SOIL-STRUCTURE-DAMPER INTERACTION IN STRUCTURAL VIBRATION INDUCED BY WIND

H. GAO, K.C.S. KWOK
School of Civil and Mining Eng., The University of Sydney

B. SAMALI
Graduate School of Eng., University of Technology, Sydney

ABSTRACT: The effect of inertial soil-structure interaction on the superstructure response to wind excitation in the presence of a tuned mass damper (TMD), a tuned liquid column damper (TLCD) or a tuned liquid column mass damper (TLCMD) was investigated. The soil-structure-damper system includes: (1) a simple 3n-degree-of-freedom shear building system (n storeys and each storey with one torsional and two lateral degrees of freedom); (2) a TMD (or a TLCD or a TLCMD) installed on the top of the structure; (3) a rigid rectangular foundation possessing five degrees of freedom (two translational and three rotational DOFs), set on or embedded in an elastic half space foundation soil. Numerical analyses were carried out in time domain and structural frequency responses were calculated. The structure frequency responses with different soil conditions confirm the influence of soil compliancy on the efficiency of the damper. The damper should be tuned according to the fundamental frequency of the soil-structure system. The performance of different dampers (TMD, TLCD) installed in a sixty-storey example building subjected to wind excitation was numerically analysed.

INTRODUCTION

The application of mechanical dampers, such as tuned mass damper (TMD) and tuned liquid column damper (TLCD), to control structural vibrations induced by environmental loads, such as wind and earthquake, has received increasing attention in recent years. Most of the procedures developed, so far, to investigate the effects of these dampers on structural vibrations have been carried out without considering soil-structure interaction. All optimum parameters of these dampers in controlling structural vibrations have been obtained based on a rigid foundation assumption. It is well recognised that because of soil's compliancy, soil-structure interaction will affect structural vibrations induced by wind, earthquake and other environmental loads. Hence, it is necessary to know how soil compliancy affects the efficiency of a damper which has been tuned on the basis of a rigid soil assumption; and how to optimise a damper to control the vibrations of a structure resting on a compliant soil.

To tune a mass damper or liquid column damper for suppressing structural vibrations induced by environmental loads, the fundamental frequency of the structure is one of most important parameters to be considered (Warburton,1982, Tsi,1993). When the flexibility of soil or foundation is taken into account, the natural frequencies of the soil-structure system are altered to some extent which depend on the properties of the soil-structure system (Novak & Hifnawy,1988, Lin and Wu,1984). Whether this change of frequency will dramatically affect the efficiency of a damper, has caught researcher's attention since 1991. Xu and Kwok used a frequency domain transfer matrix method to investigate soil-structure-damper interaction under wind loading situation. Their results show that when soil is very soft, a tuned mass damper can not effectively reduce soil-structure system response; and when soil is moderately stiff (approaching rock condition), the mass damper should be tuned to the natural frequency of the soil-structure system rather than the natural frequency of the structure with a clamped base; and the effectiveness of the mass damper will decrease with decreasing soil stiffness (1991). Samali et al.(1992) used the similar method to investigate soil-structure system under earthquake excitation and obtained similar conclusions, ie. the TLCD and TMD systems are most effective for rigid foundations and their efficiencies decrease as the soil stiffness decrease.