非剛性儲存槽之隔震研究

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摘要

本文探討應用摩擦單擺隔震支承於非剛性儲存槽防震設計之可行性。由於摩擦單擺支承隔震結構之周期僅與滑動介面之曲率半徑有關，因此無論儲存量多寡，其滑動周期均保持不變且能完全掌握。本研究首先根據一足以忠實反應儲存槽動力特性之簡化模式(考慮徑向振動模態為一懸臂梁，且儲存槽斷面仍保持圓形)建立非剛性儲存槽隔震系統之結構—流體動力方程式，進而利用剪力平衡法解析非線性動力系統之動態反應。本研究之數值模擬分析考慮不同之地震波與強度，以瞭解非剛性儲存槽在隔震前、後動力特性的差異。分析結果顯示，槽壁的振動與液面激盪位移之互制效應極微，故流體之液面激盪位移可利用剛性儲存槽之分析模式估算；非剛性儲存槽以摩擦單擺支承隔震後，儲存槽之受震反應無論是基底剪力或傾覆力矩均有顯著折減，證實其應用於工業儲存槽之防震甚為可行。

關鍵詞：隔震、摩擦單擺支承、非剛性儲存槽、動水壓、液面激盪

A Study on Seismic Isolation of Non-rigid Storage Tanks

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ABSTRACT

In this thesis, the feasibility of using the friction pendulum bearings (FPS) for seismic isolation of non-rigid storage tanks is investigated. Since the fundamental period of an FPS-isolated structure depends only on the radius of curvature of the sliding interface, the dynamic characteristics of such an isolated tank is invariant and fully controllable, regardless of the storage level. In this study, the structural-hydrodynamic equation of non-rigid tanks under seismic load has been derived based on a simplified model, which reflects the dynamic characteristics of non-rigid tanks with fidelity. The nonlinear dynamic equation is solved by employing the shear-balance method. A series of numerical simulations has been conducted to explore the isolation effects of FPS on non-rigid tank via earthquakes of various intensity levels. Simulation results indicate that the coupling effect of surface sloshing with the shell vibration is negligible in the cases studied, which suggests the sloshing displacement can be estimated from the hydrodynamic analysis of rigid tanks. Seismic responses including the base shear and overturning moment of non-rigid tank are significantly reduced when isolated with FPS. Feasibility of using FPS for seismic protection design of industrial tank is confirmed.

Keywords: seismic isolation, friction pendulum bearing, storage tank, dynamic pressure, sloshing displacement.