Question 4

24 February 2022 15:28

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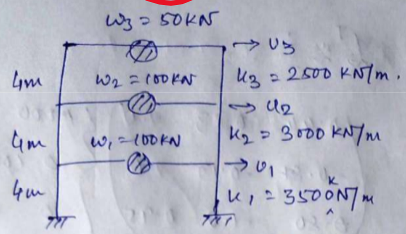
Q:-(4).



$g = 10 m/s^2$.

$$\phi = \begin{bmatrix} 0.44 & -0.81 & 0.80 \\ 0.83 & -0.17 & -1.0 \\ 1.0 & 1.0 & 0.95 \end{bmatrix}.$$

$\Downarrow \phi_1$. $\Downarrow \phi_2$ $\Downarrow \phi_3$.

$\omega = \{9.34\ 24.21\ 32.04\}$.

We first determine $\underset{\sim}{S_n} = \underset{\sim}{m}\, \underset{-}{i} = \sum_{n=1}^{N} s_n$

$$S_{jn} = \Gamma_n m_j \phi_{jn}$$

$$\Gamma_n = \frac{\underset{\sim}{\phi_n}^T \underset{\sim}{m}\, \underset{-}{i}}{M_n} = \frac{L_n^h}{M_n}$$

$$\underset{\sim}{m} = \begin{bmatrix} \cancel{5000}\ 10{,}000 & 0 & 0 \\ 0 & 10{,}000 & 0 \\ 0 & 0 & \cancel{10{,}000}\ 5000 \end{bmatrix}.$$

$$M_n = \underset{\sim}{\phi}^T \underset{\sim}{m}\, \phi.$$

$$M_{n_1} = \phi_1^T \underset{\sim}{m}\, \phi_1$$

$$= (0.44\ \ 0.83\ \ 1.0) \begin{bmatrix} \cancel{5000}\ 10000 & 0 & 0 \\ 0 & 10{,}000 & 0 \\ 0 & 0 & \cancel{10{,}000}\ 5000 \end{bmatrix} \begin{Bmatrix} 0.44 \\ 0.83 \\ 1.0 \end{Bmatrix}$$

$$= 1.3825 \times 10^4 \text{ kg}.$$

Similarly $M_{n_2} = \phi_2^T \underset{\sim}{m}\, \phi_2 = 1.185 \times 10^4$ kg

$M_{n_3} = \underset{\sim}{\phi_3}^T \underset{\sim}{m}\, \phi_3 = 2.0913 \times 10^4$ kg.

Now $L_n^h = \sum_{j=1}^{N} m_j \phi_{jn} = \underset{-}{\phi_n}^T \underset{\sim}{m}\, \underset{-}{i}$

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Or $L_n^h = \underset{\sim}{\phi}^T \underset{\sim}{m}\, \underset{-}{i}$.

$$= \begin{pmatrix} 0.44 & 0.83 & 1.0 \\ -0.81 & -0.17 & 1.0 \\ 0.80 & -1.0 & 0.95 \end{pmatrix} \begin{Bmatrix} 10000 & 0 & 0 \\ 0 & 10000 & 0 \\ 0 & 0 & 5000 \end{Bmatrix} \begin{Bmatrix} 1 \\ 1 \\ 1 \end{Bmatrix}$$

$$= 10^4 \begin{Bmatrix} 1.7700 \\ -0.4800 \\ 0.2750 \end{Bmatrix}$$

unit?

(0.2750).

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$$\therefore M_n^* = \frac{(L_n^h)^2}{M_n}$$

$$M_{n_1}^* = \cancel{\frac{10^4 \times (1.7700)^2}{1.3825 \times 10^4}} = \frac{(1.7700 \times 10^4)^2}{1.3825 \times 10^4} = 22661.12 \text{ kg}.$$

$$M_{n_2}^* = \frac{(-0.4800 \times 10^4)^2}{1.185 \times 10^4} = 1944.3 \text{ kg}.$$

$$M_{n_3}^* = \frac{(0.2750)^2 \times 10^8}{2.0913 \times 10^4} = \underline{361.62 \text{ kg}}$$

Now, for effective Modal height

$h_n^* \rightarrow$

$$L_n^\theta = \sum_{j=1}^{N} h_j m_j \phi_{jn}$$

$$= \underset{\sim}{\phi}^T \underset{\sim}{m} \underset{\sim}{h}.$$

$$\underset{\sim}{h} = \begin{Bmatrix} 4 \\ 8 \\ 12 \end{Bmatrix} m$$

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$$L_n^\theta = \begin{pmatrix} 0.44 & 0.83 & 1.0 \\ -0.81 & -0.19 & 1.0 \\ 0.50 & -1.0 & 0.95 \end{pmatrix} \begin{pmatrix} 10000 & 0 & 0 \\ 0 & 10000 & 0 \\ 0 & 0 & 5000 \end{pmatrix} \begin{Bmatrix} 4 \\ 8 \\ 12 \end{Bmatrix}.$$

$$= 10^5 \times \begin{Bmatrix} 1.44 \\ 0.14 \\ 0.09 \end{Bmatrix}.$$

unit ?

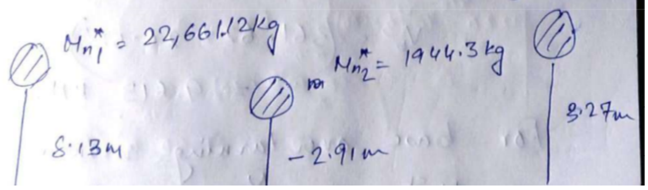
$$\therefore h_n^* = L_n^\theta / L_n^h$$

$$h_{n_1}^* = (10^5 \times 1.44) / 10^4 \times 1.77$$

$$= 8.13 \text{ m}.$$

$$h_{n_2}^* = \frac{10^5 \times 0.14}{10^4 \times (-0.48)} = -2.91 \text{ m}.$$

$$h_{n_3}^* = \frac{10^5 \times 0.09}{10^4 \times 0.2750} = 3.27 \text{ m}$$



mode 1 mode 2 mode 3.

Now, we know, $M_n^* = V_{bn}^{st}$.

$\therefore V_{b1}^{st} = M_1^* = 22,661.12$ kg.

A_1 (as obtained from response spectrum for $t_{n_1} = 2\pi/\omega_1 = 0.673s$)

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$A_1 = 2.71 \times 9.81$ m/s.

$= 26.585$ m/s.

$V_b^1 = V_{b1}^{st} A_1 = (22,661.12 \times 26.585$

$= 602.446$ KN.

Similarly A_2 $\left(t_2 = \frac{2\pi}{24.21} = 0.259s\right)$

$= 2.71 \times 9.81$ m/s.

$= 26.585$

$V_b(t) = ?$

$V_b^2 = M_2^* A_2$

$= (1944.3 \times 26.585)$ kg m/s²

$= 51.68$ KN

$V_b^3 = M_3^* \cdot A_3$

A_3 = for $T_n = \frac{2\pi}{32.04} = 0.2$

$A_3 = 2.71 \times 9.81 = 26.585$ m/s.

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$V_b^3 = (361.62 \times 26.585)$

$= 9.613$ KN.

$M_b(t) = ?$

For base overturning moment

$M_{bn}^{st} = \sum_{j=1}^{N} S_{jn} h_j = \sum_{j=1}^{N} \Gamma_n m_j \phi_{jn} h_j = \Gamma_n L_n^\theta \Rightarrow M_n^* h_n^*$ By def.

$M_{bn} = M_{bn}^{st} A_n(t)$

$= M_n^* h_n^* A_n(t)$

$= V_{bn}^{st} h_n^* A_n(t)$

$\boxed{M_{bn} = V_{bn} h_n^*}$

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(c) Yes it is possible to determine

the peak modal base shear and base overturning moments without determining time histories of $A_n(t)$. We can use the response spectrum for this purpose. We only need the peak pseudo acceleration response values.

equivalent static force $= f_n(t) = s_n A_n(t)$

$$\underline{f}_n = \underline{s}_n A_n$$

$$\Rightarrow f_{jn} = s_{jn} A_n$$

$\Downarrow$

We can do any analysis for this force now. instead of s_n in RHA.

Question 5 :-

Roof slab dimensions $= 7m \times 5m$.

Weight $= 5\ KN/m^2$

Total weight $= (5 \times 7 \times 5)\ KN$.

$= 175\ KN. = \frac{175 \times 10^3}{10}$

$= 17500\ kg$

$K_A = K_B = 500\ KN/m.$

$K_C = 250\ KN/m$

$K_D = 400\ KN/m.$

$PGA = 0.3g.$

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