Question 3: Solution

24 February 2022 15:28

Question #3 [15]	CE629A	C. Kolay, IITK	2

a)

$W = 250\ kN$, $F = 10\ kN$, $\Delta = 2.5mm$

$k = F/\Delta = \frac{10 kN}{2.5 mm} = 4000\ kN/m$ +2

$m = \frac{W}{g} = \frac{250 kN}{9.81} = 25492.9\ kg$

$T_n = 2\pi \sqrt{\frac{m}{k}} = 2\pi \sqrt{\frac{25492.9}{4000}} = 0.502\ sec. \Rightarrow \omega_n = \frac{2\pi}{T_n} = 12.526\ rad/sec$ +3

b) $PGA = 0.4g$, PGA in figure is $1g \Rightarrow$ Scale factor $= \frac{0.4g}{1g} = 0.4$ +1

i) Elastic case ($\mu = 1$):

From Fig-1 $V_y = 80 \times 0.4\ in/sec \Rightarrow A_y = \omega_n V_y = 1.038g$ +1

Design force $F_y = \frac{A_y}{g} \cdot W = 259.60\ kN$ +2

Peak deformation $u_m = \mu \cdot u_y = \mu \cdot \frac{A_y}{\omega_n^2} = 2.554 in. = 64.9\ mm$ +1

ii) Inelastic case ($\mu = 4$):

From figure, $V_y = 20 \times 0.4\ in/sec \Rightarrow A_y = \omega_n V_y = 0.260\ g$ +1

Design force $F_y = \frac{A_y}{g} \cdot W = 64.9\ kN$ +2

Peak deformation $u_m = \mu \cdot \frac{A_y}{\omega_n^2} = 2.56\ in = 64.9\ mm$ +2

Observe that $u_m = u_o$, i.e., peak deformations of elastic and elastoplastic systems are identical. This indicates that the "equal displacement rule" is applicable.

Let's check: $R_y = \frac{A_y^{(1)}}{A_y^{(2)}} = \frac{1.298g}{0.324g} = 4.0 = \mu$ as expected.

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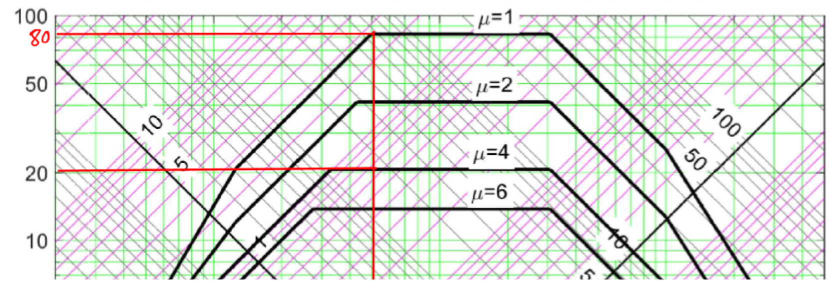

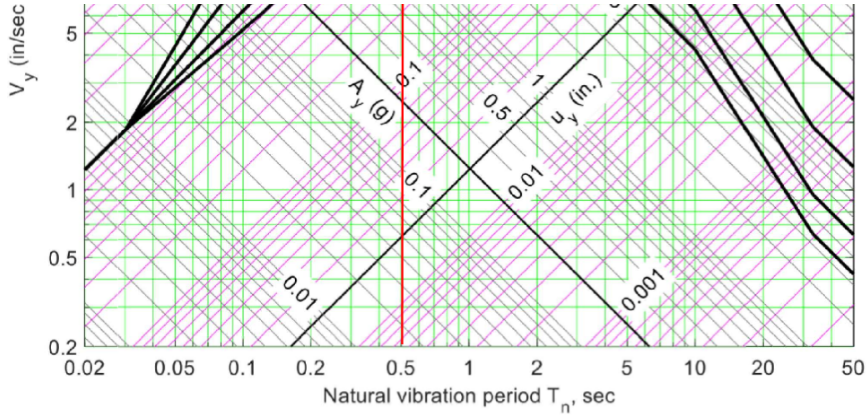

Figure 1: Constant-ductility design spectra for ζ = 5% for Question 4