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Response control of wind turbines with ungrounded tuned mass inerter system (TMIS) under wind and seismic loads

Kaoshan Dai [a*], Ruifu Zhang [b], and Yanru Cao [b]

[a] *Department of Civil Engineering and Institute for Disaster Management & Reconstruction, Sichuan University, Chengdu 610065, China*
[b] *Department of Disaster Mitigation for Structures, Tongji University, Shanghai 200092, China*

Abstract

Wind turbine towers are sensitive to wind and seismic loads and lose efficiency when suffering excessive wind-induced vibrations. Structural control techniques such as tuned mass dampers (TMD) can be used to reduce the vibration response of the tower. However, the additional mass of this system would occupy a large amount of space within the wind turbine device, which can inconvenience installation and maintenance. An inerter is a high-efficiency two terminal mechanical element for vibration control with the characteristic of mass and damping enhancements. An ungrounded tuned mass inerter system (TMIS) – composed of a tuned mass, a tuned spring and an inerter subsystem – has potential to control wind and earthquake induced vibration efficiently. In this study, a simple design method for wind turbine towers equipped with a TMIS under wind and seismic loads is proposed, based on structural performance demand as well as control cost. A 1.5 MW wind turbine tower benchmark model is adopted to exemplify the proposed design method. Comparative analyses are conducted between a conventional TMD and the TMIS. Results show that the TMIS can achieve the same vibration control effect as the TMD while using a smaller tuned mass. A sensitivity study of the TMIS is also carried out to investigate the impact of mechanical element parameters on the performance of the vibration mitigation system. It is concluded that the optimal designed TMIS has the advantage of lightweight tuned mass over TMDs in vibration control of wind turbine towers.

Keywords

lightweight tuned mass; wind turbine tower; tuned mass damper; tuned mass inerter system

[*] Corresponding author.
Email address: kdai@scu.edu.cn