CAMBRIDGE UNIVERSITY ENGINEERING DEPARTMENT

ENGINEERING TRIPOS PART IB

INTEGRATED COURSEWORK REPORT

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Date submitted for marking: 11th March 2020 Lab Group: 73

Title: <Using 3 absorbers to reduce all 3 resonances>

Main topic area(s): *(delete as appropriate)* Vibration A1

Marker: .... Date: ....

Please circle one mark in each row:

Technical content mark:	8	7	6	5	4	3	2	1	0
Report quality mark:	8	7	6	5	4	3	2	1	0

Marker's Comments:

Objectives

1. To test the vibration absorber design from the 1A short lab on the model structure. To compare the computer modelled frequency response around resonance with the measured behaviour of the model structure.
2. Tune an absorber at each floor to respond to a different natural frequency of the model structure. To investigate the overall behaviour in response to harmonic loading.
3. To investigate the frequency response before and after the addition of tuned mass damper, explore the effect of damper on wider frequency spectrum.

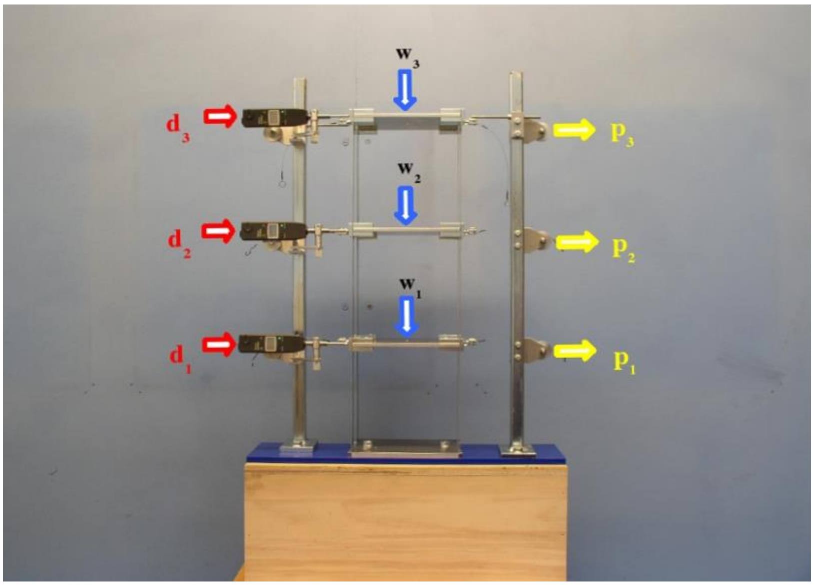

Figure 1. Model structure setup, the basic assumption is that the floors of the model can only move horizontally, consequently it is a three-degree of freedom problem.

Harmonic responses: frequency analysis

An earthquake is simulated by applying a sinusoidal force to the structure at the structure at its ground floor level. We now apply a single sine force input and record the transfer function of the model structure vibration (d1, d2, d3) in response to the sine sweep. (recording time is set long enough to let any initial transient response decay and ensuring that the sampling rate is at or above the Nyquist frequency to avoid aliasing.)

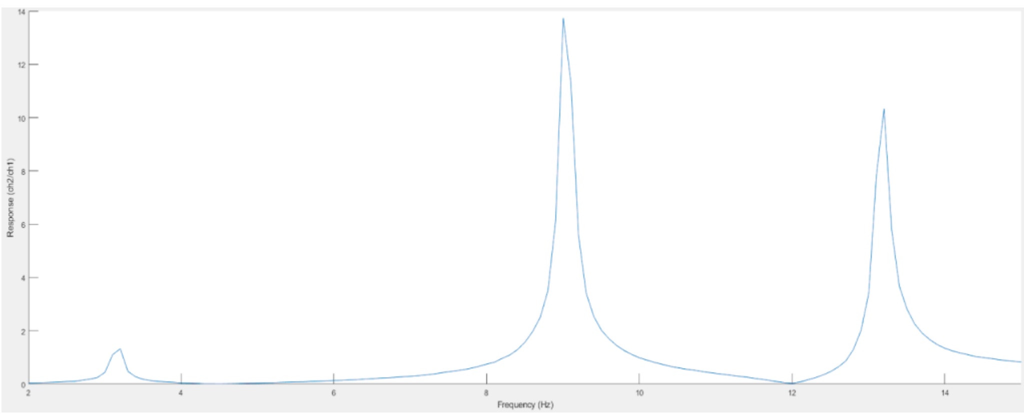

Figure 2. Transfer function of the model structure displacements(with no vibration absorber)

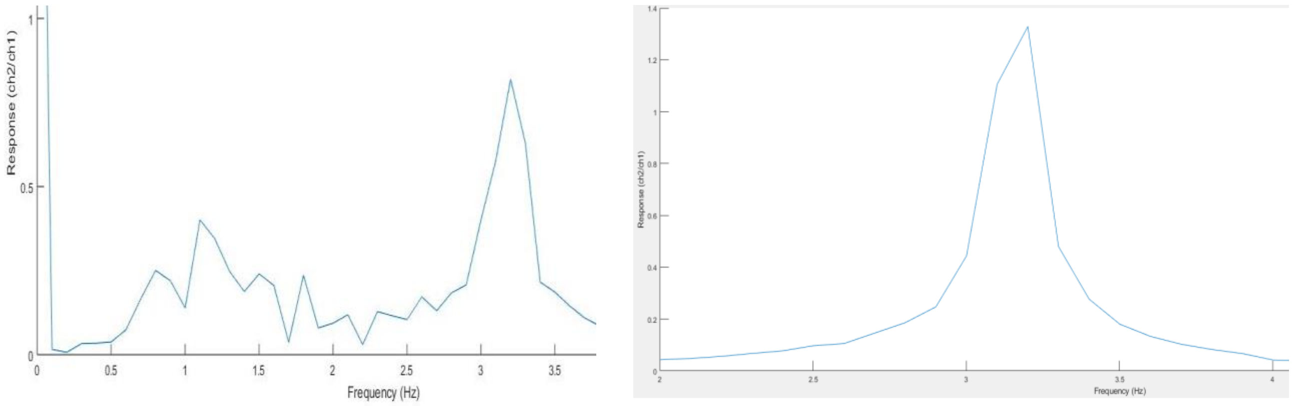

Figure 3. (Left) the fundamental mode of the model structure on its own (without the addition of an absorber); (Right) the frequency response around first resonance with tuned absorber.

It is noticed that although the vibration is damped significantly at the resonate frequency, there are significant but yet smaller peaks to the either side of the old resonance.

Comparing the measured frequency response around first resonance and the previous A1 prediction made by a computer model we notice:

1. In computer simulated model, the ratio of structure displacement magnitude with/without tuned absorber is 0.116; while the same parameter is measured to be 0.57 in our experiment.

(Discussion on possible reasons: the absorbers used in the lab is limited by the moving mass available which are only in 100g, most of the metal joints are highly bent. Therefore, the undamped natural frequency of the absorber in isolation is not the same as the first resonance frequency of the model structure. i.e. the absorbers used for the test is not perfectly “tuned”.)

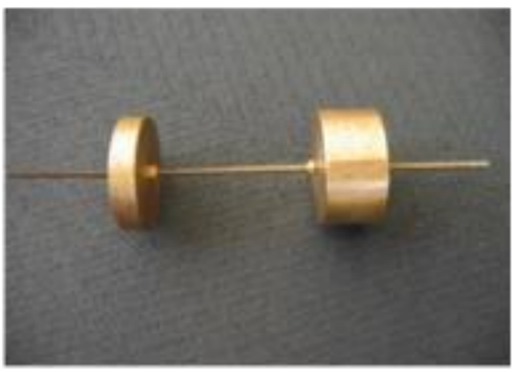

Figure 4. “non perfectly tuned” absorber used on the model structure testing.

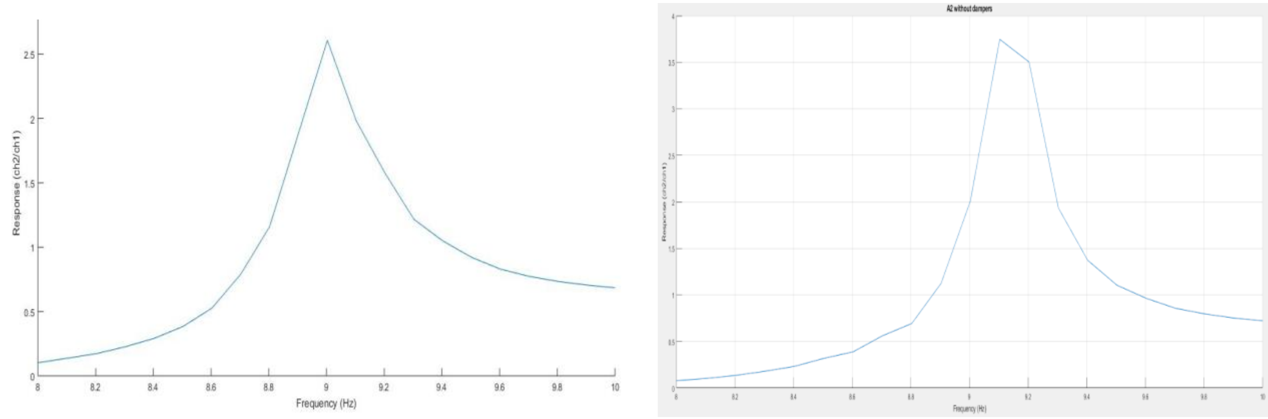

Figure 5. (Left) the mode of the second natural frequency when model structure on its own (without the addition of an absorber); (Right) the frequency response around the second resonance with tuned absorber.

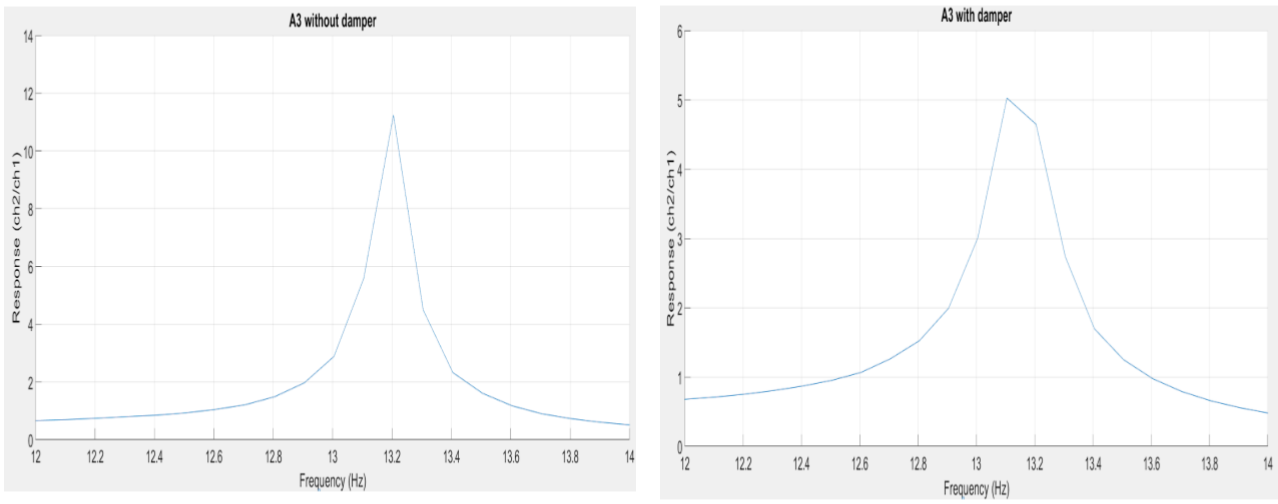

Figure 6. (Left) the mode of the third natural frequency when model structure on its own (without the addition of an absorber); (Right) the frequency response around the third resonance with tuned absorber.

It is noticed that at the third natural frequency, the model structure has the largest undamped vibration amplitude; however, it is also at this frequency, the vibration is the least significantly damped.

In order to determine the effectiveness of each absorber in damping corresponding harmonic frequency response.

We calculate: Amplitude at resonance with absorber/without absorber. The values we obtained:

- First resonance = 0.58
- Second resonance = 0.69
- Third resonance = 0.45

It has been later mentioned by the presentation maker that the plot above does not have enough data point to give further details. It is been suggested that if we further increase the time in data recording, it will result in more data points in the Fourier Transform domain.

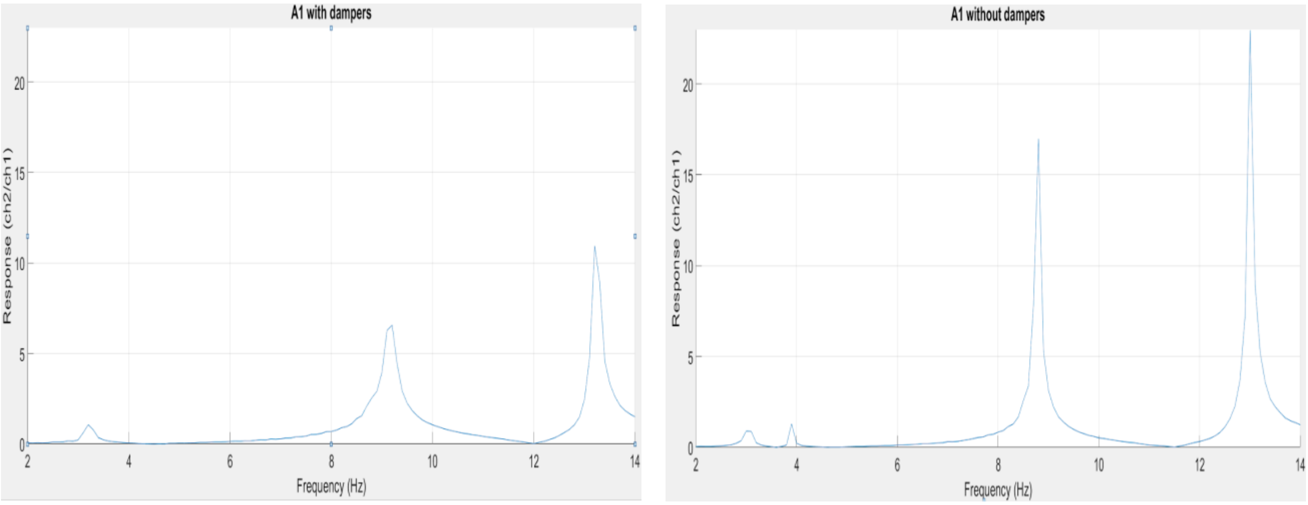

Figure 7. Vibration amplitude of 1st floor of the structure (Fourier transform) before (Right) and after (Left) all three tuned absorbers being applied.

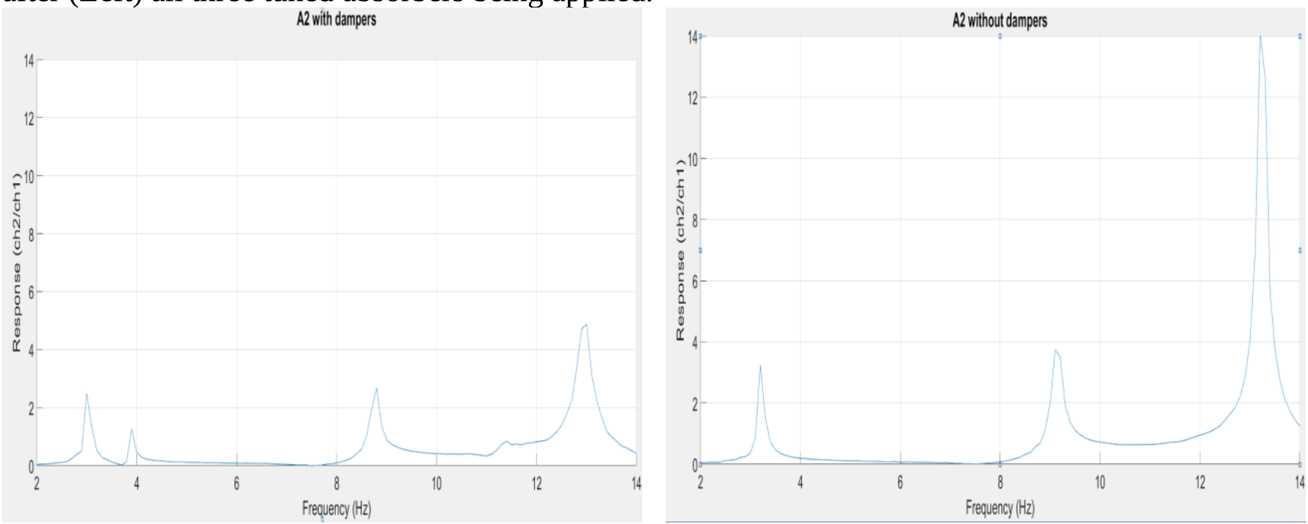

Figure 8. Vibration amplitude of 2nd floor of the structure (Fourier transform) before (Right) and after (Left) all three tuned absorbers being applied.

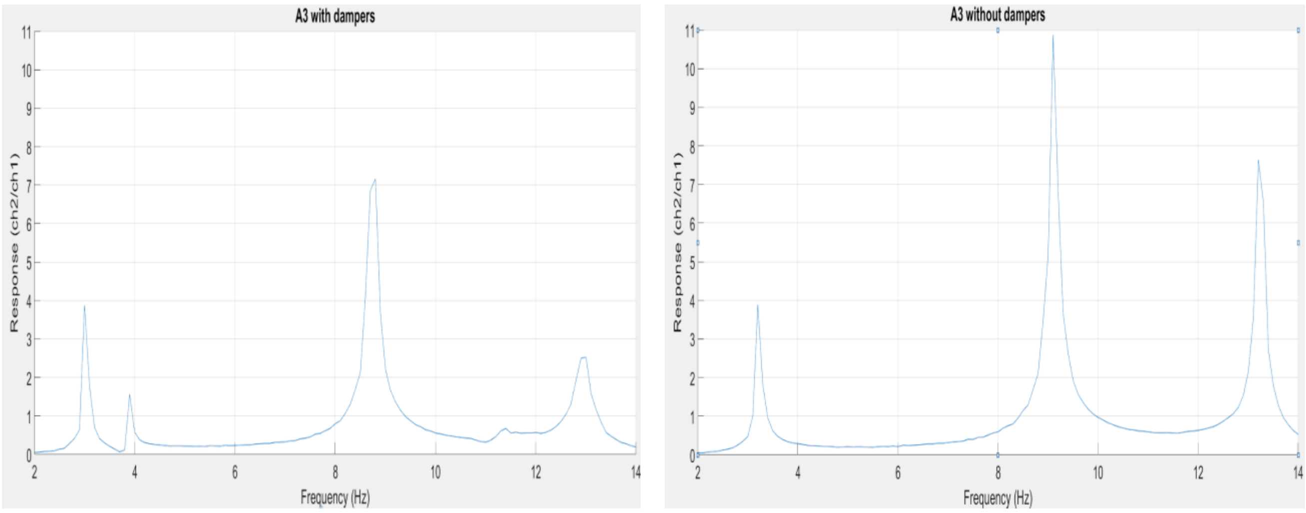

Figure 8. Vibration amplitude of 2nd floor of the structure (Fourier transform) before (Left) and after (Right) all three tuned absorbers being applied.

Conclusions

- We found that although the vibration is damped significantly at the resonant frequency, there are significant peaks to either side of the old resonance. (especially for the first resonance)
- The damping for the first resonance frequency is less significant when all 3 dampers are applied.
- The damping effectiveness for the second and third resonance frequency has changed when dampers applied together than when they applied individually, but remain effective in both cases.