SHAKING TABLE TESTS

Politecnico di Torino – Sede di Alessandria

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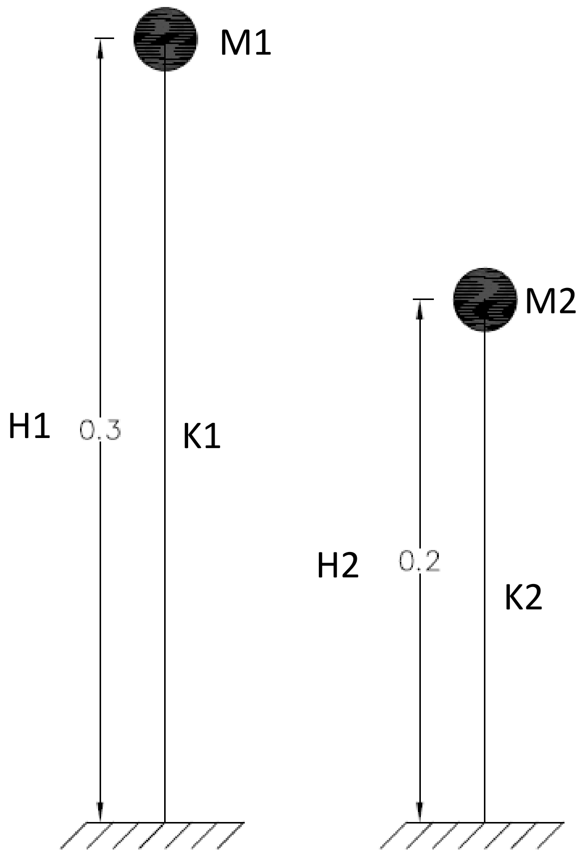
Acknowledgments

- Eng. Franchini Fausto

Case 1: Resonance phenomenon in SDOF models (1)



DATA

$M1 = M2 = 0.21\ kg$

$H1 = 0.3\ m$ $\qquad$ $H2 = 0.2\ m$

$K1 < K2$

$f = w_n/2\pi$ $\qquad$ $w_n = \sqrt{\frac{K}{M}}$

$f1 < f2$

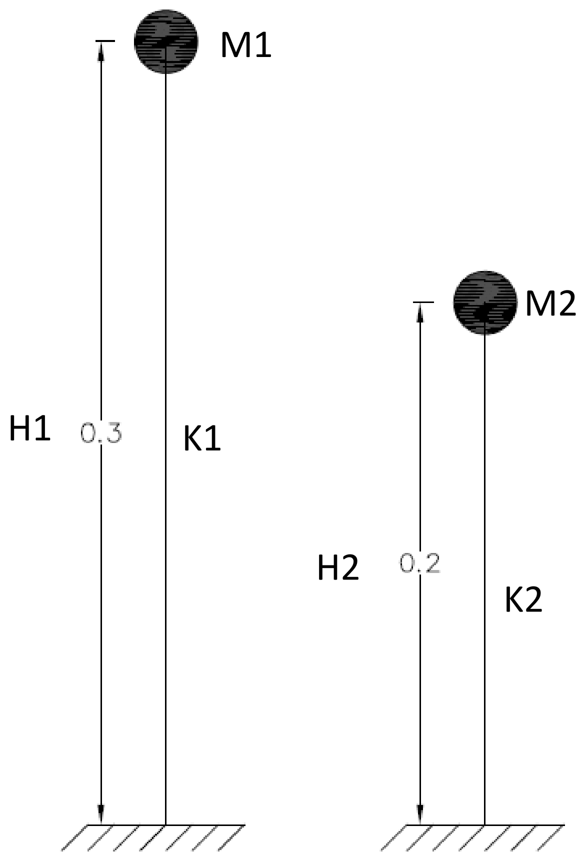
OUTPUT DATA

$f1 = 2.5\ Hz$ $\qquad$ $f2 = 4.3\ Hz$

$(M1, f1) \rightarrow K1 = 51.81\ ^N/_m$

$(M2, f2) \rightarrow K2 = 156.72\ ^N/_m$

Case 2: Resonance phenomenon in SDOF models (2)



DATA

$M1 = 0.21\ kg$

$M2 = M2_0 + M_{extra}$ $\qquad M2_0 = 0.21\ kg$

$H1 = 0.3\ m$ $\qquad H2 = 0.2\ m$

$K1 = 51.81\ ^N/_m$ $\qquad K2 = 156.72\ ^N/_m$

$f1 = 2.5\ Hz$

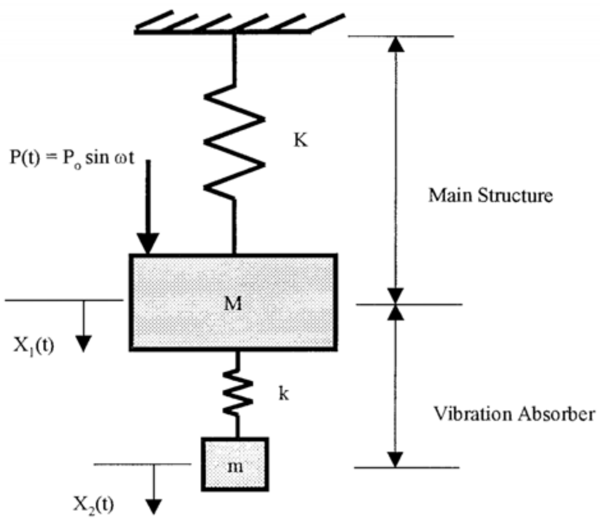
$f = w_n/2\pi$ $\qquad w_n = \sqrt{\frac{K}{M}}$

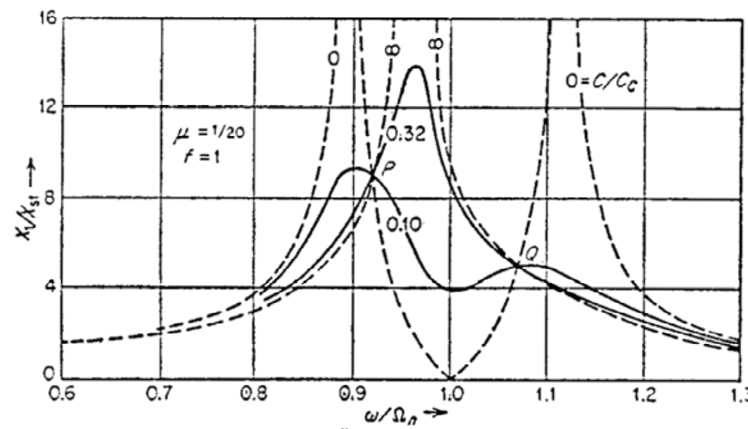
$$f1 = f2 \Rightarrow \frac{K1}{M1} = \frac{K2}{M2} \longrightarrow M2 = \frac{K2 \cdot M1}{K1} = 0.635\ kg$$

$$M_{extra} = M2 - M2_0 = 0.46\ kg$$

Case 3: Resonance phenomenon with Tuned Mass Damper

A **tuned mass damper** is a device (Passive Seismic Control system) mounted in structures to reduce the amplitude of mechanical vibrations. Their application can prevent discomfort, damage or structural failure.





Amplitudes of the main mass for various values of absorber damping (Den Hartog, 1956).

Tuned mass damper Taipei 101 building

Case 4: Resonance phenomenon with base isolation system

A **seismic base isolation system** is a Passive Seismic Control system* which involves the installation of isolators beneath every supporting point of the structure. The isolators, that have a much lower lateral stiffness tan the structure, separate it from the ground. From an energy point of view, the base isolation system limit seismic energy transfer to the structure.

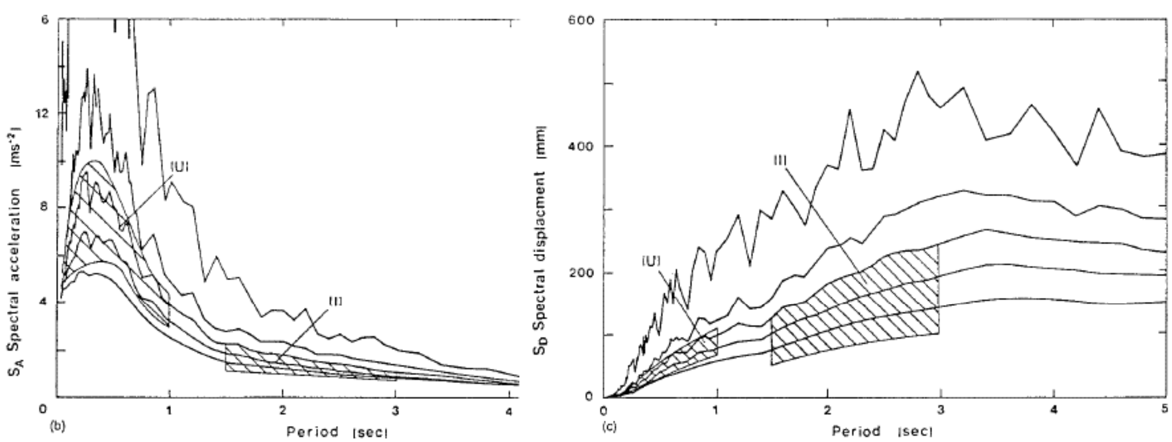
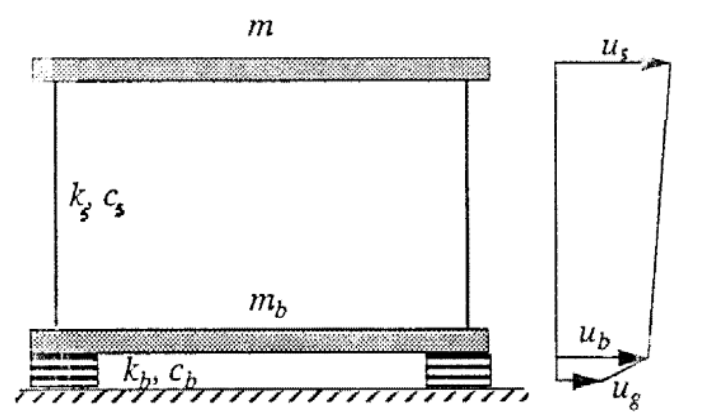


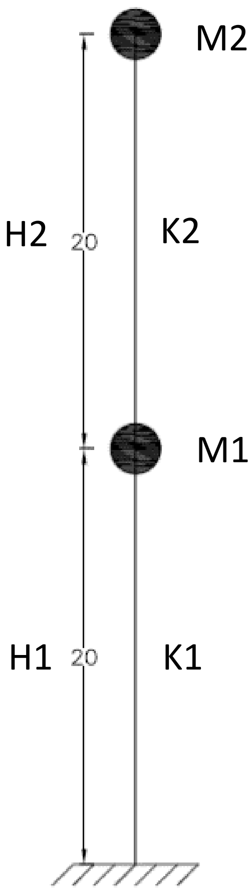
Figure 7.2 Spectral Response of Unisolated (U) and Isolated (I) Structures, Weighted Average of Eight California Records, 0, 2, 5, 10 and 20% damping (Skinner et al., 1993).



Single-Story Structure isolated with a Linear Base Isolation System.

*Passive Seismic Control devices have no feedback capability between them, structural elements and the ground.

Case 5: Resonance phenomenon in a two-story shear frame



DATA

$M1 = M2 = 0.380\ kg$ $\quad H1 = H2 = 0.2\ m$ $\quad K1 = K2 = 121\ ^{N}/_{m}$

Solving by MATLAB

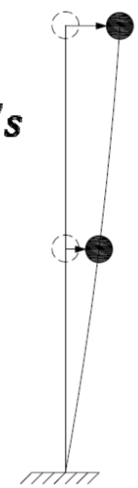
$M = [M] \quad K = [K] \qquad [F,E] = eig(K,M) \xrightarrow{\text{solves}} [K]\{\phi\} = \lambda[M]\{\phi\}$

$$E = \begin{bmatrix} w_1^2 & 0 \\ 0 & w_2^2 \end{bmatrix} \qquad F = \left[\left(\phi_1 \right) \left(\phi_2 \right) \right]$$

$w_1 = 11.02\ rad/s$

$f_1 = 1.75\ Hz$

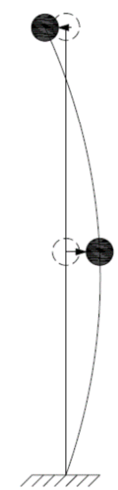
$$\phi_1 = \begin{pmatrix} 1.000 \\ 1.618 \end{pmatrix}$$



$w_2 = 28.87\ rad/s$

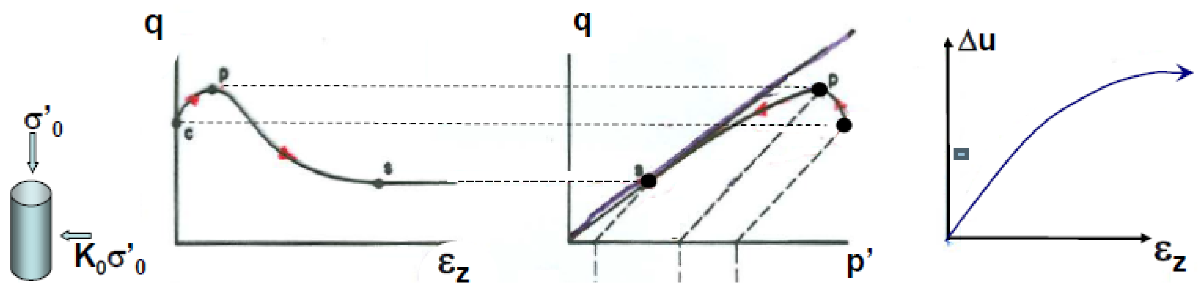
$f_2 = 4.59\ Hz$

$$\phi_2 = \begin{pmatrix} 1.000 \\ -0.618 \end{pmatrix}$$



SOIL LIQUEFACTION

Soil liquefaction: describes a phenomenon where by a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied stress, usually earthquake shaking or other sudden change in stress condition, causing it to behave like a liquid.



$$\begin{cases} p=(\sigma_z+\sigma_3)/2 \\ q=(\sigma_z-\sigma_3)/2 \end{cases}$$

1964 Niigata (Japan) earthquake

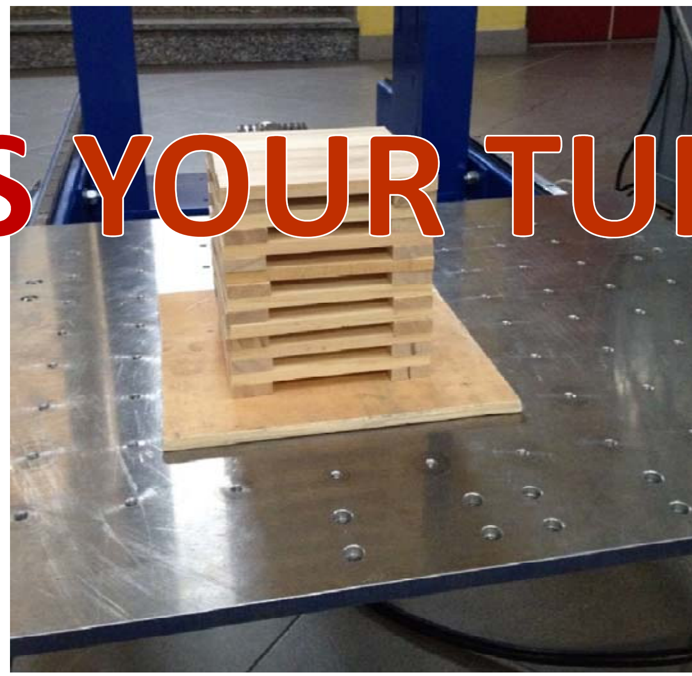
2011 Christchurch (New Zealand) earthquake

SOIL LIQUEFACTION

SEISMIC DESIGN COMPETITION

El Centro earthquake: occurred on May 18th, 1940 in the Imperial Valley in Southern California as a result of a rupture along the Imperial Fault. It was the first major earthquake to be recorded by a strong-motion seismograph located next to a fault rupture and also the strongest recorded earthquake to hit the Imperial Valley with a moment magnitude of 6.9 (6.5 on Richter scale magnitude).

IT’S YOUR TURN!



THANK YOU!