November 5, 2002 Ahmed Elgamal
Earthquake Engineering

Homework

Experimental verification of the linear vibration of a SDOF system based on Webshaker site http://webshaker.ucsd.edu. Note that the installed models exhibit extremely low damping (e.g. ζ = 0.001 or 0.0015, i.e., ζ = 0.1% or 0.15%). Response with higher damping can be assessed based on a calibrated numerical model in which higher damping ratios can be specified by the user.

1) Go to SDOF model and choose sinusoidal input. Using the default values (normalized amplitude = 0.2, input frequency = 4 Hz, and shaking time = 10 sec.):

a) What was the peak relative displacement?

b) Estimate (from the free-vibration time domain response)
   Natural Period, T_n (sec)
   Natural Frequency, f_n (Hz)
   Angular Frequency, ω_n (rad/sec)

c) Go to frequency domain (top floor displacement) and find more accurate value of natural frequency in Hz.

d) Why is there a second prominent peak in the frequency response?

2) Repeat above, but go ahead and shake the system at its resonance and record maximum relative displacement.

Why is the displacement amplitude increasing in every cycle of excitation in this case?

3) Repeat above, but shake at 6 Hz, and record maximum relative displacement. Compare this to its counterpart in 1) and 2) above.

Why are these values so different?

4) repeat above, with a “Beating” response scenario. Choose an excitation frequency that clearly demonstrates this phenomenon. Include the relative displacement figure that you obtained.

(note: you can click on “Save All Graphs” to print a copy or include in your Word file)

5) Go to Webshaker vs. SDOF and select Earthquake-like input. Choose the Loma Prieta (1989), LGPC motion, and push “Select”. When result is shown, scroll down and modify the SDOF natural frequency to be the resonant value, and make the damping very small (as we discussed at the very top, e.g., 0.0015).

You should be getting a good match with these values (please check).

Now, go ahead and change the damping to $\zeta = 0.02$ (i.e., $\zeta = 2\%$ viscous damping). Comment on change in peak displacement, and also on how the (nearly) free vibration phase is affected. Repeat for 5% and 10% damping ratios, and compare to the 2% case.

6) Repeat above for Imperial Valley (1940). Comment on results and include figure showing how unrealistic the very low damping scenario compares with the 2% or higher damping scenarios.

7) <u>Optional:</u> Repeat 6 for Northridge (1994), Rinaldi Receiving Station.