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Chapter 1 Introduction:

There are no problems provided in this chapter, but the instructor can assign case study essay style questions regarding past earthquakes, or performance of specific buildings during one of the earthquakes discussed. Students could then write short essays and make brief presentations of their findings.

Chapter 2 Engineering Seismology Overview:

2.1 A Richter magnitude earthquake of 6.8 would radiate how much more energy than an M_L 5.8 earthquake?

Answer:
Equation 2-2 results in a 32 fold increase in energy radiated for each unit increase in M_L. Therefore, in this case we have one unit increase in M_L, resulting in an increase of 32 times more energy.

2.2 A Richter magnitude earthquake of 5.0 is how much stronger than an M_L3.0 earthquake?

Answer:
The base ten logarithmic scales in Equation 2-1 indicate that each unit increase in M_L corresponds to a tenfold increase of the earthquake wave amplitude. Therefore, in this case we have a two unit increase in M_L resulting in the 5.0 M_L earthquake being 100 (10x10 = 100) times stronger than the 3.0 M_L event.

2.3 Estimate the local magnitude of a southern California earthquake recorded using a standard Wood-Anderson seismograph that shows trace amplitude of 23*mm*, and the P- and S-wave arrival times at the recoding station of 07:19:45 and 07:20:09, respectively.

Answer:
i) The amplitude in millimeters, A is given as 23*mm*.
ii) Determine the time between the arrival of P- and S-waves in seconds, $\Delta t_{p\text{-}s}$.
$\Delta t_{p\text{-}s}$ = 07:20:09 – 07:19:45 = 69*sec* – 45*sec* = 24*sec*
iii) Determine the Richter magnitude, M_L using Equation 2-1.

$$M_L = \log_{10} A + 3\log_{10}(8\Delta t_{p-s}) - 2.92$$
$$= \log_{10}(23mm) + 3\log_{10}(24sec) - 2.92$$
$$= 2.58$$

2.4 An earthquake at a transformed fault caused an average strike-slip displacement of 2.5*m* over an area equal to 80*km* long by 23*km* deep. Assuming the rock along the fault has average shear stiffness of 175*kPa*; estimate the seismic moment and moment magnitude of the earthquake.

Answer:
i) Determine the fault's rupture area, A_f and fault slip, D in centimeters.

$$A_f = (80km)(23km) = (80\text{x}10^5 cm)(23\text{x}10^5 cm) = 18.4\text{x}10^{12} cm^2$$
$$D_s = 2.5m = 250cm$$

ii) Determine the seismic moment, M_0 using Equation 2-5.

$$M_0 = GA_fD_s$$
$$= (3.2\text{x}10^{11} dyne/cm^2)(18.4\text{x}10^{12} cm^2)(250cm)$$
$$= 14.72\text{x}10^{26} dyne\text{-}cm$$

iii) Determine the moment magnitude, M_w using Equation 2-7.

$$M_w = 2/3 \log_{10} M_0 - 10.7$$

$= 2/3 \log_{10} (14.72\text{x}10^{26}\ \textit{dyne-cm}) – 10.7$
$= 7.41$

2.5 Estimate the seismic moment and moment magnitude of the February 27, 2010 Chile earthquake. It is estimated that the thrust fault (the slip plane ends before reaching the Earth's surface) caused an average strike-slip displacement of 5*m* over an area equal to 600*km* long by 150*km* deep. Assume the rock along the fault has average shear rigidity of $3\text{x}10^{11} dyne/cm^2$.

Answer:

i) Determine the fault's rupture area, A_f and fault slip, *D* in centimeters.

$A_f = (600km)(150km) = (600\text{x}10^5 cm)(150\text{x}10^5 cm) = 9\text{x}10^{14} cm^2$

$D_s = 5m = 500cm$

ii) Determine the seismic moment, M_0 using Equation 2-5.

$M_0 = GA_fD_s$
$= (3\text{x}10^{11} dyne/cm^2)(9\text{x}10^{14} cm^2)(500cm)$
$= 1.35\text{x}10^{29} \textit{dyne-cm}$

iii) Determine the moment magnitude, M_w using Equation 2-7.

$M_w = 2/3 \log_{10} M_0 – 10.7$
$= 2/3 \log_{10} (1.35\text{x}10^{29}\ \textit{dyne-cm}) – 10.7$
$= 8.72$

It is worth noting that a magnitude 8.8 M_w was widely reported in the media.

2.6 What is the energy difference between the Haiti and Chile earthquakes from Example 2 and Problem 2.5, respectively?

Answer:

Since Equation 2-2 was calibrated using various types of seismic waves, it is also applicable to magnitude scales other than Richter's. Therefore, Equation 2-2 results in a 32 fold increase in energy radiated for each unit increase in M_w. In this case then we have 8.72 – 6.94 = 1.78 units increase in M_w, resulting in an increase of $32^{1.78} = 478$ times more energy.

Also, using Equation 2-1we can estimate the relative strength of the two events. The base ten logarithmic scales in Equation 2-1 indicate that each unit increase in M_w corresponds to a tenfold increase of the earthquake wave amplitude. Therefore, in this case we have 8.72 – 6.94 = 1.78 units increase in M_w, resulting in the Chilean earthquake being $10^{1.78} = 60$ times stronger than the Haiti event.

Chapter 3 Single Degree-of-Freedom Structural Dynamic Analysis:

3.1 Determine the effective weight at the roof and floor levels for a 60*ft* by 150*ft*, three-story office building with equal story heights of 10*ft* and the following loading:

Roof DL = 20*psf*,
Roof LL = 20*psf*,
Floor DL = 20*psf*,
Floor LL = 60*psf*,
Wall DL = 10*psf*,
Also, the partition load is 10*psf* since the occupancy is designated as office building and the floor live load is less than 80*psf*.

Answer:

i) Calculate individual weights of components tributary to floors and roof.
The weight of the walls is calculated by multiplying the area of the walls with the wall dead load.

Roof (effective height of wall is 5*ft*):

$$W_{walls} = Area_{walls} \cdot \text{Wall DL} = 2(60ft + 150ft)(5ft) \cdot 10psf = 21{,}000lbs$$

Floors (effective height of wall is 10*ft*):

$$W_{walls} = Area_{walls} \cdot \text{Wall DL} = 2(60ft + 150ft)(10ft) \cdot 10psf = 42{,}000lbs$$

The weight of the roof and floor diaphragms is calculated by multiplying the area of the roof or floors with the roof or floors dead load.

Roof:

$$W_{rooflevel} = Area_{roof} \cdot \text{Roof DL} = (60ft)(150ft) \cdot 20psf = 180{,}000lbs$$

Floors:

$$W_{floorlevel} = Area_{floor} \cdot (\text{Floor DL} + \text{partition}) = (60ft)(150ft) \cdot (20psf + 10psf)$$
$$= 270{,}000lbs$$

This problem specifies a live load pressure, which is not included in the seismic weight calculations because it is not a storage load.

ii) The effective seismic weight for the roof and floors can be determined by summing the weight contribution from each of the components.

The effective seismic weight of the roof is denoted as W_3 (3rd level):

$$W_3 = 21{,}000lbs + 180{,}000lbs = 201{,}000lbs = 201kips$$

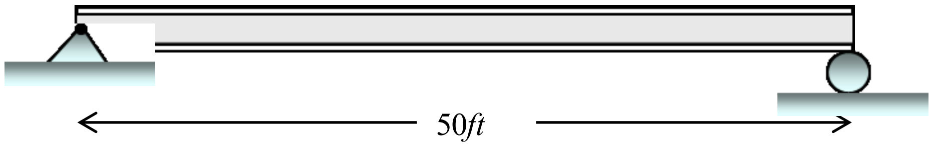
The effective seismic weight of the 2nd level is denoted as W_2:

$$W_2 = 42{,}000lbs + 270{,}000lbs = 312{,}000lbs = 312kips$$

The effective seismic weight of the 1st level is denoted as W_1:

$$W_1 = 42{,}000lbs + 270{,}000lbs = 312{,}000lbs = 312kips$$

3.2 The bridge beam depicted below supports a rigid deck that weighs 200*kips*. Assuming the weight is lumped at midspan, determine the natural frequency and period of the system. (E = 29,000kip/in^2 and I_x = 13,000in^4).



Answer:

i) Idealize the structural system.
The weight of the beam is considered negligible with respect to the weight of the bridge deck. Also, consider only the vertical displacement of the beam.

ii) Determine the stiffness prarmeters.
From Example 3, the stiffness of the SDOF system is,

$$k = \frac{48EI}{L^3} = \frac{48(2.9\times10^7\ psi)(13{,}000 in^4)}{(50\,ft \times 12\,\frac{in}{ft})^3} = 83{,}778\,\frac{lb}{in}$$

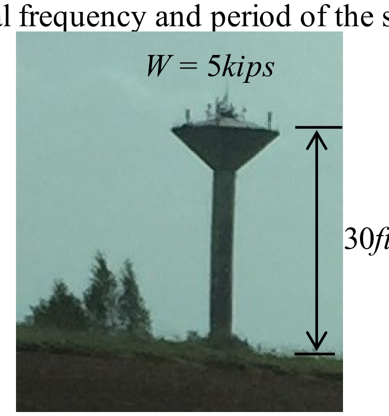
iii) Determine the natural frequency and period of the system.
Since the bridge is modeled as a SDOF system, the equation of motion is described by Equation 3.1. The natural frequency of bridge is determined using Equation 3.2.

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{83{,}778\,\frac{lb}{in}}{\left(\dfrac{200{,}000 lb}{32.2\,\frac{ft}{s^2}\times 12\,\frac{in}{ft}}\right)}} = 12.72\,\frac{rad}{s}$$

The natural period of vibration is determined using Equation 3.5.

$$T_n = \frac{2\pi}{\omega_n} = \frac{2\pi}{12.72\,\frac{rad}{s}} = 0.49\sec$$

3.3 Given a water tank supported on a slender (I = 10,000in^4), concrete (E = 3x$10^7 psi$) column as shown, determine the natural frequency and period of the system.



Answer:

i) Idealize the structural system.
The weight of the column is considered negligible with respect to the weight of the water tank. Also, consider only the horizontal displacement of the water tank.

ii) Determine the stiffness prarmeters.