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VIBRATION CONTROL OF FOOTBRIDGES UNDER PEDESTRIAN LOADING USING TUNED MASS DAMPER SYSTEMS WITH EDDY CURRENT DAMPER TECHNOLOGY

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Summary

Modern designs of footbridges often lead to slender constructions with long spans which results in structural systems with a low stiffness and comparatively low masses. A low natural frequency combined with low modal masses is the consequence. This makes footbridges prone to vibrations induced by pedestrians.

Well-known measures to increase the structural damping of a footbridge and hence control the risk of vibrations are Tuned mass dampers (TMD). One of the factors defining the effectiveness of a TMD is its damping mechanism. Characteristics of eddy current dampers can improve TMD performance significantly. An innovative TMD design using eddy current dampers as damping element for an application on footbridges is developped in this paper. First, the theoretical potential is analyzed analytically. A detailed discussion on the optimization of TMD parameters combined with the characteristics of eddy current dampers shows its advantages. In the second part a TMD construction using an eddy current damper is designed based on a case study of a footbridge.

Keywords: footbridge; vibration control; tuned mass damper; eddy current damper

1. Vibrations and footbridges

Modern designs of footbridges often lead to slender constructions with long spans which result in structural systems with a low stiffness and comparatively low masses. This makes footbridges prone to vibrations induced by pedestrians. In case vibrations of the bridge structure exceed certain limits mitigation measures have to been undertaken. Several approaches exist for this target:

- Stiffening of the bridge structure
- Increase of structural damping
- Installation of devices for vibration reduction like Tuned Mass Dampers (TMD)

2. Tuned Mass Dampers

A TMD can be used for vibration control of footbridges under pedestrian loading. A TMD construction is primarily composed of a moving mass, a damping element and a stiffness element. The stiffness is often realized by either a pendulum design or by the use of springs. Common damping elements are viscoelastic dampers, hydraulic dampers, or friction dampers. Most damping elements have damping properties as well as stiffness properties. It is therefore difficult to realize optimum tuning as well as optimum damping parameters at the same time. In addition damping elements can be temperature dependent. This means changing environment temperatures will have an influence on the damping parameters as well as the tuning frequency of the TMD. One approach to realize optimum tuning and damping of a TMD construction is by the use of eddy current dampers as damper element within a TMD.

3. Eddy current dampers

The working mechanism of an eddy current damper is that a conductive plate is moved through a magnetic field. Permanent magnets can be used for the creation of a magnetic field. The relative movement between conductive plate and permanent magnets lead to an induction of eddy currents. The flux of eddy currents creates its own magnetic field which counteracts the creation of the eddy currents itself. Because the creation of eddy currents results by the relative movements between conductive plate and permanent magnets a damping force is produced in the opposite way to the movement.

4. Case study: TMD design using eddy current dampers for a footbridge in Australia

A new footbridge is under construction in Western Australia. This paper shows the design of a Tuned Mass Damper using eddy current dampers for the control of pedestrian induced vibrations. For this purpose a TMD with a mass of 12000 kg is selected. The requirements regarding TMD travel, environment conditions and tuning accuracy made this design especially challenging. It will be the first time an eddy current damper is used as part of a TMD on a footbridge in such a size.

Figure 1 shows the final TMD construction as it will be installed on the bridge.

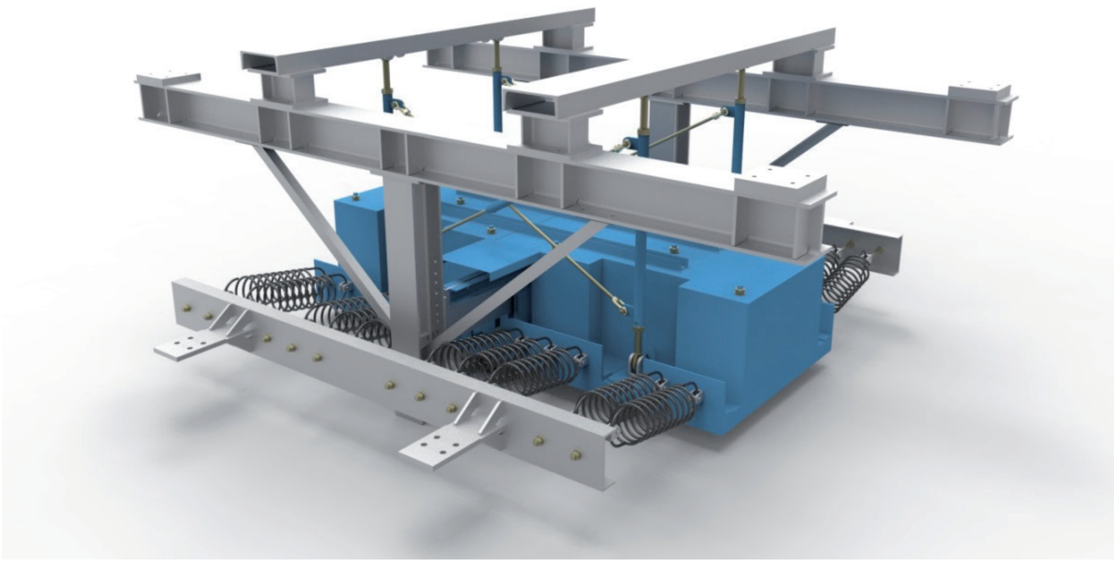

Fig. 1. TMD design

5. Conclusion

A TMD construction with eddy current dampers was proposed as mitigation measure to reduce the risk of pedestrian induced vibrations on a footbridge. It has been shown that eddy current dampers have several advantages and that they are suitable as damper component on TMDs. Thanks to its pure damping properties TMDs using eddy current dampers can be tuned accurately and their tuning frequency will be stable over its lifetime. Furthermore constant damper behaviour is achieved for long TMD travels and for changing environmental conditions. The footbridge which was used as case study for this paper is currently under construction. After its completion the described TMD will be installed and a detailed measurement campaign will take place. In the next step the theoretical analysis can be further tested and verified by a field study.