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Experimental study of a tuned liquid column damper with liquid turbine

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Abstract: Tuned liquid column dampers (TLCDs) are attractive for application in mitigating wind or seismic-induced vibrations of engineering structures. On the basis of the existing TLCDs, this paper designs a novel type of TLCD equipped with liquid turbine that has the potential to simultaneously control vibration and generate power. A Savonius-type turbine is employed in a conventional TLCD. Shaking table tests are performed to examine the control efficiency of the TLCDs with and without liquid turbine. Furthermore, a simple circuit connection is made for the TLCD equipped with the Savonius-type turbine to check its power generation performance. The experimental findings confirm that the proposed TLCD is capable of mitigating the resonant response of structures. More importantly, the light-emitting diode connected to the turbine can be continuously and stably lit. This implies that the turbine successfully generates electricity, which provides a feasible basis for the autonomous semi-active control of TLCDs.

Keywords: TLCD, liquid turbine, shaking table test

1. Introduction

The tuned liquid column damper (TLCD) concept for vibration control of civil engineering structures was proposed by Sakai et al. [1] in 1989. Since its initial development, numerous researchers have investigated the optimization scheme of control solution based on TLCDs through passive, semi-active and active strategies [2]. Meanwhile, TLCDs have successfully achieved the multidirectionality, and the combination of inerters for improving control efficiency [3,4]. Nevertheless, the existing TLCDs are proposed solely for vibration control.

This paper creatively designs the configuration of TLCD equipped with liquid turbine that has the potential to simultaneously control vibration and generate power. The rotating turbine in the oscillating liquid column provides additional liquid damping for the TLCD, also the energy when it is connected to an electric motor. The experimental results reveal that the proposed solution can achieve simultaneous vibration mitigation and power generation, which verifies its feasibility for application in semi-active TLCDs.

2. Results and Discussion

Shaking table tests are performed to examine the control efficiency of the TLCD with Savonius-type turbine. It is found that the TLCD can reduce the vibration of the structure, as shown in Figure1. It is also found that during the excitation, the light-emitting diode connected to the Savonius-type turbine can be continuously and stably lit, as shown in Figure 2. The results prove that the TLCD with

Savonius-type turbine designed in this paper is capable of mitigating the resonant response of structures, and has the potential to generate electricity during the vibration.

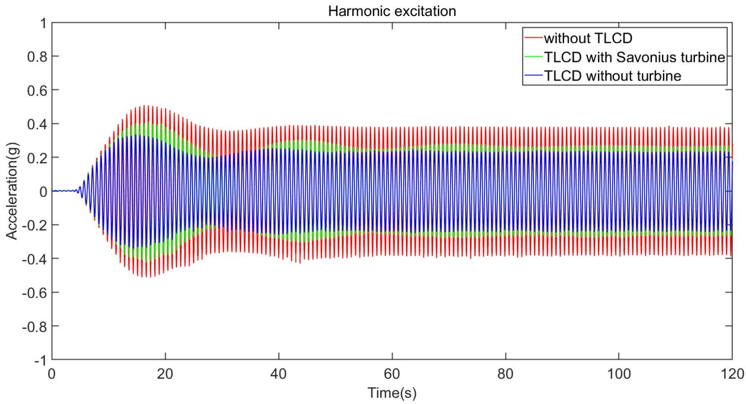

Fig.1. Acceleration of the structure with and without TLCD

(a) (b)

Fig.2. TLCD with Savonius-type turbine before excitation(a) and during excitation(b)

3. Concluding Remarks

This paper proposes the configuration of TLCDs equipped with liquid turbine, which can provide additional liquid damping and generate power. A Savonius-type turbine is used in the shaking table tests. It is demonstrated that the proposed device can be applied to simultaneously suppress vibration and produce electricity.

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