Jinyu Li, Peng Huang and Hongyin Geng, 2026, Robust design of tuned viscous mass dampers for wind-induced vibration control of high-rise buildings: An info-gap decision theory approach to manufacturing uncertainty, *Buildings,* vol. 16, Issue 15, 10.3390/buildings16152931

Abstract Tuned viscous mass dampers (TVMDs) are effective devices for wind-induced vibration control in supertall buildings, but their performance depends on a precise resonance condition that can be disturbed by manufacturing tolerances. This study identifies an insufficiently examined asymmetric sensitivity mechanism, termed the "dangerous diagonal effect", in which opposite-sign errors in TVMD inertance and stiffness amplify tuning-frequency drift and create a worst-case sensitivity space that conventional symmetric uncertainty models may underestimate. To tackle this challenge without requiring prior statistical distributions unavailable at the design stage, an Info-Gap Decision Theory (IGDT) robust optimization framework tailored to TVMDs under stochastic wind excitation is developed. A Kriging-metamodel-assisted Efficient Global Optimization bi-level strategy reduces the computational burden of the nested worst-case search. Applied to a 76-story, 306 m benchmark building under a dual-criterion constraint combining the ISO 10137 comfort limit and a 30% relative degradation bound, the framework certifies comfort compliance for manufacturing errors up to 23.44% along the dangerous-diagonal direction. Under the most severe coupled degradation scenario, which integrates opposite-sign manufacturing detuning, 50-year power-law aging, and Arrhenius thermal drift, the nominal H2-optimal design collapses to 36.7% vibration reduction efficiency while the IGDT robust design sustains 51.7%, reducing the Monte Carlo failure probability from 3.8% to 1.2% across 500 random realizations. An aeroelastic wind tunnel campaign spanning 620 detuning configurations on a 1:350 scaled model provides physical validation of IGDT design reliability for a TVMD system. The experiments corroborate the dangerous-diagonal sensitivity asymmetry, support the predicted robustness plateau under severe parameter detuning, and show that the IGDT framework maintains comfort compliance where the H2-optimal design fails.

Keywords tuned viscous mass damper; Info-Gap Decision Theory; robust optimization; wind-induced vibration; wind tunnel test.