Vibration suppression and energy harvesting potential of a non-grounded tuned mass-damper-inerter (TMDI) attached to white noise excited flexural structures with varying cross-sections

Zixiao Wang* **and Agathoklis Giaralis***

*Department of Civil Engineering
City, University of London
Northampton Square, EC1V 0HB, London, UK
e-mail: agathoklis.giaralis.1@city.ac.uk

ABSTRACT

Passive tuned mass-dampers (TMDs) are widely considered for suppressing large-amplitude low-frequency oscillations in relatively large-scale dynamically excited primary structures as well as for generating energy by such oscillations [1]. They consist of a secondary vibrating mass attached to the oscillating primary structure through stiffeners and dampers designed to minimise primary structure motion. Energy generation is achieved by using electromagnetic motors (EMs) with energy harvesting capabilities as damping devices. Marian and Giaralis [2] demonstrated analytically that by supporting the secondary TMD mass through an ideal inerter (i.e., a device resisting relative acceleration) to a different location from the one that the TMD mass is attached to the host structure enhances significantly the TMD motion control efficiency. Further, it was shown in [3,4] that improved vibration control and energy harvesting is achieved by employing EMs in TMDs with secondary mass supported to the ground via an inerter acting as an inertial/mass amplifier. This paper extends the efforts in [3,4] by exploring the concurrent vibration control and energy harvesting potential of TMDs with an inerter linking the secondary mass to the primary structure rather than to the ground. The herein considered tuned mass-damper-inerter (TMDI) configuration is applicable to control the first dominant vibration mode of vertical cantilevered structures in which the secondary mass is attached close to their free end (i.e., away from the ground) as in the case of wind-excited tall buildings [5]. Herein, an analytical model of a TMDI equipped cantilevered flexural structure with an EM acting as an ideal dashpot is adopted treating the primary structure as a generalised single degree of freedom whose mass and stiffness properties depend on its first mode shape. It is analytically shown that the further away the inerter is attached to from the tip of the primary structure the more improved suppression of the free-end primary structure displacement is achieved and, *at the same time*, the more energy becomes available for harvesting under stationary white noise excitation. It is further proved that enhanced concurrent vibration suppression and energy harvesting is achieved by shaping the primary structure such that its mass and flexural resistance reduces with height. The latter effect suggests that judicial design of primary structure enables better performing TMDI-equipped flexural structures in terms of dynamic response and energy generation contrary to the case of the conventional TMD shown to be indifferent to the primary structure mode shape.

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