Abstract

Recent advancements in technologies and development of lightweight, high-strength material are resulting in frequent construction of high-rise buildings. Increased flexibility and lack of sufficient damping make these buildings vulnerable to external dynamic loads such as due to wind or earthquake. To reduce the risk of structural failures, it is necessary in exploring mechanisms to suppress the vibrations of such high-rise buildings using some suitable device.

Passive liquid dampers such as tuned liquid dampers (TLD), also known as tuned sloshing damper (TSD) and tuned liquid column damper (TLCD) are used widely as possible vibration controlling devices in high-rise buildings. Traditional TLDs or TSDs are placed typically at the rooftop, where the modal deflection of the high-rise building is maximum. When tuned to the natural frequency of the building, these partially filled tanks can efficiently control the acceleration response of the building. When the tank is a U-shaped container, it is named as TLCD.

Experiments were carried out with a U-shaped container (TLCD without orifice) to understand the liquid sloshing behavior and flow characteristics inside the container. Laboratory model of a single bay single storey structural frame was developed and the efficacy of the U-shaped container to reduce the acceleration response of the frame subjected to harmonic and scaled earthquake excitation was explored.

Finite element code in MATLAB environment is developed to numerically model the liquid sloshing phenomenon in U-shaped containers. A suitable numerical scheme, based on computational fluid dynamics in ANSYS (FLUENT) platform, is proposed for multi-phase modelling of the fluid flow dynamics in U-shaped containers considering the flow turbulence. The numerical results thus obtained are compared with the experimental ones to demonstrate the applicability of the developed numerical model.

Amongst different passive control strategies, the present research explores the utilization of liquid storage service tanks placed at the roof of high-rise buildings. These deep liquid tanks (DLTs) have a higher depth ratio than the conventional TLD/TSD. The focus of the work is to develop a computational framework to demonstrate the efficacy of such liquid storage tanks considering the fluid-structure interaction (FSI) effect using coupled FEA-CFD analysis. The aim is to arrive at an appropriate damper efficiency considering the position of the tank, the size of the tank, and different liquid filling levels. The applicability of the proposed framework is further demonstrated through numerical examples of high-rise buildings and various liquid dampers. Finally, it is observed that a suitably designed DLT may be an effective alternative to a multiple tuned liquid damper system.

KEYWORDS: *High-rise buildings; Tuned liquid dampers; Tuned liquid column dampers; U-shaped containers; Finite element analysis; Deep liquid tanks; Multiple tuned liquid dampers*