CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)
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Project Number
S0318

Project Title
Seismic Vibration Control: Finding the Best Strategy for Minimizing Damage to a Structure During an Earthquake

Abstract

Objectives/Goals
The objective of the experiment was to determine the most effective mechanism to reduce structural vibration during earthquakes.

Methods/Materials
A plywood and metal structure was constructed and installed on a shake table, which was designed to to simulate an earthquake. Devices such as a tuned mass damper and base isolator were installed in different configurations and combinations on the building and were tested. Each earthquake engineering strategy was evaluated based on the model building#s sway relative to a rigid structure mounted on the shake table. The extent of the usefulness of each device was determined based on video of the test, viewd at a slower speed. To maintain a consistent shake magnitude, only the intervals during which the shake table was moving at a specific speed relative to a distinct, immobile entity were assessed.

Results
The base isolator and mass damper combination, with the mass damper located at the top, was the most effective. However, the system using only the mass damper located at the top was the least effective, allowing the most sway. When the base isolator and mass damper were used in tandem, effectiveness decreased as the damper was placed progressively lower on the structure. However, the opposite effect was observed with the damper alone, with effectiveness increasing as the damper was situated lower and lower on the structure.

Conclusions/Discussion
Every system provided a significant improvement over not having any control mechanisms at all, indicating the importance of vibration control during earthquakes. The experiment also demonstrated the importance of a holistic approach to earthquake management; the base isolator and mass damper interacted at times, affecting each. When used together, a mass damper located near the bottom of the structure interfered with the base isolator, allowing more sway than the isolator alone. When located at the top, it was able to nearly eliminate the remaining sway not prevented by the isolator. When used alone, the mass damper was ineffective when located at the top; the amount of sway near the highest point of a building was simply too much for the damper to compensate for. Instead, it was most effective near the bottom, where the building was moving less. Without the distinction between combined and separate mechanism, earthquake management strategies can work to each other's detriment, ultimately destabilizing the structure.

Summary Statement
This project determines the most effective combination and configuration of earthquake-control strategies to find the ideal earthquake protection system for a structure.

Help Received
Father provided advice for the construction of the apparatus.