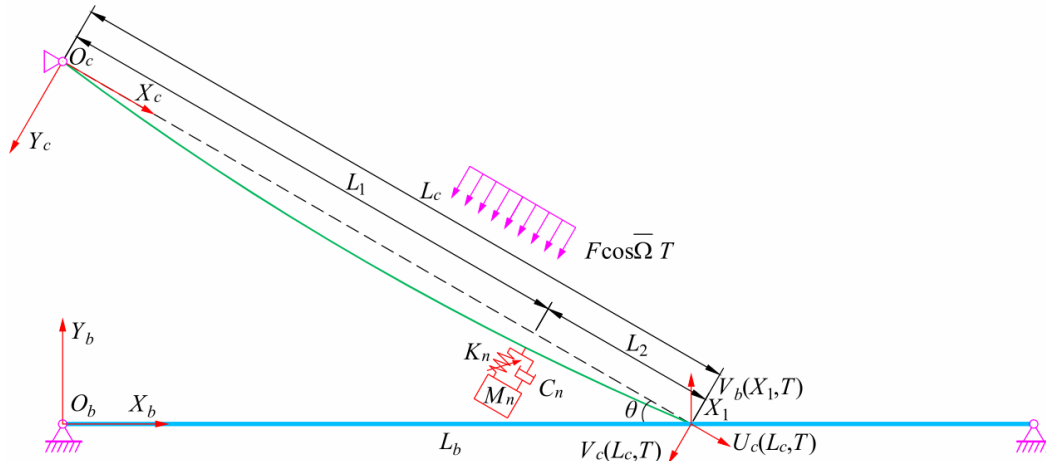


Figure 1: Coupled vibration model of cable-beam-NES

Results and discussion

The cable-beam coupling vibration has a great negative impact on the vibration reduction effect of NES. Moreover, the stronger the degree of cable-beam coupling vibration, the worse the vibration reduction effect of the NES on the cable. In the design phase of cable-stayed bridges, the effect of cable-beam coupling vibration on the vibration reduction of the cable should be considered.

The beam mainly has coupled vibration with the 1st mode of the cable. This is the main reason why the effect of cable-beam coupling vibration on the vibration reduction effect of the 1st mode of the cable with additional NES is greater than that of the 2nd and 3rd modes.

References

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