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SEISMIC CONTROL OF OFFSHORE STEEL JACKET PLATFORMS USING TUNED LIQUID COLUMN DAMPER

Ahmadreza M. GHARABAGHI
Professor, Sahand University of Technology, Tabriz, Iran
mgharabaghi@sut.ac.ir
Mohamadhosein MOHASEL
Ph.D. Candidate, Sahand University of Technology, Tabriz, Iran
m_mohasel@sut.ac.ir

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Offshore platforms are widely used to explore, drill, produce, store, and transport ocean resources and are usually subject to environmental loading, such as waves, winds, ice, earthquake and currents, which may lead to failure of deck facilities, fatigue failure of platforms, inefficiency of operation, and even discomfort of crews. In order to ensure reliability and safety of offshore platforms, it is of great significance to explore a proper way of suppressing vibration of offshore platforms. Earthquake loading has to be considered when the offshore platform is constructed in active fault zone.

There are mainly three types of control schemes, i.e. passive control schemes, semi-active control schemes, and active control schemes, to deal with vibration of offshore platforms. While general seismic control strategies have been investigated and demonstrated to be effective for structural seismic mitigation, there currently is limited research highlighting the specific methods available for design engineers and researchers concerned with vibrations of marine offshore structures.

This paper provides a seismic passive control technique and its application for marine offshore structures. Tuned Liquid Column Dampers (TLCDs) have been recently considered as a viable passive control mechanism in this regard but limited information is available in relation to their experimental performance. Although there has been an increasing use of these devices for structural seismic control, it is shown that the existing model does not always lead to accurate prediction of the liquid motion. Tuned systems (such as Tuned Mass Dampers (TMDs)), Tuned Liquid Dampers (TLDs) and tuned liquid column dampers are used for the vibration control of tall and slender structures (such as offshore platforms). TLCD which was first proposed by TLCD relies on the motion of a column of liquid in a U-tube container to counteract the forces acting on the structure. This device has drawn significant attention of the researchers as one type of secondary systems. The frequency of a TLCD is tuned with the fundamental frequency of the structure by changing the length of the liquid column in the U-tube. Damping is introduced in the oscillating liquid column through an orifice in the liquid passage. Unlike TMDs, the damping in TLCD is amplitude dependent and hence the damping is non-linear. The advantages of TLCD systems include low cost and maintenance. Let us consider a U-shaped TLCD installed on a SDOF system. The schematic diagram showing the combined structure-TLCD is provided in Figure 1.

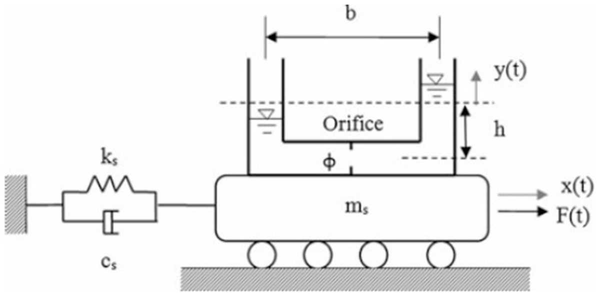

Figure 1. Schematic diagram showing U-shaped TLCD installed on a SDOF system.

The equations of motion of the structure and the liquid column can be written as:
For structure:

$$(m_s + m_d)\ddot{x}(t) + c_s\dot{x}(t) + k_s x(t) + \alpha m_d \ddot{y}(t) = F(t) \quad (1)$$

For liquid column:

$$\alpha m_d \ddot{x}(t) + m_d \ddot{y}(t) + \frac{1}{2}\rho A \xi |\dot{y}(t)| \dot{y}(t) + k_d y(t) = 0 \quad (2)$$

At first, a tuned liquid column damper is proposed for seismic mitigation of SPD18B platform located in Persian Gulf. SPD18B is a four-leg jacket platform, as illustrated in Figures 2 and 3.

The influence of key parameters of the tuned liquid column damper on the vibration suppression of the offshore structure is studied in detail. In order to examine the seismic control effectiveness of the tuned liquid column damper for the steel jacket platform, a comprehensive numerical study is carried out. This paper shows the potential of TLCD to reduce motions in offshore platforms for different designs and platforms of TLCD and provides a comparison of the levels of reduction of dynamic responses achieved. The optimum effect of liquid column damper in the steel jacket platform can be specified by displacing the place of the tuned liquid column damper and optimum parameters of damper, simultaneously. It can reduce the effect of the earthquake force. In this study, a TLCD system as a passive control system, is developed to mitigate the response of a fixed SPD18B jacket offshore platform (Persian Gulf). The TLCD system is composed of steel tubes and water. In the proposed strategy the deck is separated from substructure and the TLCD system is installed between the deck and substructure for response suppression of the jacket offshore platform. The contents of this study mainly include the investigation of the influence of the TLCD system on seismic control of offshore jacket platform under the actions of earthquake excitations. The platform is investigated under four different ground motion accelerations (Tabas 1978, Kube 1995, Northridge 1994 and El Centro 1940 earthquakes) scaled to PGA=0.3 g. Displacement time history of one of the earthquake records for comparison is shown in Figure 4 (using finite element software, such as ABAQUS). The results of this study show that the proposed TLCD system improves the structural behaviour of the jacket platform and reduce its response under earthquake drastically.

Figure 2. Picture of SPD18B platform.

Figure 3. Computer model of SPD18B platform.

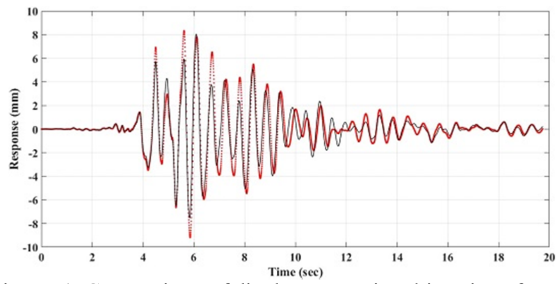

Figure 4. Comparison of displacement time histories of top of the platform for uncontrolled (red dotted line) and controlled (TLCD) status (black solid line).

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