Adaptive TMD System for Reduced Space Demand in Tall Buildings

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1 Abstract

Tuned mass dampers (TMDs) are widely used to mitigate wind-induced tall building vibrations. However, two major disadvantages of passive TMDs exist. The installation height of pendulum TMDs consumes expensive space and passive TMDs cannot cope with the time-varying excitation frequency of wind loading which will excite several structural modes. Also, the pendulum mass may impact the structure due to seismic excitation which necessitates huge snubbing systems. The presented adaptive TMD System addresses all these shortcomings. The installation height is reduced by up to 50 % by the inclination of the pendulum cables as this method enlarges the radius of the pendulum mass center being equivalent to the reduction of the natural pendulum frequency. The efficiency of the adaptive TMD is improved by adjusting the oil damper characteristics in real-time which allows reducing the pendulum mass up to 20 %. The overdamping control approach activated at wind return periods greater than 10 years reduces the maximum pendulum relative motion by up to 25 %. The adaptive TMD with inclined cables therefore minimizes the installation space which helps to maximize the economic benefit of the building.

Keywords: damping; tall building; semi-active; tuned mass damper; wind excitation.

2 Introduction

Passive tuned mass dampers (TMD) are widely used to reduce the acceleration response of tall buildings due to wind loading. Typically, the eigenfrequency of the first sway mode of tall buildings is between 0.08 Hz and 0.16 Hz whereby the length of a single pendulum is between 39.8 m and 9.7 m. The associated effective modal mass may be between 40,000 and 120,000 metric tons. Considering the typical TMD mass ratio of 1.5 % (usually between 1 % and 2 %) the pendulum mass becomes 600 to 1,800 metric tons. Considering the

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