CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Jerry Y. Chen

Project Number

S0307

Project Title

Time-Variant Damping Method to Reduce Vibration Damages to Mechanical Structures

Abstract

Objectives/Goals

The objective is to try to improve the performance of the tuned mass damper by using a time-variant damping coefficient (a time-variant damping function). A damping function could result in lower building movement amplitude and lower building energy than a traditional constant damping coefficient.

Methods/Materials

The study is done entirely using computer simulations in MATLAB. The building and tuned mass system are represented using the 2-degree-of-freedom spring-mass-damper system. First, building parameters are researched for a realistic representation in the study. Control runs are performed using a constant damping coefficient at three distinct frequencies near the system's natural frequency. The time-variant damping function is then applied under the same conditions as the constant damping coefficient, and the performance of each damping method is compared and investigated. The building displacement and building energy are compared and are used as performance criteria.

Results

The study was carried out at the frequencies of 12, 12.5, and 13 rad/s. At the frequency of 12 rad/s, a 33% reduction in building movement from 17.08 centimeters to 11.46 centimeters and a 52% reduction in building energy from 436 megajoules to 210 megajoules were achieved. At the frequency of 12.5 rad/s, there appeared to be no distinct improvement from the constant damping coefficient. At the frequency of 13 rad/s, a 27% reduction in building movement from 17.04 centimeters to 12.62 centimeters and a 45% reduction in building energy from 527 megajoules to 290 megajoules were achieved.

Conclusions/Discussion

The time-variant damping function has the potential to outperform the traditional constant damping coefficient by reducing building movements by up to 33% and building energy by over 50%. However, the time-variant damping function is frequency specific and not all frequencies exhibit similar improvement in performance. It is also difficult to find the ideal combination of values for the time-variant damping function that will result in the ideal performance in an earthquake. While clearly it is an ideal improvement over the constant damping coefficient, further research is necessary to make a time-variant damping function practical for common use.

Summary Statement

This project studies time-variant damping functions for the purpose of improving tuned mass damper effectiveness at reducing building movements and damages during an earthquake.

Help Received

Professor Chung-Kuan Cheng helped supervise and guide the research, Graduate students Xiang Zhang and Howard Zhuang helped with MATLAB issues, and parents helped with assembling the board