

高樓抗風TLCD系統之分析與試驗

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摘 要

高樓建築具有質量輕、強度高、高寬比大且自然振動頻率及阻尼較低等特性，故對風力所造成的擾動十分敏感。因此，如何降低風力所引起的結構變位及加速度以改善其舒適性，遂為土木結構工程領域之重要課題。調諧水柱消能系統(TLCD)為單自由度之非線性動力系統，具備調頻容易、兼具消防及抗振功能等優點。本研究的目的將建立調諧水柱消能系統 TLCD 系統之非線性動力分析模式，並製作等斷面 TLCD 與變斷面 VTLCD 裝置以進行元件試驗與性能試驗。元件試驗結果顯示，TLCD 及 VTLCD 系統之理論振動頻率與元件試驗所得之頻率均十分吻合，而水頭損失係數則與閘門孔徑大小、擾動頻率有關。性能試驗結果顯示，結構安裝 TLCD 與 VTLCD 系統當閘門開口率 $\Phi = 0.36$ 時，則無論結構自由振動試驗或地表簡諧波擾動試驗均能有良好的減振效果。最後，本文完成台北 101 大樓安裝 TLCD 系統之抗風減振性能評估，確認 TLCD 系統可達到與諧調質塊阻尼系統 (TMD) 相當的減振效果。

關鍵字：調諧水柱消能系統、高層建築、水頭損失係數、抗風

An Analytical and Experimental Study on TLCD System for Wind-resisting of High-rise Buildings

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ABSTRACT

High-rise buildings possess characteristics of light-weighted, high strength, large aspect ratio, long period and low damping. They are therefore quite sensitive to wind disturbances. As a result, it has become a critical issue in the field of civil and structural engineering to try to reduce wind-induced displacement and acceleration responses for serviceability. Tuned Liquid Column Damper (TLCD) is a nonlinear single-degree-of-freedom system possessing advantageous features such as easy-tuning and dual functions for fire protection and vibration control. The objective of this study is to establish an analytical model for dynamic analysis of nonlinear TLCD systems, and fabricate both a TLCD and VTLCD device for component tests as well as performance tests. Results by component tests indicate good agreement of the fundamental frequency with the theoretical prediction, and the headloss is found to be dependent on both the orifice size and disturbing frequency. Performance tests, regardless of free vibration or harmonic excitation tests, indicate

both the TLCD and VTLCD are effective in vibration control provided that the opening ratio Φ is greater than 36%. Finally, this study assesses the performance of TLCD system in wind-induced vibration control of Taipei 101, confirming that TLCD achieves equivalent control effectiveness as the TMD system.

Keyword: Tuned Liquid Column Damper, High-rise Buildings, Headloss Coefficient, wind-resisting

