CLASE AUXILIAR

ORIGIN ≡ 1

$W := 800 \qquad g := 9.8$

$i := 1 .. 3$

$j := 1 .. 3$

$$M := \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \frac{W}{g} \qquad M = \begin{pmatrix} 81.633 & 0 & 0 \\ 0 & 81.633 & 0 \\ 0 & 0 & 81.633 \end{pmatrix}$$

$$K1 := \begin{pmatrix} 24 & -24 & 0 \\ -24 & 48 & -24 \\ 0 & -24 & 48 \end{pmatrix} \cdot \frac{1}{8} \qquad K1 = \begin{pmatrix} 3 & -3 & 0 \\ -3 & 6 & -3 \\ 0 & -3 & 6 \end{pmatrix}$$

$w2 := \text{eigenvals}\left(M^{-1} \cdot K1\right)$

$$w2 = \begin{pmatrix} 0.00728 \\ 0.05714 \\ 0.11933 \end{pmatrix}$$

$\Phi := \text{eigenvecs}\left(M^{-1} \cdot K1\right)$

$$\Phi = \begin{pmatrix} 0.737 & -0.591 & 0.328 \\ 0.591 & 0.328 & -0.737 \\ 0.328 & 0.737 & 0.591 \end{pmatrix}$$

$Mm := \Phi^{T} \cdot M \cdot \Phi \qquad Mm = \begin{pmatrix} 81.6 & -0 & -0 \\ 0 & 81.6 & -0 \\ -0 & -0 & 81.6 \end{pmatrix}$

$$\Phi_{i,j} := \frac{\Phi_{i,j}}{\sqrt{Mm_{j,j}}} \qquad \Phi = \begin{pmatrix} 0.0816 & -0.0654 & 0.0363 \\ 0.0654 & 0.0363 & -0.0816 \\ 0.0363 & 0.0816 & 0.0654 \end{pmatrix}$$

$Mm := \Phi^{T} \cdot M \cdot \Phi \qquad Mm = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

$$EI := \left(\frac{2 \cdot \pi}{0.5}\right)^2 \cdot \frac{1}{w2_1} \qquad EI = 21695 \qquad K := K1 \cdot EI$$

$$T := \frac{2 \cdot \pi}{\sqrt{w2 \cdot EI}} \qquad T = \begin{pmatrix} 0.5 \\ 0.178 \\ 0.123 \end{pmatrix} \qquad K = \begin{pmatrix} 65085 & -65085 & 0 \\ -65085 & 130170 & -65085 \\ 0 & -65085 & 130170 \end{pmatrix}$$

$$w2 := w2 \cdot EI \qquad w2 = \begin{pmatrix} 157.91 \\ 1239.76 \\ 2588.79 \end{pmatrix}$$

chequeo:

$$w2 := \text{eigenvals}\left(M^{-1} \cdot K\right) \qquad w2 = \begin{pmatrix} 157.91 \\ 1239.76 \\ 2588.79 \end{pmatrix}$$

$$\Phi := \text{eigenvecs}\left(M^{-1} \cdot K\right) \qquad \Phi = \begin{pmatrix} 0.737 & -0.591 & 0.328 \\ 0.591 & 0.328 & -0.737 \\ 0.328 & 0.737 & 0.591 \end{pmatrix}$$

$$Mm := \Phi^{T} \cdot M \cdot \Phi \qquad Mm = \begin{pmatrix} 81.6 & -0 & -0 \\ -0 & 81.6 & -0 \\ -0 & -0 & 81.6 \end{pmatrix}$$

$$\Phi_{i,j} := \frac{\Phi_{i,j}}{\sqrt{Mm_{j,j}}} \qquad \Phi = \begin{pmatrix} 0.0816 & -0.0654 & 0.0363 \\ 0.0654 & 0.0363 & -0.0816 \\ 0.0363 & 0.0816 & 0.0654 \end{pmatrix}$$ Normalizado

$$Mm := \Phi^{T} \cdot M \cdot \Phi \qquad Mm = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Fin de chequeo

$$Km := \Phi^{T} \cdot K \cdot \Phi \qquad Km = \begin{pmatrix} 157.91 & -0 & -0 \\ 0 & 1239.76 & -0 \\ -0 & -0 & 2588.79 \end{pmatrix} \qquad w2 = \begin{pmatrix} 157.91 \\ 1239.76 \\ 2588.79 \end{pmatrix} \qquad Km := w2$$

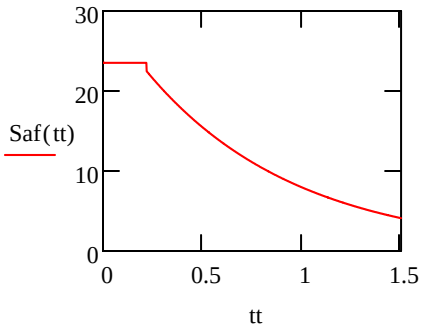
Factor de Participacion Modal:

$$r := \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \qquad Lm := \Phi^{T} \cdot M \cdot r \qquad Lm = \begin{pmatrix} 14.962 \\ 4.282 \\ 1.645 \end{pmatrix}$$

chequeo

$$Meff := Lm^{2} \qquad Meff = \begin{pmatrix} 223.856 \\ 18.337 \\ 2.705 \end{pmatrix} \qquad \sum_{t=1}^{3} Meff_{t} = 244.898 \qquad \sum_{t=1}^{3} M_{t,t} = 244.898$$

$$Saf(Tn) := \begin{cases} 2.4 \cdot 9.8 & \text{if } 0 \le Tn \le 0.22 \\ 3.071 \cdot 9.8 \cdot e^{-1.33 \cdot Tn} & \text{if } Tn > 0.22 \end{cases}$$



$$Sa_i := Saf(T_i) \qquad Sa = \begin{pmatrix} 15.477 \\ 23.52 \\ 23.52 \end{pmatrix}$$

$$Qmax_i := Meff_i \cdot Sa_i \qquad Qmax = \begin{pmatrix} 3464.73 \\ 431.29 \\ 63.61 \end{pmatrix}$$

$$Qbasal := \sqrt{\sum_{t=1}^{3} \left(Qmax_t\right)^2} \qquad Qbasal = 3492.05$$

$$Sd_i := \frac{Sa_i}{w2_i} \qquad Sd = \begin{pmatrix} 0.098 \\ 0.019 \\ 0.009 \end{pmatrix}$$

$$vmax_{j,i} := Sd_i \cdot \Phi_{j,i} \cdot Lm_i \qquad vmax = \begin{pmatrix} 0.1196 & -0.0053 & 0.0005 \\ 0.0959 & 0.0029 & -0.0012 \\ 0.0532 & 0.0066 & 0.0010 \end{pmatrix} \qquad vmaxcomb := \sqrt{diag\left(vmax \cdot vmax^T\right)}$$

$$vmaxcomb = \begin{pmatrix} 0.1197 \\ 0.0960 \\ 0.0537 \end{pmatrix}$$

$k := 1 .. 2$

$$dvmax_{k,i} := vmax_{k,i} - vmax_{k+1,i} \qquad dvmax_{3,i} := vmax_{3,i}$$

$$dvmaxcomb := \sqrt{diag\left(dvmax \cdot dvmax^T\right)}$$

$$dvmax = \begin{pmatrix} 0.0237 & -0.0083 & 0.0018 \\ 0.0427 & -0.0037 & -0.0022 \\ 0.0532 & 0.0066 & 0.0010 \end{pmatrix} \qquad dvmaxcomb = \begin{pmatrix} 0.0252 \\ 0.0429 \\ 0.0537 \end{pmatrix}$$

$$Mmax := \max(dvmaxcomb) \cdot 6 \cdot \frac{EI}{4} \qquad Mmax = 1746$$

Máximo momento

Caso con aislador: $i := 1 .. 4$ $j := 1 .. 4$ $\mu := 0.1$

$$\alpha := \left(\frac{2\cdot\pi}{0.5}\right)^2 \cdot \frac{\mu\cdot W}{g} \cdot \frac{0.5^3}{12\cdot EI} \qquad \alpha = 0.00062 \qquad M := \begin{pmatrix} \mu & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \frac{W}{g}$$

$$M = \begin{pmatrix} 8.163 & 0 & 0 & 0 \\ 0 & 81.633 & 0 & 0 \\ 0 & 0 & 81.633 & 0 \\ 0 & 0 & 0 & 81.633 \end{pmatrix} \qquad t2 := 2\cdot\pi\cdot\sqrt{\frac{0.5^3\cdot W\cdot\mu}{(12\cdot EI\cdot\alpha)\cdot g}} \qquad t2 = 0.5$$

$$K := \begin{pmatrix} 96\alpha & -96\cdot\alpha & 0 & 0 \\ -96\cdot\alpha & 96\cdot\alpha + 3 & -3 & 0 \\ 0 & -3 & 6 & -3 \\ 0 & 0 & -3 & 6 \end{pmatrix} \cdot EI \qquad K = \begin{pmatrix} 1289 & -1289 & 0 & 0 \\ -1289 & 66374 & -65085 & 0 \\ 0 & -65085 & 130170 & -65085 \\ 0 & 0 & -65085 & 130170 \end{pmatrix}$$

$$\Phi := \text{eigenvecs}\left(M^{-1}\cdot K\right) \qquad \Phi = \begin{pmatrix} 0.963 & -0.941 & -0.086 & -0.021 \\ 0.202 & 0.242 & 0.593 & 0.331 \\ 0.155 & 0.205 & -0.321 & -0.737 \\ 0.084 & 0.117 & -0.733 & 0.59 \end{pmatrix}$$

$$w2 := \text{eigenvals}\left(M^{-1}\cdot K\right)$$

$$T := \frac{2\cdot\pi}{\sqrt{w2}}$$

$$Mm := \Phi^T\cdot M\cdot\Phi \qquad Mm = \begin{pmatrix} 13.4 & -0 & 0 & 0 \\ -0 & 16.6 & 0 & 0 \\ 0 & 0 & 81.1 & -0 \\ 0 & 0 & -0 & 81.6 \end{pmatrix} \qquad w2 = \begin{pmatrix} 124.83815 \\ 198.59233 \\ 1246.12177 \\ 2590.61813 \end{pmatrix} \qquad T = \begin{pmatrix} 0.562 \\ 0.446 \\ 0.178 \\ 0.123 \end{pmatrix}$$

$$\Phi_{i,j} := \frac{\Phi_{i,j}}{\sqrt{Mm_{j,j}}} \qquad \Phi = \begin{pmatrix} 0.2628 & -0.2310 & -0.0096 & -0.0024 \\ 0.0550 & 0.0595 & 0.0659 & 0.0366 \\ 0.0423 & 0.0504 & -0.0356 & -0.0815 \\ 0.0229 & 0.0288 & -0.0814 & 0.0653 \end{pmatrix} \text{ Normalizado}$$

$$Mm := \Phi^T\cdot M\cdot\Phi \qquad Mm = \begin{pmatrix} 1 & -0 & 0 & 0 \\ -0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Factor de Participacion Modal:

$$r := \begin{pmatrix} 1 \\ 1 \\ 1 \\ 1 \end{pmatrix} \qquad Lm := \Phi^{T} \cdot M \cdot r \qquad Lm = \begin{pmatrix} 11.965 \\ 9.44 \\ -4.254 \\ 1.64 \end{pmatrix}$$

chequeo

$$Meff := Lm^{2} \qquad Meff = \begin{pmatrix} 143.154 \\ 89.123 \\ 18.095 \\ 2.689 \end{pmatrix} \qquad \sum_{t=1}^{4} Meff_{t} = 253.061 \qquad \sum_{t=1}^{4} M_{t,t} = 253.061$$

$$Sa_{i} := Saf\left(T_{i}\right) \qquad Sa = \begin{pmatrix} 14.246 \\ 16.633 \\ 23.52 \\ 23.52 \end{pmatrix} \qquad Qmax_{i} := Meff_{i} \cdot Sa_{i} \qquad Qmax = \begin{pmatrix} 2039.35 \\ 1482.39 \\ 425.58 \\ 63.25 \end{pmatrix}$$

$$Qbasal2 := \sqrt{\sum_{t=1}^{4} \left(Qmax_{t}\right)^{2}} \qquad Qbasal2 = 2557.64 \qquad \frac{Qbasal2}{Qbasal} = 73.242\,\%$$

REDUCCION

$$Sd_{i} := \frac{Sa_{i}}{w2_{i}} \qquad Sd = \begin{pmatrix} 0.114 \\ 0.084 \\ 0.019 \\ 0.009 \end{pmatrix}$$

$$vmax_{j,i} := Sd_{i} \cdot \Phi_{j,i} \cdot Lm_{i} \qquad vmax = \begin{pmatrix} 0.3588 & -0.1826 & 0.0008 & -0.0000 \\ 0.0751 & 0.0470 & -0.0053 & 0.0005 \\ 0.0578 & 0.0399 & 0.0029 & -0.0012 \\ 0.0313 & 0.0228 & 0.0065 & 0.0010 \end{pmatrix}$$

$$vmaxcomb := \sqrt{diag\left(vmax \cdot vmax^{T}\right)} \qquad vmaxcomb = \begin{pmatrix} 0.4026 \\ 0.0888 \\ 0.0703 \\ 0.0393 \end{pmatrix}$$

$k := 1 .. 3$

$$dvmax_{k,i} := vmax_{k,i} - vmax_{k+1,i} \qquad dvmax_{4,i} := vmax_{4,i} \qquad dvmaxcomb := \sqrt{diag\left(dvmax \cdot dvmax^{T}\right)}$$

$$dvmax = \begin{pmatrix} 0.2836 & -0.2297 & 0.0061 & -0.0006 \\ 0.0174 & 0.0072 & -0.0081 & 0.0018 \\ 0.0264 & 0.0171 & -0.0037 & -0.0022 \\ 0.0313 & 0.0228 & 0.0065 & 0.0010 \end{pmatrix} \qquad dvmaxcomb = \begin{pmatrix} 0.365 \\ 0.0206 \\ 0.0318 \\ 0.0393 \end{pmatrix}$$

$n := 1 .. 3$

Máximo momento

$$dvmaxcomb2_{n} := dvmaxcomb_{n+1}$$

$$Mmax2 := \max(dvmaxcomb2) \cdot 6 \cdot \frac{EI}{4} \qquad Mmax2 = 1278.821 \qquad \frac{Mmax2}{Mmax} = 73.242\,\%$$