

The technology advances modern civil engineering engineering essay

[Engineering](#)



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Introduction

As the technology advances modern civil engineering tend to construct relatively light, flexible and tall structures. The typical examples are the Taipei 101 Building(508m) in Taipei, Taiwan and the super-high building—Burj Dubai(828m)in Dubai. These structures are more sensitive to dynamic loading such as wind and earthquake because they are built from light, flexible materials with relatively low levels of intrinsic damping. Thus the structural vibration level might exceed safety criteria or cause the upper floors occupant discomfort. It is thus necessary to find a cost effective solution to alleviate wind, ocean wave and earthquake-induced vibrations in large-scale structures like tall buildings, long span bridges and offshore platforms. Adding more mass to the structure is a traditional method to reduce the vibrations on account of the increase of structural stiffness. Nevertheless , this will lead to the inefficiency of aesthetics and economies. [1]The ability to dissipate energy is a determinant factor of the structural dynamic response of a tall building. Thus the inherent damping of the large-scale structures is insufficient to limit its vibration. The basic idea of solving the problem is to use the vibration reducing devices to absorb a certain, critical part of the input energy thereby dissipating the additional energy of the main structure and thus preventing it from serious structural damage. It is their own momentum of damping devices to counteract the structural vibrating motions. These auxiliary damping devices are large equipments that are installed high up or on the top of the building where the amplitude of the oscillation is the biggest. Hence it has become important to search for effective and practical devices for suppression of these vibrations. In the

past decades, many active and passive control mechanical dampers such as the active mass dampers (AMD), active tendons (AT), tuned liquid dampers (TLD), impact dampers (ID) and tuned liquid column dampers (TLCD) have been proposed to mitigate these excessive vibrations.[2] Among these devices is the tuned liquid column damper (TLCD), which initially was proposed by Sakai and his co-authors.[3] It consists of two vertical columns that are connected with a horizontal chamber as the base, forming the shape of a U-tube. It filled with liquid, preferably water. C:

UsersappleAppDataRoamingTencentUsers395673853QQWinTempRichOleM63X56(E~RM0Y)CRTWG4J1A. jpghttp://whowired. net/100827Tuned liquid column damper (TLCD) relies on the motion of liquid mass in the container to counteract the external force. The liquid oscillates horizontally in the connecting chamber and vertically in the columns due to gravity. It is the momentum of the latter flow that counteracts the motion of the building. And some tuned liquid column dampers also have an orifice in the middle of container for inducing damping forces that dissipate energy. http://ars. els-cdn. com/content/image/1-s2. 0-S0141029697001569-gr1. gifCompared to other auxiliary damping devices the main merits of TLCDs insist of low installation costs, easy installation to either new buildings or existing structures, and the maintenance requirements of the system is practically nonexistent. It is easy to adjust their frequencies, hence it is a simple tuning mechanism which allows adaptation to modified building dynamics. Also they can be combined with active control devices to function as hybrid systems.

[4] Indeed, a TLCD may not cause significant additional weight or cost if the construction also need a water reservoir for water supply or fire fighting. The

water in container can be a serviceable source for daily use or fire protection. And Unlike tuned mass dampers, a large space for stroke lengths is unnecessary for TLCDs. Furthermore, Kareem[5]has proved, TLCDs can be used to dissipate energy in two directions synchronously by using a bi-directional U-tube. Consequently it is a preferable device for vibration control of large-scale structures. Comprehensive studies and researches have been done on the properties and applications of using TLCD to suppress structural oscillations. Since the TLCD was introduced, many analytical and experimental works are conducted aiming to assess its effectiveness and to find its optimal design parameters. This paper will concern on the tuned liquid column damper with an alterable horizontal chamber height and column widths. The phenomenon about liquid oscillating in an asymmetric U-tube were first researched by Bernoulli (1738)[6]. Through a geometrical model, Bernoulli set the length of a pendulum with the same frequency as the oscillations in an asymmetric U-tube. And it demonstrates that as the asymmetry is increased the length of the isochronous pendulum becomes shorter which means the frequency of oscillation is increased too.

Literature Review

Categories of Auxiliary Damping Devices

The basic idea of most Auxiliary damping devices is to counteract the input energy by their own momentum. Successful and practical vibration control has been achieved by the application of dynamic vibration absorbers.

However, there are various basic methods of these vibration reducing devices.[7] They are broadly categorised as either passive, such as Tuned Mass Dampers (TMDs), or active. Active ControlAn active control system is

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one in which an external source powers control actuator that can produce forces to both add and dissipate energy in the structure. Contrary to passive control, there are time dependent control parameters which can be adjusted to obtain a desired system behavior in active control. In an active feedback control system, the physical sensors will measure the response of the system and send the signals of response function to the control actuators. Active structural control is commonly classified as semi-active, hybrid and purely active control. Passive Control The external power source is unnecessary for a passive control system. Passive control devices afford forces that are absorbed from the initial impact and through the motion of a solid or liquid mass to counteract the structural movement. Contrary to purely active systems, which provide structural system with mechanical energy and therefore depend on external power supply, the amount of power consumption for passive control systems and semi-active control systems is orders of magnitude less. According to a widely accepted definition, a passive control device cannot add mechanical energy into the controlled structural system, but has passive energy dissipation properties which can be adjusted to reduce the response of the system.[4] Hybrid Control Hybrid control means the combination of active and passive control systems. They typically almost achieve the vibration reducing capabilities of active systems while the level of energy consumption is significantly reduced. They can be modified from passive systems by adding an active mechanism, thereby overcoming the limitations of purely passive systems, while still keeping the energy consumption low. For example, a structure equipped with distributed viscoelastic damping with an active mass damper on or near the top of the

structure, or a base isolated structure with actuators actively controlled to enhance performance. Semi-active Control Semi-active control systems are a class of active control systems while it requires less of the external energy than typical active control systems. Semi-active control devices are often regarded as controllable passive devices. A possible semi-active device can for example adjust the damping properties of a traditional TMD.

Reviews of basic methods of damping devices

Tuned Mass Dampers

The concept of the tuned mass damper (TMD) dates back to the 1940s. It consists of a mass with properly tuned spring and damping elements, providing a frequency-dependent hysteresis that increases damping in the primary structure. The frequency of the damper is tuned to a particular structural frequency so that when that frequency is excited, the damper will resonate out of phase with the structural motion. Energy is dissipated by the damper inertia force acting on the structure. http://www.taipei-101.com.tw/en/Tower/images/building/pict_14-1.jpg TMD in Taipei 101. <http://www.taipei-101.com.tw>

Tuned Liquid Dampers

The tuned liquid damper which is also called tuned sloshing damper is the simplest form of liquid based damping devices. Similar in concept to a tuned mass damper, the tuned liquid damper (TLD) impart indirect damping to the system and thus improve structural performance. A TLD absorbs structural energy by means of viscous actions of the fluid and wave breaking, which means that the liquid in the rigid container oscillates to absorb and dissipate

vibrational energy. primarily the wave breaking on the free surface leads to the dissipation. http://www.construction.com/CE/CE_images/0806edit_6.jpg<http://continuingeducation.construction.com>This kind of system have already been successfully put into application and are studied further by Holmes (2001).[8] The natural frequency in this system is dependent only on the fluid depth due to the dimensions of the tank are fixed. Recent work by Sakamoto et al. (2001) [9] also describes controlling the natural frequency of a TSD by applying an electric field to an electrorheological fluid.

Tuned Liquid Column Dampers

Tuned liquid column damper (TLCD) is the improved design of a tuned liquid damper (TLD). Based on a TLD, there are two vertical columns that are joined at the both ends of the chamber, forming the U-tube shape.

Historically TLCDs can date back to the early 20th century, when the German shipbuilder Frahm suggested to apply anti-rolling tanks to minimize the ship's roll induced by wave motion, see, e. g., Den Hartog [10]. As ship stabilizers, the initial models were simple rectangular tanks filled with liquid, which were similar to the TLD model. A U-shaped design was later proposed by Field & Martin (1976)[11]. The TLCD considering a U-tube with a constant cross sectional area is the original design method which is discussed by Xu et al. (1992)[12]. The same as TLD, the natural frequency of this method can only adjusted by varying the volume of fluid in the tank. The design was improved by Hitchcock et al. (1997a)[13] to make the horizontal chamber with the fixed configuration into the chamber with variable height. This allows greater flexibility and versatility as it is the geometry of the tank rather than just the volume of fluid determines the natural frequency. Gao et <https://assignbuster.com/the-technology-advances-modern-civil-engineering-engineering-essay/>

al.[14] have promoted the traditional uni-directional design to the bi-directional method, and hybrid systems have been investigated, see, e. g. Haroun [15] et al. Kagawa et al. [16] have made life-size applications, where a 9-story steel structure was equipped with a semi-active TLCD. Teramura and Yoshida [17] have implemented a bi-directional vibration control system based on a TLCD in a 26-story, 106 m high hotel in Japan. Reiterer [18] has indicated that the TLCD is generally adequately damped and the parametric resonance would not be caused by the vertical component of the seismic excitation. Computer simulations and small scale experimental testing under time-harmonic, single seismogram and random forcing confirmed the excellent performance and stabilization of the TLCD. Reiterer [19] also proved experimentally and by computer simulation the effectiveness of TLCDs when applied to vibration prone long span footbridges, where they appear superior to alternative countermeasures, especially for pedestrian or wind induced vibrations. Work by Gao et al. (1999) gives a theoretical analysis of systems of more than one TLCD with natural frequencies distributed around the natural frequency of the building. This latter technique results in the system being less sensitive to changes in external loading.

Basic Governing Equations

Experiment of Asymmetric TLCD

Kobine et al.[1] have made a theoretical, numerical and experimental study of liquid oscillations in an asymmetric tuned liquid column damper. The result of the experiment will be used here for the comparison with the theoretical study. The experimental apparatus will be introduced first.(a)

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(b)C:

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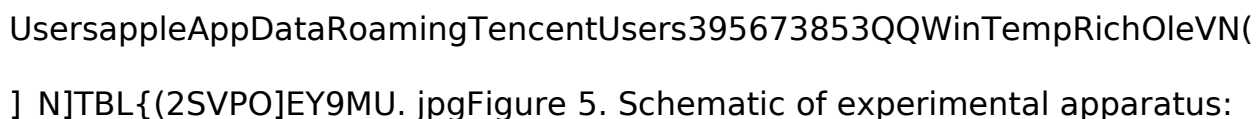


Figure 5. Schematic of experimental apparatus: (a) overall configuration and (b) dimensions of tank and insert. The experimental configuration is shown schematically in figure. A cubic Perspex tank is fixed on a table with 200 mm interior length and the linear bearings could allow it to move horizontally. There is a PVC insert of 140 mm width that spanned the tank and formed the inner walls of the U-tube. In order to adjust the geometry of the oscillator, the insert was moved horizontally and vertically by two independent lead screws. The accuracy of the horizontal displacement is 0. 01 mm which was measured by micrometer. A graduated scale which was attached to the outside of the Perspex tank measures the vertical displacement, with an accuracy of 0. 2 mm. And to reduce any streamline separation and hence ensure that the flow remained locally parallel to the boundaries, it is necessary to make the corners of the insert rounded. An optimal radius of curvature is 19. 0 mm which was found by means of finite-element simulations of steady flow through the domain. Nevertheless, this method of minimizing separation will be inapplicable for the flow will separate regardless of the corner profile when chamber heights over approximately 20 mm. Water at room temperature was used as the working fluid in all the experiments reported here. And about 0. 001% per volume of wetting agent was added to reduce surface tension and to increase the mobility of the contact lines on the inner surfaces of the device. The equilibrium depth of the fluid was kept constant at 140 mm, the maximum height of the horizontal channel was 60 mm, and the liquid in the

columns to oscillate with a maximum displacement of approximately 55 mm. The experiments were observed by eye in real time and by means of video recordings taken at a rate of 25 Hz. The free-surface displacements were measured against the graduated scale on the tank to an accuracy of 0.2 mm.

Methodology

Formulation

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UsersappleAppDataRoamingTencentUsers395673853QQWinTempRichOlePH RRY6`EJQHUC2R[\$K4GPMI. jpgFigure is a schematic of the two-dimensional cross-section of a generalized liquid-column oscillator. The TLC devices are normally designed with a uniform cross-section in one horizontal direction and are aligned so as to move predominantly in the perpendicular horizontal direction. According to this characteristics, it is assumed fundamentally that the global flow can be treated as two dimensional in the formulation of the theoretical which means the velocity component perpendicular to the diagrammatic plane equals to zero. The H , a and b are used to denote the height of the horizontal chamber and the widths of the left and right columns respectively. It is assumed that $H > a + b$. The h' means the liquid height above the base when the liquid fills both columns and at equilibrium state. The h denotes the amplitude in the right column when oscillating due to the gravity. h_m is the maximum amplitude of the oscillation. The assumption is made that the columns are tall enough to contain the maximum vertical extent of such oscillations. It is also assumed that $h_m < H - a$, so that both columns are always at least partially filled some liquid.

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