Slow dynamics of the transient response of a structure with tuned-mass damper

Anass Mayou, Vincent Denoël

Abstract

The dynamic behavior of structures equipped with tuned-mass dampers (TMDs) has been well-studied under steady-state conditions. However, the transient response that occurs passing through the resonance at a finite sweep rate, particularly with frequency mistuning, remains less understood. In this work, the transient dynamics of a simplified two-degree-of-freedom (2DOF) linear system is analyzed. It is characterized by four key parameters: mass ratio, damping ratio, frequency mistuning, and sweep rate. The small mass ratio encountered in typical applications allows to frame this transient problem in a perturbation perspective. Using the multiple-timescale method, the fast and slow dynamics of the system are separated, with a particular focus on the envelope to capture the maximal structural displacement of the primary system. The proposed analytical solution for the transient response of a tuned system is compared with numerical simulations to assess its accuracy and applicability. The findings reveal how sweep rate and frequency mistuning influence the performance of the TMD, providing deeper insights into the conditions under which it mitigates or fails to mitigate structural displacements.