

University Consortium on Instructional Shake Tables



MDOF System: Vibration Absorber

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Objective

Design and validate the performance of a vibration absorber by observing and comparing the responses of the system with and without the vibration absorber. You will be provided with the measured responses of the structure without the vibration absorber. You will obtain the measured responses of the structure with your vibration absorber.

Experiment Background Information

The multiple degree of freedom, MDOF, system consists of a two story building model, with a vibration absorber, which is driven by an instructional shake table. The shake table provides an acceleration input to the structural system. An accelerometer is placed on the moving surface of the shake table to measure the input forcing function, and another accelerometer is attached to each of the floors of the building model to measure the output response function. The acceleration of the third degree of freedom, the vibration absorber, is not measured.

Read your textbook regarding free and forced responses of multiple degree of freedom systems for a more thorough explanation of the mathematical model.

UCIST Background Information

This experiment is to be conducted using several cyberinfrastructure tools designed by the Network for Earthquake Engineering Simulation, NEES (<http://nees.org>). You will have the ability to control the instructional shake table remotely, view the experiment in real time through a webcam, and collect the resulting data for analysis.

A Graphical User Interface, GUI, will enable you to select the frequency and amplitude of the motion of the shake table, and then to start the motion. The video of the resulting motion and the data obtained from the two integrated circuit DC accelerometers will then be automatically streamed from the server to your remote computer using the Ring Buffered Network Bus, RBNB. The video and data will then be available for you to store through the use of the real-time data viewer, RDV.

Prior to the Lab

1. Create a simplified mass spring mathematical model of the structure without the tuned mass damper, TMD.
2. Using the structural parameters (i.e. mass, stiffness, etc.) provided by your instructor, develop the equation of motion of this undamped system.
3. Validate this model by comparing the predicted response from the equation of motion with the undamped response provided by the instructor.
 - Do the natural frequencies match?
 - Are the maximum response amplitudes similar to what was expected?



Fig. 1. Shake Table Lab Station.

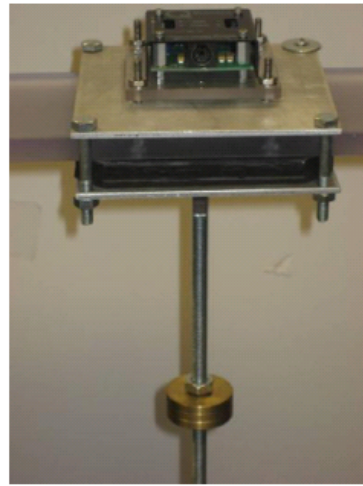


Fig. 2 Vibration Absorber.

4. Next, develop the equation of motion for the model with the TMD.

Note: As an initial assumption, the TMD may be modeled as a simple pendulum attached to the mass of the second floor.

5. Design the TMD to reduce the response of the test structure.

Note: Your design of a pendulum type vibration absorber (i.e. its length and mass) must comply with the following physical constraints:

- The pendulum arm itself is fixed to be a steel threaded rod with a length of **19.00 cm** and a diameter of **0.8cm**.

- The mass (based on your design) can be placed on the rod with a maximum permitted length of **17.00 cm** measured from the top of the rod to the center of gravity of the mass.
 - You can select any number of masses between **1 and 5** for your design, each having a mass of **46g** and thickness of approximately **0.50 cm (3/16")**.
 - Two nuts are used to affix the masses to the threaded rod.
 - *Note:* The pendulum arm itself is not massless and therefore must be accounted for in your design.
6. Perform simulations in MATLAB to examine the ability of your design to reduce the responses of the structure. Choose an appropriate input for the simulation for demonstrating the performance of your design.
- Note:* Include the code for this simulation as an appendix in your lab report. Also include figures demonstrating the simulated performance of this system.
7. Send your TMD design to the instructor or assistant running the lab. The number of masses and the position of them on the pendulum *must be emailed by 9am on the day of your lab* so that he/she can set up the proper design before your lab session begins. Your ability to communicate the design clearly to your TA will factor in your grade for this lab.

Procedure

1. Follow the instructions provided in Appendix to open the RDV client from your computer.
2. From the video, sketch the experimental apparatus, test specimen and location of the sensors. Plan on including a clean version of this schematic diagram in your report.
3. Run the system with your vibration absorber design.
4. Set the Ground Motion Parameters in the client GUI to a sinusoid input with a frequency equal to that of the first mode of the primary structural system and an amplitude as indicated below:
 - The first mode frequency should be considered as 1.75 Hz, but use 1.70 Hz to avoid resolution limitations.
 - Use an amplitude of 0.0011 m.
5. Run the excitation. Observe and record the responses.
6. Export the data for the entire response. Refer to the Appendix for help.

7. Repeat steps 4-6 at the frequency corresponding to the second mode of the primary structural system and the same amplitude as indicated below:
 - The second mode frequency should be considered as 4.70 Hz.
 - Use the same amplitude of 0.0011 m.
8. Disconnect the RDV client so that the next user will be able to connect.

Report

The lab report should be a formal report. Organize your report into sections (e.g. Abstract, Introduction, Procedure, Theory, Results, Discussion, Conclusions, References, and Appendices as needed). Write concisely and clearly, and use MATLAB for your plots.

The mass, m , and stiffness, k , of the structure will be provided by your instructor.

Using the data provided to you for the response of the system without the vibration absorber at the two natural frequencies and the data that you obtained during the experiment for the response of the system with the vibration absorber, evaluate your design. Comment on the ability of your design to reduce the vibrations of the primary system.

Appendix

Setting up the Experiment

1. Open the Teleoperation Control Panel at: http://mase.wustl.edu/wusceel/UCIST/MASE431/lab2_page.htm
2. Click on “Click Here to Launch Experiment” and choose “Open.” A window containing Figure 1 will open, indicating everything is working properly.
3. If you cannot view the video and vibration data simultaneously, try manually changing the “Time Scale” from the drop down menu to a larger number.

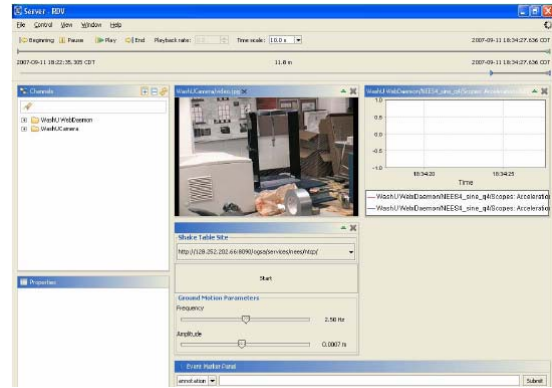


Figure 1 View of the RDV window in operation.

Saving Data

Note: The red data corresponds to accelerometer placed on the shake table. The blue data corresponds to the accelerometer placed at the top of the building.

1. To export the data as a file, follow the path File > Export > Export Data Channels. A window called “Export Data to Disk” will appear.
2. Choose the desired time and select the desired channels. Check only the channels labeled “...a_tbl(g)/1” and “...f1(g)/0.”
3. Select the location to send the obtained data by using the “Browse” button and click on “Export.”
4. A “data.dat” file will be created at the location that you choose containing the data for that run.