Tuned Liquid Column Damper Inerter (TLCDI) for seismic vibration control of fixed-base and base-isolated structures

Chiara Masnata*, Alberto Di Matteo*, Christoph Adam** and Antonina Pirrotta*

*Department of Engineering, University of Palermo, viale delle Scienze, 90128 Palermo, Italy

**Unit of Applied Mechanics, University of Innsbruck, Technikerstr. 13, Innsbruck, Austria

Abstract. In this paper, the use of a novel passive control device defined as Tuned Liquid Column Damper Inerter (TLCDI) is studied to mitigate the seismic response of both fixed-base and base-isolated structures. The TLCDI optimal parameters for pre-design purposes are obtained by means of a statistical linearization technique and an optimization procedure which considers the minimization of the structural displacement variance and a white noise process as base excitation. The performance of a fixed-base and base-isolated TLCDI-controlled structure is examined using a set of 44 real recorded seismic signals as external input. Numerical simulations are carried out and results show that the TLCDIs can be considered as an appealing means to effectively control the response of both fixed-base and base-isolated structures.

Introduction

In the field of passive vibration control devices, the Tuned Mass Damper (TMD) and the Tuned Liquid Column Damper (TLCD) are among the most widely used for reducing structural vibrations. However, these devices may require large masses to be efficient. Consequently, inerter-based devices, have gained increasing interest as lightweight solutions [1]. On this basis, following the same logical flow which led to the development of the Tuned Mass Damper Inerter (TMDI) [2] as a more efficient strategy compared to the classical TMD, the Tuned Liquid Column Damper Inerter (TLCDI) [3] has been recently proposed as a promising passive control device which exploits the synergetic beneficial features of the inerter and the TLCD. TLCDs, being simple U-shape liquid tanks, show some convenient characteristics such as low cost, easy implementation, lack of required maintenance, no need to add mass to the structure using the liquid as water supply. Unlike the classical TLCD, the proposed TLCDI is supposed to be able to translate through a sliding support and it is connected to the structure by a linear spring and a damper and to the ground by an inerter. In this manner, the TLCDI dissipates the structural vibrations by means of a combined action which involves the vertical motion of the liquid and the horizontal motion of the container.

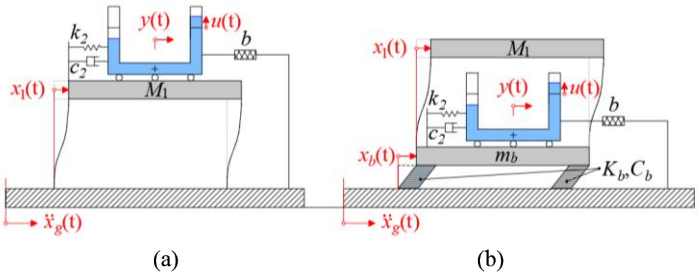

Figure 1: Analyzed systems: (a) fixed-base TLCDI-controlled SDOF structure; (b) base-isolated TLCDI-controlled SDOF structure.

Results and Discussion

The optimal design of the TLCDI plays a key role to obtain the best mitigation effect of the structural response. In this regard, in this paper, the TLCDI is firstly optimized for fixed-base structures and then for base-isolated structures (Figure 1 (a)-(b)). Notably, since the governing equations of the TLCDI are nonlinear, this process may be time consuming. Thus, in this study, TLCDI parameters are evaluated by taking into account a statistical linearization technique and some simplifying hypothesis. Specifically, an optimization procedure based on the minimization of the variance of the structural response is proposed. In this manner, the control performance of TLCDI for fixed-base and base isolated structures is discussed for both white noise excitation and considering a set of 44 real earthquake records. Numerical analyses indicate that coupling the inerter with a TLCD device significantly reduces the structural responses compared to the uncontrolled structure and to other traditional devices.

References

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