Tuned mass dampers in structures subjected to dynamic soil-structure interaction

R. N. Jabary[1] and S. P. G. Madabhushi[2]

1. PhD Student, Department of Engineering, Geotechnical and Environmental Research Group (GERG), rnj22@cam.ac.uk
2. Professor of Civil Engineering, Department of Engineering, Geotechnical and Environmental Research Group (GERG), mspg1@cam.ac.uk

INTRODUCTION

Tuned mass dampers (TMD) are popular vibration resisting devices commonly used in buildings and bridges to reduce vibrations resulting from imposed wind and/or earthquake loads (see Fig. 1).

The use of TMDs in seismically-excited structures has not been as extensively explored as their long-established effectiveness under wind loading [1-2]. Often in practice, buildings subjected to seismic loads undergo soil-structure interaction (SSI) and possibly structure-soil-structure interaction (SSSI).

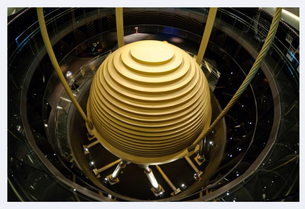

Fig. 1 Taipei 101 TMD [3]

RESEARCH OBJECTIVE

To investigate the effects of TMD configurations on the response of multi-storey sway frame structures undergoing dynamic soil-structure interaction (SSI).

METHODS

Series of geotechnical centrifuge tests and shaking table tests were conducted on 2- and 3-storey sway frame structures situated on soil strata. Various soil profiles, configurations between the structures and TMDs, and scenarios of isolated and adjacent structures were considered [4-6].

Fig. 2-6 show a range of scenarios that were tested in a geotechnical centrifuge and using a shaking table.

Fig. 2 Single-TMD configurations under soil-structure interaction (SSI) and structure-soil-structure interaction (SSSI) (centrifuge)

Fig. 3 Single-TMD configurations under soil-structure interaction (SSI) (centrifuge)

Fig. 4 Multi-TMD configurations under soil-structure interaction (SSI) (centrifuge)

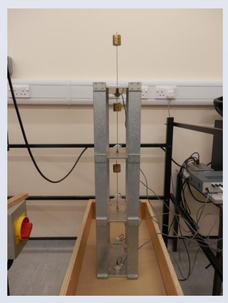

Fig. 5 Multi-TMD configurations under soil-structure interaction (SSI) (shaking table)

Fig. 6 Single-TMD configurations under fixed-base conditions (shaking table)

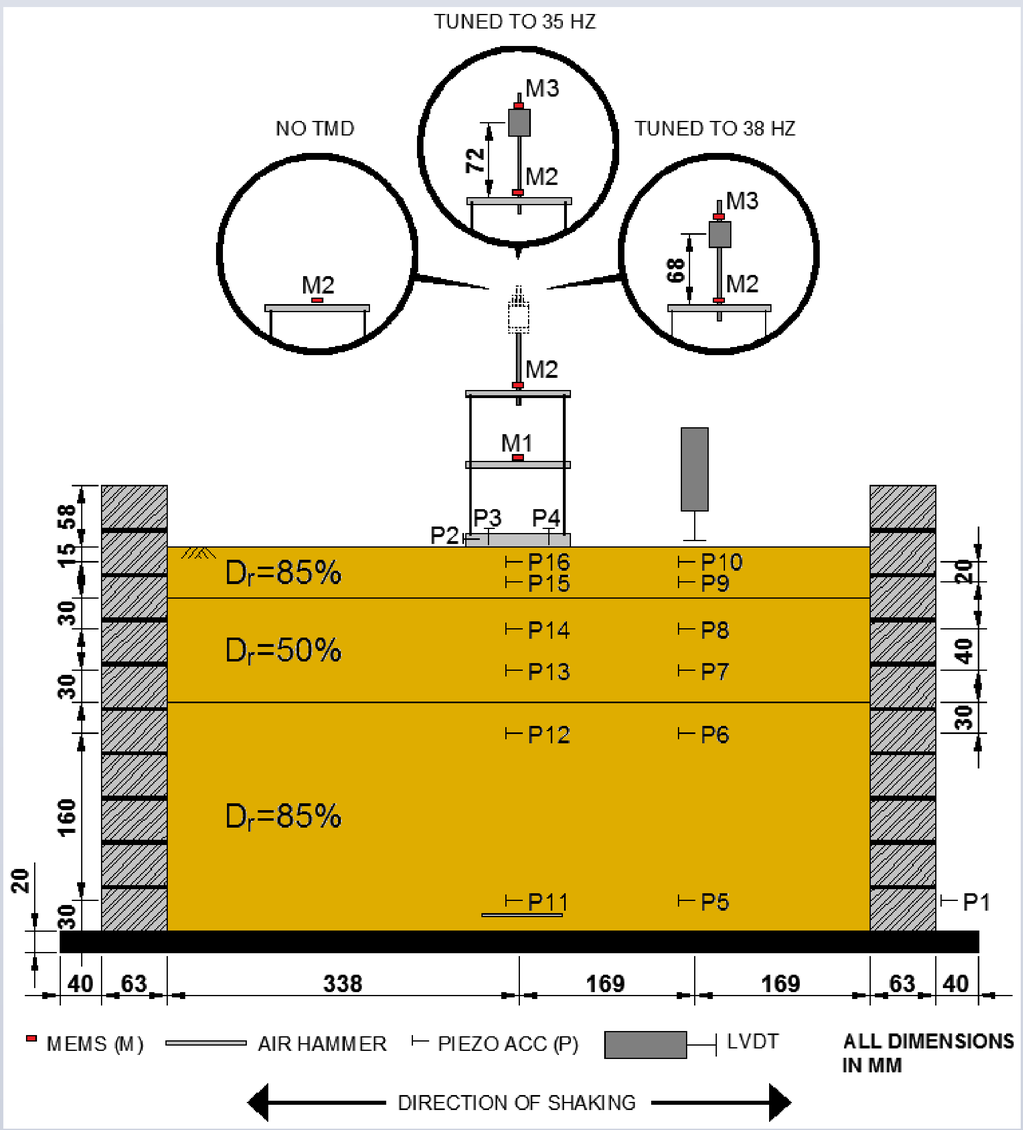

Fig. 7 Typical centrifuge model test set-up with Hostun HN31 sand

RESULTS

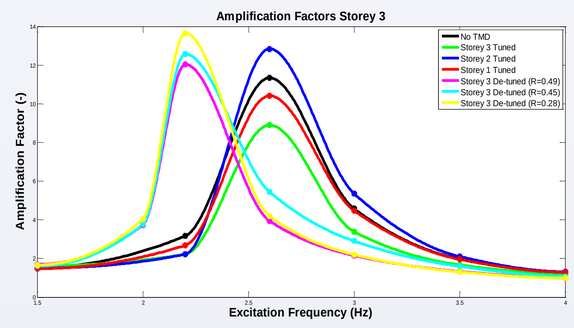

Fig. 8 Amplification factors for the upper storey of a 3-storey sway frame structure fitted with a single-TMD (shaking table results) [5]

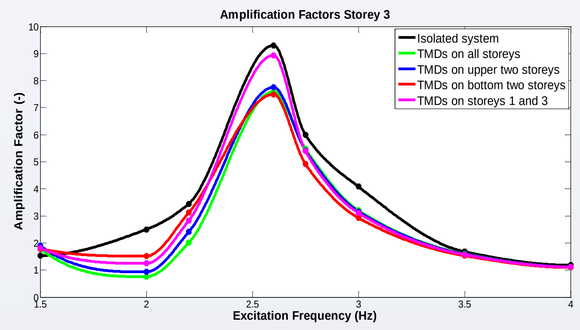

Fig. 9 Amplification factors for the upper storey of a 3-storey sway frame structure fitted with multiple TMDs (shaking table results) [6]

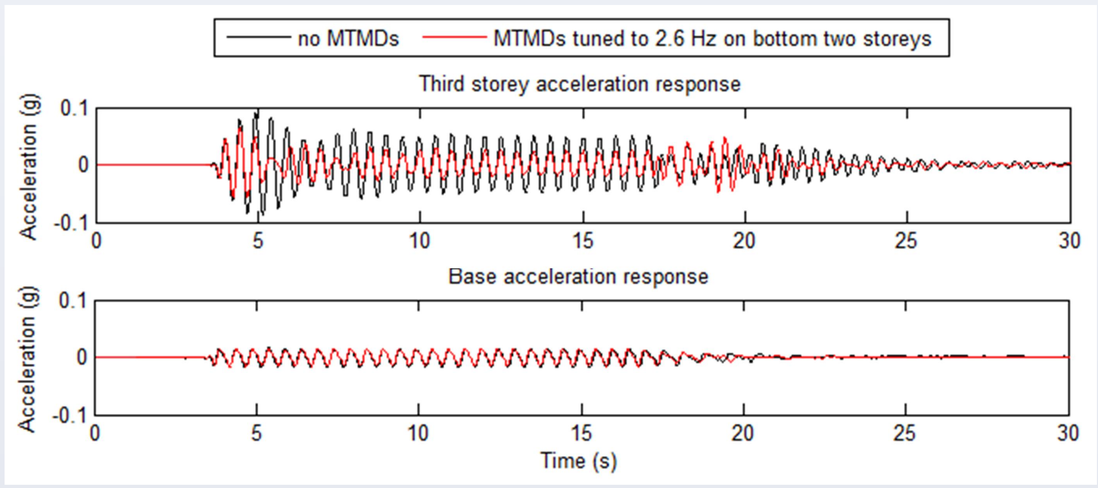

Fig. 10 Acceleration-time histories of the third storey and base responses of a 3-storey sway frame structure fitted with multiple TMDs (shaking table) [6]

FURTHER WORK

There is a need to link in observations from the experimental performance of TMDs and their effects on the behaviour of soil-structure systems to an analytical framework. In addition, further centrifuge tests with a greater variation in soil conditions have been planned.

CONCLUSIONS

The responses of multi-storey sway frame structures fitted with a range of TMD configurations were experimentally investigated for a range of earthquake characteristics and soil foundations. This was accomplished in a series of geotechnical centrifuge tests and shaking table tests. In order to make sense of the experimentally observed performance of TMDs and their effects on the behaviour of soil-structure systems, there is a need for the development of an analytical framework to link in with the test results. A greater variety of soil profiles and structures are yet to be modelled in upcoming centrifuge tests.

REFERENCES

[1] Rana R, Soong TT. Parametric study and simplified design of tuned mass dampers. *Engineering Structures* 1998;20(3): pp. 193-204.

[2] Lin CC, Ueng JM, Huang TC. Seismic response reduction of irregular buildings using passive tuned mass dampers. *Engineering Structures* 1999;22(5): pp. 513-524.

[3] Rauw MO. *Taipei 101 Wind Damper*. [Online]. Available from: http://www.flickr.com/photos/amstelbright/8199926402/ [Accessed 2nd May 2013].

[4] Jabary RN, Madabhushi SPG. An experimental investigation of tuned mass dampers on the seismic response of a multi-storey structure. In: Vemury C, Elia G, Rouainia M, Wilkinson S. (eds.) *SECED Young Engineers Conference 2013: proceedings of the Young Engineers Conference, SECED 2013, 3-4 July 2013, Newcastle upon Tyne, United Kingdom*. Newcastle upon Tyne: Newcastle University; 2013. pp. 76-81.

[5] Jabary RN, Madabhushi SPG. An experimental investigation of soil-structure interaction in a sway frame structure with tuned mass dampers. *EURODYN 2014: IX International Conference on Structural Dynamics, 30 June-2 July 2014, Porto, Portugal. Manuscript accepted for publication.*

[6] Jabary RN, Madabhushi SPG. An experimental investigation of a multiple-tuned-mass-damper-structure system with soil-structure interaction. *2ECEES Second European Conference on Earthquake Engineering and Seismology, 25 Aug-29 Aug 2014, Istanbul, Turkey. Manuscript accepted for publication.*

ACKNOWLEDGEMENTS

The authors would like to thank the staff of the GERG. The first author would like to thank the EPSRC for funding his research at the University of Cambridge.

This poster was produced for the Geotechnical and Environmental Research Group (GERG) Workshop on 23rd June 2014 in the Department of Engineering.