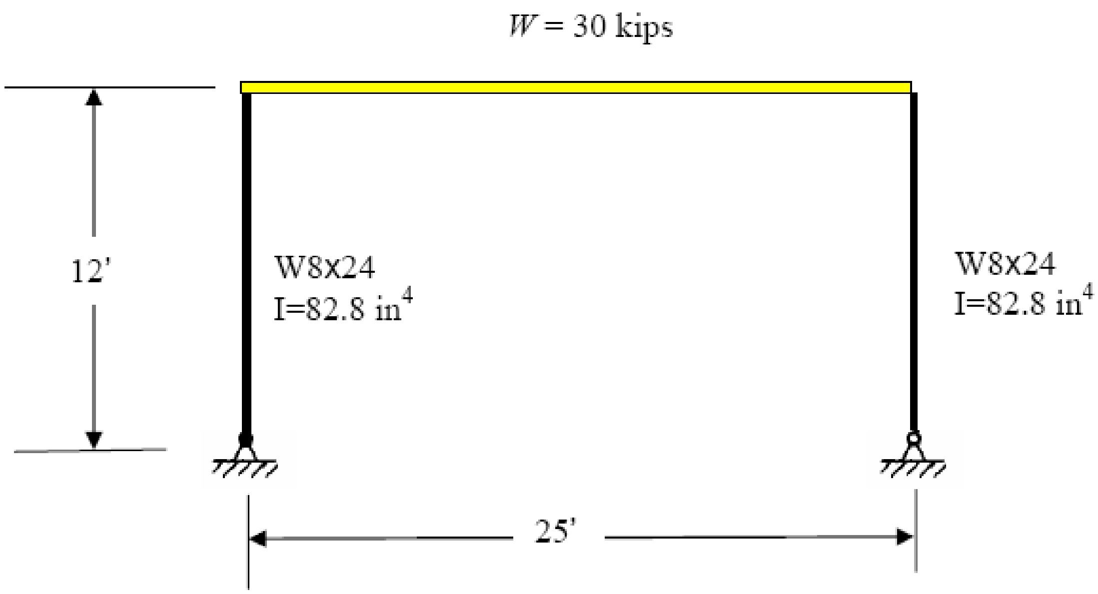
The portal frame in the figure is located in Memphis (35.11 Lat. -89.94 Long.). Compute the confidence levels on having:

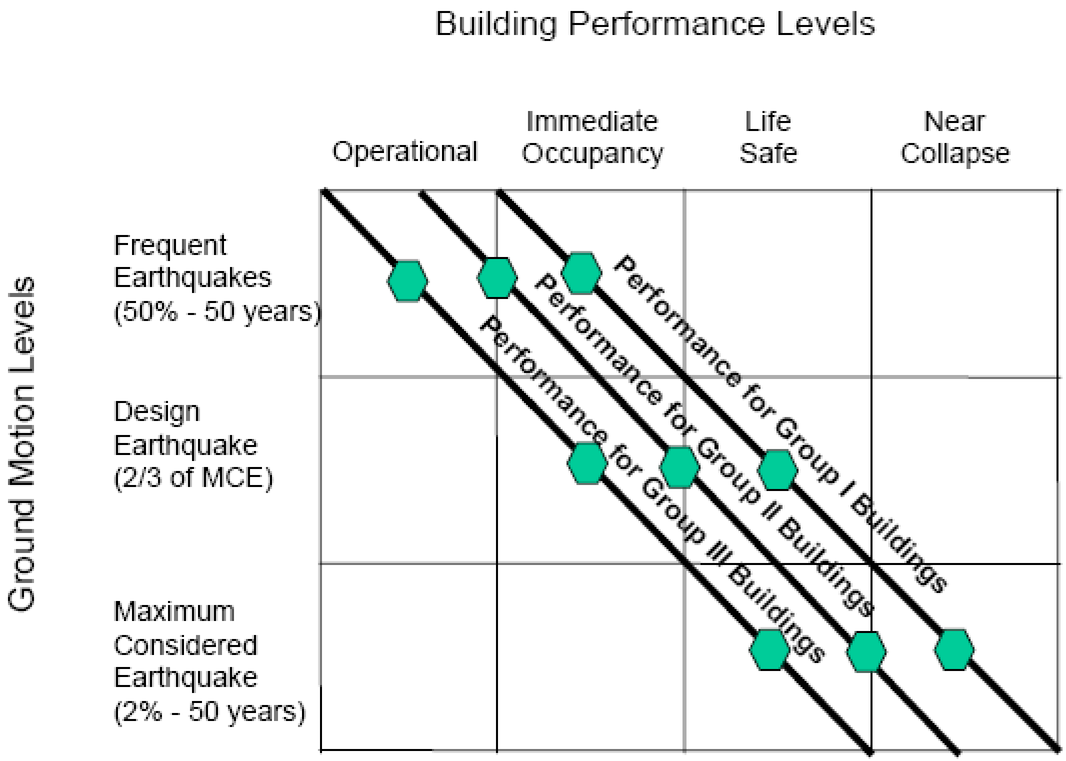
- Less that 5% probability of a performance poorer that Collapse Prevention (CP) in 50 years life cycle of the building, and
- Less that 50% probability of having a performance poorer that Immediate Occupancy (IO) in 50 years.

Use *LSP*.

Assume first mode equivalent damping ratio of 8%. Shear wave velocity at the site is measured 2000 *ft/sec*. Assume post-Northridge pre-qualified dog-bone moment connections in a shear building.



dog bone moment connections or reduced beam section (RBS) imply special moment frames or intermediate moment frames, assuming special moment frames
assuming rigid floor
using elf procedure for lateral loads



Part 2, General data and functions

$ORIGIN := 1 \quad k := 1000lb \qquad Int(x1, y1, x2, y2, x) := \left(\frac{y2 - y1}{x2 - x1}\right) \cdot (x - x1) + y1$

$E_s := 29000 \frac{k}{in^2}$

Part 3, Definition of structure and site.

1 is furthest from ground

$llf := (0)\frac{lb}{ft^2} \qquad frsp := 1ft \quad bay := 25ft \quad nfr := 1 \qquad dlf := (1.2)\frac{k}{ft^2}$

$llwf := llf \cdot frsp \cdot bay \qquad llbrf := \frac{llwf}{2} \qquad dlwf := dlf \cdot frsp \cdot bay \qquad dlbrf := \frac{dlwf}{2}$

$llwf = (0)\,k \qquad llbrf = (0)\,k \qquad dlwf = (30)\,k \qquad dlbrf = (15)\,k$

$F_y := 50 \frac{k}{in^2}$ $R_y := 1.1$ $Z_{xc} := 23.2in^3$

$h := (12)ft$ $bldg_{height} := \sum_{i=1}^{length(h)} h_i$ $bldg_{height} = 12\,ft$

Seismic force resisting system (SFRS), SFRS := "Special Steel Moment Frames"

$v_s := 2000 \frac{ft}{sec}$ LOC := "Memphis, Tennessee" $\zeta := 0.08$

lat := 35.11 lon := −89.94

$I_c := (82.8)\cdot in^4$ $mf := \frac{dlwf}{g}$ $mf = (0.078)\,k\cdot\frac{s^2}{in}$ $kf := \left(\frac{6\cdot E_s\cdot I_c}{h^3}\right)$ $kf = (4.825)\frac{k}{in}$

Part 4, General Code information:

Chapter 1, General Provisions

1.2 Occupancy importance factor (pg 4)

Seismic Use Group (enter as integer): SUG := 1

1.3 Occupancy importance factor (pg 5)

$$I_f := \begin{cases} 1.0 & \text{if } SUG = 1 \\ 1.25 & \text{if } SUG = 2 \\ 1.5 & \text{otherwise} \end{cases}$$

$I_f = 1$

1.4 Seismic Design catagory (SDC) (pg 5)

Determination of SDS and SD1 from chapter 3 of code:

Ss and S1, section 3.3.1 (pg 19), Figures 3.3-1 through 3.3-14 (pgs 20 to 37), or USGS website

LOC = "Memphis, Tennessee" lat = 35.11 lon = −89.94

$S_s := 1.166g$ $S_1 := 0.325g$

Sms and Sm1, section 3.3.2 (pg 19)

Site class, section 3.5 (pg 47) $v_s = 2 \times 10^3 \frac{ft}{s}$

SiteClass := "C"

Fa and Fv from tables 3.3-1 and 3.3-2 (pgs 19 and 38, respectively)

$F_a := 1.0$ $F_a = 1$

$F_v := Int\left(0.3, 1.5, 0.4, 1.4, \frac{S_1}{g}\right)$ $F_v = 1.475$

$S_{MS} := F_a \cdot S_s$ Eq. 3.3-1 $S_{MS} = 1.166\,g$

$S_{M1} := F_v \cdot S_1$ Eq. 3.3-2 $S_{M1} = 0.479\,g$

$S_{DS} := \frac{2}{3} \cdot S_{MS}$ Eq. 3.3-3 $S_{DS} = 0.777\,g$

$S_{D1} := \frac{2}{3} \cdot S_{M1}$ Eq. 3.3-4 $S_{D1} = 0.32\,g$

$SDC_1 :=$ "D" Based on Table 1.4-1, (pg 6)

$SDC_2 :=$ "D" Based on table 1.4-2, (pg 6)

$$SDC := \begin{cases} \text{"E"} & \text{if } (SUG = 1 \lor SUG = 2) \land \frac{S_1}{g} \ge 0.75 \\ \text{"F"} & \text{if } SUG = 3 \land \frac{S_1}{g} \ge 0.75 \\ \max(SDC) & \text{otherwise} \end{cases}$$

Seismic design Category:

SDC = "D"

Note: may follow procedures of section 1.5 (pg 6) if seismic design category is A

Chapter 2 is based on quality assurance
Chapter 3, Ground Motion

3.2.1, Site Class (pg 19) SiteClass = "C"

3.2.2, Procedure selection: General Procedure

3.3.1, Mapped Acceleration parameters. $S_s = 1.166\,g$ $S_1 = 0.325\,g$

3.3.2, Site coefficients and adjusted accelerration parameters.

$F_a = 1$ $F_v = 1.475$ $S_{MS} = 1.166\,g$ $S_{M1} = 0.479\,g$

3.3.3, Design acceleration parameters (pg 38)

$S_{DS} = 0.777\,g$ $S_{D1} = 0.32\,g$

3.3.4, Design response spectrum

$T := 0sec, 0.001sec .. 15sec$ $T_L := 12sec$ T.L given in figures 3.3-16 through 3.3-21 on pages 40 through 45

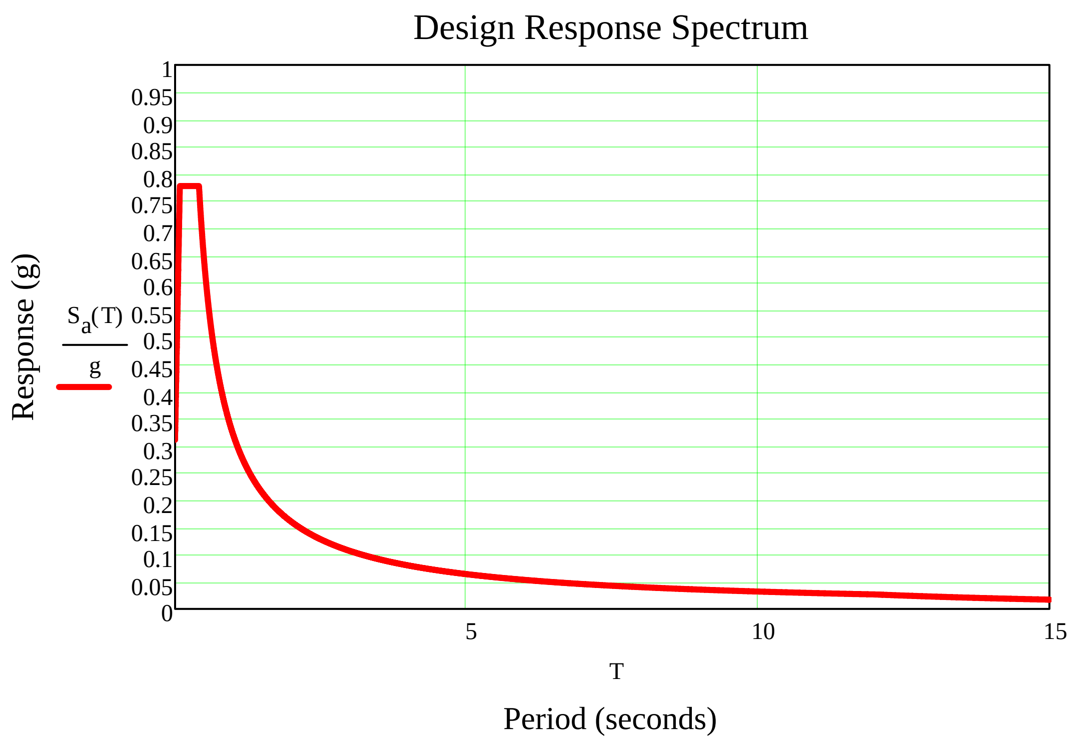
$T_S := \frac{S_{D1}}{S_{DS}} \cdot sec$ $T_S = 0.411\,s$ $T_0 := 0.2 \cdot T_S$ $T_0 = 0.082\,s$

$$S_a(T) := \begin{cases} 0.6\cdot\frac{S_{DS}}{T_0}\cdot T + 0.4\cdot S_{DS} & \text{if } T \le T_0 \\ S_{DS} & \text{if } T_0 < T \le T_S \\ \frac{S_{D1}\cdot sec}{T} & \text{if } T_S < T \le T_L \\ \frac{S_{D1}\cdot T_L\cdot sec}{T^2} & \text{otherwise} \end{cases}$$

Eq. 3.3-5

Eq. 3.3-6

Eq. 3.3-7



3.5.1 Site classification for seismic design (pg 47) SiteClass = "C"

Chapter 4, Structural design Criteria

4.2.2 Combination of Load effects (pg 54), will be incorporated after loads are calculated

4.3 Seismic Force Resisting System (pg 55)

4.3.1 Selection and limitations, Table 4.3-1 (pgs 56 to 60)

SFRS = "Special Steel Moment Frames" SDC = "D"

$R_f := 8$ $\Omega_0 := 3$ $C_d := 5.5$

Detailing reference section: AISC Seismic, Part I, Sec. 9

Limitations based on Seismid Design Category: NL

Table 4.3-2 Plan Structural Irregularities (pg 64): $SDC = \text{"D"}$

No plan structural irregularities noted. $PSI := \text{"None"}$

Table 4.3-3 Vertical Structural Irregularities (pg 65)

No vertical structural irregularities noted. $VSI := \text{"None"}$

4.3.3 Redunancy

$r_{max.x} := 0.33$ $\rho := \min\left(\max\left(2 - \dfrac{20}{r_{max.x}\cdot\sqrt{\dfrac{bay}{ft}\cdot\dfrac{frsp}{ft}\cdot nfr}}, 1\right), 1.5\right)$ $\rho = 1$

(From 1997 Provisions, chapter 5, pg 55)

Table 4.4-1 Analysis Procedures

$SDC = \text{"D"}$ $PSI = \text{"None"}$ $VSI = \text{"None"}$

5.2.2.1 Approximate Fundamental Period (pg 88)

Table 5.2-2 Approximate period parameters (pg 88)

$C_r := 0.028$ $x_f := 0.8$

$T_a := C_r\cdot\left(\dfrac{bldg_{height}}{ft}\right)^{x_f}\cdot sec$ $T_a = 0.204\ s$

From Table 5.2-1 (pg 88) $S_{D1} = 0.32\ g$

$C_u := 1.4$

$T_{max} := C_u\cdot T_a$ $T_{max} = 0.286\ s$ $3.5\cdot T_S = 1.439\ s$

Tmax < 3.5Ts and no irregularities noted, All design procedures are permitted.

Table 4.5-1, Allowable Story Drift

$SUG = 1$ $SFRS = \text{"Special Steel Moment Frames"}$

$h = (12)\ ft$

$ASD_f := 0.025$

$ASD := ASD_f\cdot h$ $ASD = (3.6)\ in$

First Analysis by Response Spectrum Procedure of FEMA 302

5.3 Response Spectrum Procedure (pg 92)

5.3.2 and 5.3.3 modes and modal properties (pg 92)

$$mf = (0.078)\,\frac{k\cdot s^2}{in} \qquad kf = (4.825)\,\frac{k}{in}$$

$$M := mf_1 \qquad K := kf_1$$

$$\omega := \sqrt{\frac{K}{M}} \qquad \omega = 7.88\,\frac{1}{s} \qquad T := 2\cdot\frac{\pi}{\omega} \qquad T = 0.797\,s \qquad f := \frac{1}{T} \qquad f = 1.254\,\frac{1}{s}$$

only one lateral mode, 100% of modal mass accounted for

5.3.4 Modal base shear, pg 92

$$C_s := \frac{S_a(T)}{\frac{R_f}{I_f}} \qquad C_s = 0.05\,g$$ Eq. 5.3-3, pg 93

$$w := dlwf \qquad w = (30)\,k \qquad W := w \qquad W = (30)\,k$$

$$V_m := \frac{C_s}{g}\cdot W \qquad V_m = (1.503)\,k$$ Eq. 5.3-1 $$tm := \sum_{i=1}^{1} mf_i \qquad tm = 0.078\,\frac{k\cdot s^2}{in}$$

$$mf = (0.078)\,\frac{k\cdot s^2}{in}$$

Mode 1:

Eq. 5.3-7, pg 94 Eq. 5.3-6, pg 94

$$C_{vx1} := C_s$$

$$C_{vx1} = 1.612\,\frac{ft}{s^2} \qquad F_{x1} := \frac{C_{vx1}}{g}\cdot V_{m_1} \qquad F_{x1} = 0.075\,k$$

5.3.6, Modal story shears and moments

$V_{x1} := (F_{x1})$ $\qquad M_{x1} := (F_{x1} \cdot h_1)$

$V_{x1} = (0.075)\,k$ $\qquad M_{x1} = (0.904)\,k \cdot ft$

$\delta_{xe1} := \left(\frac{g}{4 \cdot \pi^2}\right) \cdot \left(\frac{T^2 \cdot F_{x1}}{w}\right)$ $\qquad \delta_{xe1} = (0.016)\,in$ Eq. 5.3-9, pg 94

$\delta_{x1} := \frac{C_d \cdot \delta_{xe1}}{I_f}$ $\qquad \delta_{x1} = (0.086)\,in$ Eq. 5.3-8, pg 94

5.3.7 Design values (combination of modes) pg 94:

Using cqc combination so that it will not be necessary to check against spread of periods or make a determination of what is considered too much or too little spread in the data.

no combination of modes here as there is only one mode

$F_{xm} := (F_{x1})$ $\quad V_{xm} := (V_{x1_1})$ $\quad M_{xm} := (M_{x1_1})$ $\quad \delta_{xm} := (\delta_{x1_1})$

Comparison with ELF procedure

$T = 0.797\,s$ $\quad T_{max} = 0.286\,s$ $\quad T_{elfc} := \min(T, T_{max})$ $\quad T_{elfc} = 0.286\,s$

$$C_{selfc} := \max\left[\min\left[\frac{S_{DS}}{\frac{R_f}{I_f}}, \begin{cases} \frac{S_{D1}}{\frac{T_{elfc}}{sec}\cdot\left(\frac{R_f}{I_f}\right)} & \text{if } T_{elfc} \le T_L \\ \frac{S_{D1}}{\left(\frac{T_{elfc}}{sec}\right)^2 \cdot \left(\frac{R_f}{I_f}\right)} & \text{otherwise} \end{cases}\right] \cdot \frac{1}{g}, 0.01\right]$$

Eq. 5.2-2

Eq. 5.2-3

Eq. 5.2-4

$C_{selfc} = 0.097$

$S_1 = 0.325\,g$

$$C_{selfc} := \begin{cases} C_{selfc} & \text{if } \frac{S_1}{g} < 0.6 \\ \max\left(C_{selfc}, \frac{0.5 \cdot S_1 \cdot I_f}{R_f \cdot g}\right) & \text{otherwise} \end{cases}$$

Eq. 5.2-5

$C_{selfc} = 0.097$

$bld_w := W$ $bld_w = (30)\,k$ bld.w represents one frame only

$V_{elfc} := C_{selfc} \cdot bld_w$ $V_{elfc} = (2.915)\,k$

Base shear from elf procedure: $V_{elfc} = (2.915)\,k$

Base shear from modal analysis: $V_{xm_1} = 0.075\,k$

$elfc_f := \max\left(0.85 \cdot \frac{V_{elfc}}{V_{xm_1}}, 1\right)$ $elfc_f = 32.904$

$F_{xm} := elfc_f \cdot F_{xm}$ $V_{xm} := elfc_f \cdot V_{xm}$ $M_{xm} := elfc_f \cdot M_{xm}$ $\delta_{xm} := elfc_f \cdot \delta_{xm}$

$F_{xm} = (2.478)\,k$ $V_{xm} = (2.478)\,k$ $M_{xm} = (29.733)\,k \cdot ft$ $\delta_{xm} = (2.824)\,in$

5.3.10 P-delta effects, determine P-delta in accordance with 5.2.6, determine drift limits in accordance with 5.2.6.1

5.2.6.1 Story drift determination (pg 91)

$F_{xm} = (2.478)\,k$ $kf = (4.825)\,\frac{k}{in}$ $C_d = 5.5$ $I_f = 1$ $nfr = 1$

$V_{xm} = (2.478)\,k$ $\delta_{xm} = (2.824)\,in$ $\delta_{xmt} := \left(\delta_{xm_1}\right)$ $\delta_{xmt} = (2.824)\,in$

$\Delta := \left(\delta_{xm_1}\right)$ $\Delta = (2.824)\,in$ $ASD = (3.6)\,in$

$drift_{status} :=$ | "DRIFT OK" if $\Delta_1 \le ASD_1$
| "EXCEEDS ALLOWABLE DRIFT LIMITS" otherwise

$drift_{status} =$ "DRIFT OK"

5.2.6.2 P-delta limit (pg 91)

$llcrf := \left(llbrf_1\right)$ $llcrf = (0)\,k$ $dlcrf := \left(dlbrf_1\right)$ $dlcrf = (15)\,k$

$P_x := llcrf + dlcrf + \frac{V_{xm} \cdot h}{bay}$ $P_x = (16.189)\,k$

$$\theta := \frac{P_x \cdot \Delta_1 \cdot I_f}{\frac{V_{xm_1}}{2} \cdot h_1 \cdot C_d} \qquad \theta = (0.047)$$

All θ less than 0.1, P-delta limit ok.

$$Pdelta_{status} := \begin{cases} \text{"OK"} & \text{if } \theta_1 < 0.1 \\ \text{"Must check P-delta"} & \text{otherwise} \end{cases} \qquad Pdelta_{status} = \text{"OK"}$$

Axial: Unfactored Loads at column bases, positive force is downward force:

Seismic Loadeffect of section 4.2.2.1 (pg 55) $\rho = 1$ $S_{DS} = 0.777\,g$

$$Q_E := \frac{\sum_{i=1}^{1} \left(h_1 \cdot F_{xm_1}\right)}{bay} \qquad Q_E = 1.189\,k \qquad D := \sum_{i=1}^{1} dlbrf_i \qquad D = 15\,k$$

Seismic Load effect:

$$E_p := \rho \cdot Q_E + 0.2 \cdot \frac{S_{DS}}{g} \cdot D \qquad E_p = 3.521\,k$$

$$E_n := -\rho \cdot Q_E + 0.2 \cdot \frac{S_{DS}}{g} \cdot D \qquad E_n = 1.143\,k$$

$$L := \sum_{i=1}^{1} llbrf_i \qquad L = 0\,k \qquad L_r := llbrf_1 \qquad L_r = 0\,k$$

$S := 0 \cdot kip$ $W_p := 0 \cdot kip$ $W_n := 0 \cdot kip$ $H := 0 \cdot kip$

$F := 0 \cdot kip$ $T_f := 0 \cdot kip$ $R := 0 \cdot kip$ (These loads not present or assumed to not control)

Load combinations: $f_1 := 1$

$$Comb := \begin{bmatrix} 1.4(D + F) \\ 1.2 \cdot \left(D + F + T_f\right) + 1.6 \cdot (L + H) + 0.5 \cdot \max\left(L_r, S, R\right) \\ 1.2 \cdot D + 1.6 \cdot \max\left(L_r, S, R\right) + \max\left(f_1 \cdot L, 0.8 \cdot W_p\right) \\ 1.2 \cdot D + 1.6 \cdot W_p + f_1 \cdot L + 0.5 \cdot \max\left(L_r, S, R\right) \\ 1.2D + 1.0 \cdot E_p + f_1 \cdot L + 0.2 \cdot S \\ 0.9D + 1.6 \cdot W_n + 1.6H \\ 0.9D + 1.0 \cdot E_n + 1.6H \end{bmatrix} \qquad Comb = \begin{pmatrix} 21 \\ 18 \\ 18 \\ 18 \\ 21.521 \\ 13.5 \\ 14.643 \end{pmatrix} k$$

$P_{max} := \max(Comb)$ $P_{max} = 21.521\,k$ $P_{min} := \min(Comb)$ $P_{min} = 13.5\,k$

Bending: loads due to horizontal reaction at base, assuming columns share load equally, and assuming colums are fixed at the base:

$$E := \frac{\sum_{i=1}^{1} F_{xm_i}}{2} \cdot \frac{h_1}{2} \qquad E = 7.433\,k \cdot ft$$

$D := 0 \cdot kip$ $L := 0 \cdot kip$ $L_r := 0 \cdot kip$ $S := 0 \cdot kip$ $W := 0 \cdot kip$ $H := 0 \cdot kip$

$F := 0 \cdot kip$ $T_f := 0 \cdot kip$ $R := 0 \cdot kip$ (These loads not present or assumed to not control)

Load combinations: $f_1 := 1$

$$Comb := \begin{bmatrix} 1.4(D + F) \\ 1.2\cdot(D + F + T_f) + 1.6\cdot(L + H) + 0.5\cdot\max(L_r, S, R) \\ 1.2\cdot D + 1.6\cdot\max(L_r, S, R) + \max(f_1\cdot L, 0.8\cdot W_p) \\ 1.2\cdot D + 1.6\cdot W_p + f_1\cdot L + 0.5\cdot\max(L_r, S, R) \\ 1.2D + 1.0\cdot E + f_1\cdot L + 0.2\cdot S \\ 0.9D + 1.6\cdot W_n + 1.6H \\ 0.9D + 1.0\cdot E + 1.6H \end{bmatrix} \quad Comb = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 7.433 \\ 0 \\ 7.433 \end{pmatrix} k\cdot ft$$

$M_{max} := \max(Comb)$ $M_{max} = 7.433\,k \cdot ft$ $V_{max} := \frac{M_{max}}{0.5\,h_1}$ $V_{max} = 1.239\,k$

Summary of results:

$P_{max} = 21.521\,k$ $P_{min} = 13.5\,k$ $M_{max} = 7.433\,k \cdot ft$ $V_{max} = 1.239\,k$

Part A. Analysis by Fema 350

Response spectrum from Fema 273

From 5% in 50 year hazard maps (2002 data from USGS java applet)

$S_s := 0.6563g \quad S_1 := 0.1683g$

F273, 2.6.1.4, adjustment for site class (pg 2-21)

$SiteClass := \text{"C"}$

$F_a := 1.16 \qquad F_a = 1.16$

$F_v := 1.64 \qquad F_v = 1.64$

$S_{xs} := F_a \cdot S_s \qquad S_{xs} = 0.761\ g \qquad S_{x1} := F_v \cdot S_1 \qquad S_{x1} = 0.276\ g$

F273, 2.6.1.5, general response spectrum

$T_e := 0sec, 0.001sec .. 15sec$

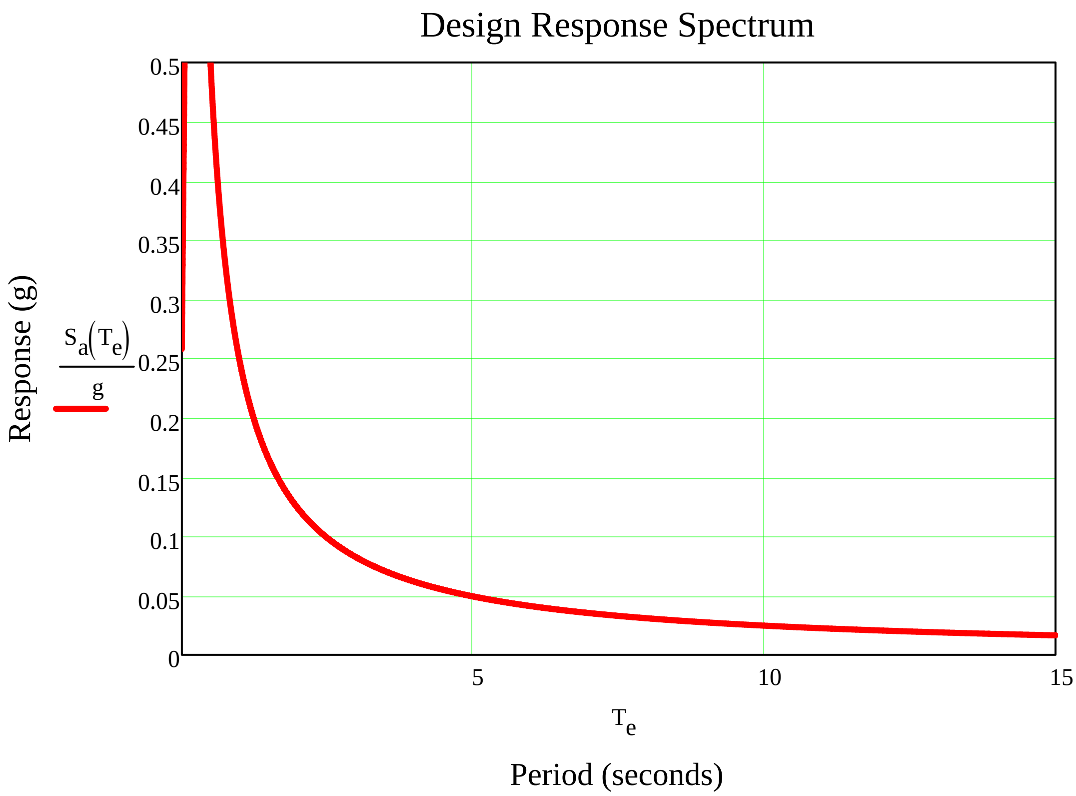
$\beta := 100\zeta \qquad \beta = 8$

$B_s := Int(5, 1.0, 10, 1.3, \beta) \qquad B_s = 1.18$

$B_1 := Int(5, 1.0, 10, 1.2, \beta) \qquad B_1 = 1.12$

$$T_0 := \left(\frac{S_{x1} \cdot B_s}{S_{xs} \cdot B_1}\right) \cdot sec \qquad T_0 = 0.382\ s$$

$$S_a(T_e) := \begin{cases} \left(\frac{S_{xs}}{B_s}\right) \cdot \left(0.4 + \frac{3 \cdot T_e}{T_0}\right) & \text{if } T_e \le 0.2 \cdot T_0 \\ \frac{S_{x1} \cdot sec}{B_1 \cdot T_e} & \text{if } T_e > T_0 \\ \frac{S_{xs}}{B_s} & \text{otherwise} \end{cases}$$



P-delta by section 3.8.6 of fema 350 (2000, pg2-17)

$P := W \qquad R_f = 8 \qquad \Delta = (2.824)\,in \qquad V_{xm} = (2.478)\,k \qquad h = (12)\,ft$

$V_y := \frac{2 \cdot R_y \cdot F_y \cdot Z_{xc}}{h_1} \qquad V_y = 17.722\,k \qquad \psi := \frac{P_{x_1} \cdot R_f \cdot \Delta_1}{V_y \cdot h_1} \qquad \psi = 0.143$

ψ is less than one, structure is stable

Using linear static procedure of analysis as given

4.4.3.2 period of structure (4-15)

$T_a = 0.204\,s$

4.4.3.3.1 Pseudo lateral load, pg 4-16

$T_S := 0.2 \cdot T_0$ $\quad T_S = 0.076\,s \quad T_0 = 0.382\,s$

$$C_1 := \begin{cases} 1 & \text{if } T_a \geq T_0 \\ 1.5 & \text{if } T_a \leq T_S \\ \text{Int}(T_S, 1.5, T_0, 1.0, T_a) & \text{otherwise} \end{cases} \qquad C_1 = 1.291$$

$C_2 := 1.0$

$C_{3IO} := 1 \quad C_{3CP} := 1.2$ Table 4.4, pg 4-18

$W := dlwf_1 \quad W = 30\,k \qquad S_a(T_a) = 0.645\,g$

$$V_{IO} := C_1 \cdot C_2 \cdot C_{3IO} \cdot \frac{S_a(T_a)}{g} \cdot W \qquad V_{IO} = 24.979\,k$$

$$V_{CP} := C_1 \cdot C_2 \cdot C_{3CP} \cdot \frac{S_a(T_a)}{g} \cdot W \qquad V_{CP} = 29.974\,k$$

$$k_{cvx}(T) := \begin{cases} 1 & \text{if } T \leq 0.5sec \\ 2 & \text{if } T \geq 2.5sec \\ \text{Int}(0.5sec, 1, 2.5sec, 2, T) & \text{otherwise} \end{cases} \qquad k_{cvx}(T) = 1.149$$

$n := 1 \quad i := 1..n$

$$sum := \sum_{i=1}^{n} \left[\frac{w_i}{k} \cdot \left(\frac{h_i}{ft}\right)^{k_{cvx}(T)} \right] \qquad sum = 520.897 \qquad C_{vx_i} := \frac{\frac{w_i}{k} \cdot \left(\frac{h_i}{ft}\right)^{k_{cvx}(T)}}{sum} \qquad C_{vx} = (1)$$

C.vx = 1 as expected for one story building

4.4.3.3.5: Interstory Drift $\quad kf = (4.825)\frac{k}{in}$

analysis uncertainty and demand variability factor from section 4.6

From Table 4-8, $\quad \gamma_{aIO} := 0.94 \quad \gamma_{aCP} := 0.70$

From Table 4-9, $\quad \gamma_{IO} := 1.5 \quad \gamma_{CP} := 1.3$

From Table 4-10, $\quad C_{IO} := 0.02 \quad C_{CP} := 0.10$

$\phi_{IO} := 1 \quad \phi_{CP} := 0.9$

From Table 4-12, $\quad But_{IO} := 0.2 \quad But_{CP} := 0.3$

$\Delta_{IO} := \frac{V_{IO}}{kf_1} \cdot \gamma_{aIO} \cdot \gamma_{IO}$ $\Delta_{IO} = 7.3\,in$

$\Delta_{CP} := \frac{V_{CP}}{kf_1} \cdot \gamma_{aCP} \cdot \gamma_{CP}$ $\Delta_{CP} = 5.653\,in$

Drift Capacities

$\Delta_{allIO} := C_{IO} \cdot \phi_{IO} \cdot h_1$ $\Delta_{allIO} = 2.88\,in$

$\Delta_{allCP} := C_{CP} \cdot \phi_{CP} \cdot h_1$ $\Delta_{allCP} = 12.96\,in$

$\lambda_{IO} := \frac{\Delta_{IO}}{\Delta_{allIO}}$ $\lambda_{IO} = 2.535$ $\lambda_{CP} := \frac{\Delta_{CP}}{\Delta_{allCP}}$

Immediate occupancy: $\lambda_{IO} = 2.535$ $But_{IO} := 0.2$

$\lambda_{CP} = 0.436$ $But_{CP} := 0.3$

From Table 4-6, Confidence levels greater than 99% for both collapse prevention and immediate occupancy

$P_{max} = 21.521\,k$ $P_{min} = 13.5\,k$ $M_{max} = 7.433\,k \cdot ft$ $V_{max} = 1.239\,k$

Part B. Analysis by Fema 350

Response spectrum from Fema 273

From 50% in 50 year hazard maps (2002 data from USGS java applet)

$S_s := 0.0432g \quad S_1 := 0.0092g$

F273, 2.6.1.4, adjustment for site class (pg 2-21)

$SiteClass := "C"$

$F_a := 1.2 \qquad F_a = 1.2$

$F_v := 1.7 \qquad F_v = 1.7$

$S_{xs} := F_a \cdot S_s \qquad S_{xs} = 0.052\,g \qquad S_{x1} := F_v \cdot S_1 \qquad S_{x1} = 0.016\,g$

F273, 2.6.1.5, general response spectrum

$T_e := 0sec, 0.001sec .. 15sec$

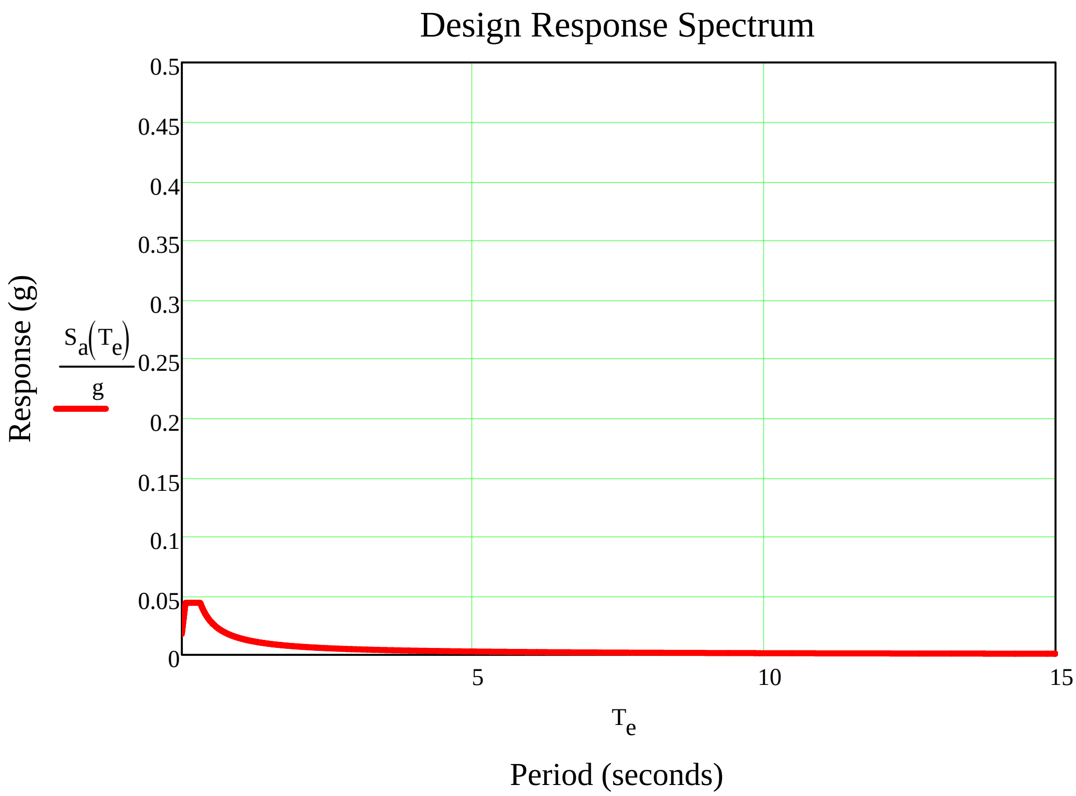
$\beta := 100\zeta \qquad \beta = 8$

$B_s := Int(5, 1.0, 10, 1.3, \beta) \qquad B_s = 1.18$

$B_1 := Int(5, 1.0, 10, 1.2, \beta) \qquad B_1 = 1.12$

$$T_0 := \left(\frac{S_{x1} \cdot B_s}{S_{xs} \cdot B_1}\right) \cdot sec \qquad T_0 = 0.318\,s$$

$$S_a(T_e) := \begin{cases} \left(\frac{S_{xs}}{B_s}\right) \cdot \left(0.4 + \frac{3 \cdot T_e}{T_0}\right) & \text{if } T_e \le 0.2 \cdot T_0 \\ \frac{S_{x1} \cdot sec}{B_1 \cdot T_e} & \text{if } T_e > T_0 \\ \frac{S_{xs}}{B_s} & \text{otherwise} \end{cases}$$



P-delta by section 3.8.6 of fema 350 (2000, pg2-17)

$P := W \quad R_f = 8 \quad \Delta = (2.824)\,in \quad V_{xm} = (2.478)\,k \quad h = (12)\,ft$

$V_y := \frac{2 \cdot R_y \cdot F_y \cdot Z_{xc}}{h_1} \quad V_y = 17.722\,k \quad \psi := \frac{P_{x_1} \cdot R_f \cdot \Delta_1}{V_y \cdot h_1} \quad \psi = 0.143$

ψ is less than one, structure is stable

Using linear static procedure of analysis as given

4.4.3.2 period of structure (4-15)

$T_a = 0.204\,s$

4.4.3.3.1 Pseudo lateral load, pg 4-16

$T_S := 0.2 \cdot T_0 \quad T_S = 0.064\,s \quad T_0 = 0.318\,s$

$$C_1 := \begin{cases} 1 & \text{if } T_a \ge T_0 \\ 1.5 & \text{if } T_a \le T_S \\ \mathrm{Int}(T_S, 1.5, T_0, 1.0, T_a) & \text{otherwise} \end{cases} \qquad C_1 = 1.223$$

$C_2 := 1.0$

$C_{3IO} := 1 \qquad C_{3CP} := 1.2$ Table 4.4, pg 4-18

$W := \mathrm{dlwf}_1 \qquad W = 30\,k \qquad S_a(T_a) = 0.044\,g$

$$V_{IO} := C_1 \cdot C_2 \cdot C_{3IO} \cdot \frac{S_a(T_a)}{g} \cdot W \qquad V_{IO} = 1.612\,k$$

$$V_{CP} := C_1 \cdot C_2 \cdot C_{3CP} \cdot \frac{S_a(T_a)}{g} \cdot W \qquad V_{CP} = 1.934\,k$$

$$k_{cvx}(T) := \begin{cases} 1 & \text{if } T \le 0.5\mathrm{sec} \\ 2 & \text{if } T \ge 2.5\mathrm{sec} \\ \mathrm{Int}(0.5\mathrm{sec}, 1, 2.5\mathrm{sec}, 2, T) & \text{otherwise} \end{cases} \qquad k_{cvx}(T) = 1.149$$

$n := 1 \qquad i := 1 .. n$

$$\mathrm{sum} := \sum_{i=1}^{n} \left[\frac{w_i}{k} \cdot \left(\frac{h_i}{ft}\right)^{k_{cvx}(T)} \right] \qquad \mathrm{sum} = 520.897 \qquad C_{vx_i} := \frac{\frac{w_i}{k} \cdot \left(\frac{h_i}{ft}\right)^{k_{cvx}(T)}}{\mathrm{sum}} \qquad C_{vx} = (1)$$

C.vx = 1 as expected for one story building

4.4.3.3.5: Interstory Drift $\quad kf = (4.825)\,\frac{k}{in}$

analysis uncertainty and demand variability factor from section 4.6

From Table 4-8, $\quad \gamma_{aIO} := 0.94 \qquad \gamma_{aCP} := 0.70$

From Table 4-9, $\quad \gamma_{IO} := 1.5 \qquad \gamma_{CP} := 1.3$

From Table 4-10, $\quad C_{IO} := 0.02 \qquad C_{CP} := 0.10$

$\phi_{IO} := 1 \qquad \phi_{CP} := 0.9$

From Table 4-12, $\quad \mathrm{But}_{IO} := 0.2 \qquad \mathrm{But}_{CP} := 0.3$

$$\Delta_{IO} := \frac{V_{IO}}{kf_1} \cdot \gamma_{aIO} \cdot \gamma_{IO} \qquad \Delta_{IO} = 0.471\,in$$

$\Delta_{CP} := \frac{V_{CP}}{kf_1} \cdot \gamma_{aCP} \cdot \gamma_{CP}$ $\Delta_{CP} = 0.365\ in$

Drift Capacities

$\Delta_{allIO} := C_{IO} \cdot \phi_{IO} \cdot h_1$ $\Delta_{allIO} = 2.88\ in$

$\Delta_{allCP} := C_{CP} \cdot \phi_{CP} \cdot h_1$ $\Delta_{allCP} = 12.96\ in$

$\lambda_{IO} := \frac{\Delta_{IO}}{\Delta_{allIO}}$ $\lambda_{IO} = 0.164$ $\lambda_{CP} := \frac{\Delta_{CP}}{\Delta_{allCP}}$

Immediate occupancy: $\lambda_{IO} = 0.164$ $But_{IO} := 0.2$

$\lambda_{CP} = 0.028$ $But_{CP} := 0.3$

From Table 4-6, Confidence levels greater than 99% for both collapse prevention and immediate occupancy