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Self-Weight Reduction Of Lateral Load-Resisting Systems In Wind-Excited Tall Buildings Using Tuned Inerter Dampers

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As modern buildings get taller and slenderer in response to high premium urban land, they become susceptible to wind-induced vibrations due to reduced lateral stiffness, low inherent damping, and structural resonance with vortex shedding (VS) effects. These vibrations can, in turn, lead to large lateral floor accelerations beyond codified limits, causing discomfort to building occupants and serviceability failure. To this end, recent works considered the use of lightweight inerter-based vibration absorbers for habitability improvement in wind-excited tall buildings through minimizing floor accelerations. Still, for routine buildings, the above dynamic serviceability issue is usually addressed by stiffening the lateral load-resisting system (LLRS) as the incorporation of vibration absorbers is considered expensive or exotic. However, LLRS stiffening results in high use of structural materials, increasing upfront costs and embodied CO2 emissions. In this context, this study investigates numerically the potential of a tuned inerter damper (TID) for LLRS self-weight in buildings whose design is governed by occupant wind comfort criteria. This is achieved through a novel multi-objective optimization-driven framework with dual objectives for the integrated design of LLRS with TID. The framework utilizes an optimality criteria (OC)-based structural sizing algorithm for weight minimization of the LLRS, and a pattern search algorithm for optimal TID tuning to meet the code-specified floor acceleration criteria with least structural weight (objective 1) and TID inertance (objective 2) possible. The framework is demonstrated using a 15-storey steel building equipped with a ground-floor TID under cross-wind excitation accounting for VS effects. It is shown that significant reductions in LLRS upfront cost and embodied CO2 are achieved by the proposed integrated design framework.