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The dynamics and control of a high-rise vertical transportation system with a hydraulic damper-actuator system

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Abstract: Tall structures often sway with large amplitude and low frequency due to resonance conditions induced by wind loads and long-period seismic excitations. These sources of excitation affect the performance of vertical transportation systems (VTS) deployed in these structures. The fundamental natural frequencies of tall buildings fall within the frequency range of the wind and seismic excitations and the sway motions form the excitation mechanism which acts upon the VTS. Particularly affected are long slender structural components such as the suspension ropes, compensating cables and travelling cables. Complex nonlinear resonance interactions arise in the system when the frequency of the excitation is tuned to the natural frequencies of those elements. To mitigate the effects of resonance interactions the masses and geometry of the VTS can be adjusted to shift the resonance regions and to avoid excessive dynamic responses. However, in most cases the structural constraints and design limitations do not leave much space for the possible changes to be effective. The methods to mitigate the effects of dynamic interactions in a high-rise VTS involve the application of hydraulic tie-down devices attached at the compensation sheave assembly. The aim of this study is to develop a numerical simulation model to predict and analyse the resonance behaviour of the system equipped with a nonlinear damper. The performance and characteristics of the hydraulic ‘tie-down’ / damping device can then be optimized and adjusted to minimize the effects of adverse dynamic responses of the system.

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