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section :- C

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subject :- Intro To Structural Dynamic & Earth Quick.

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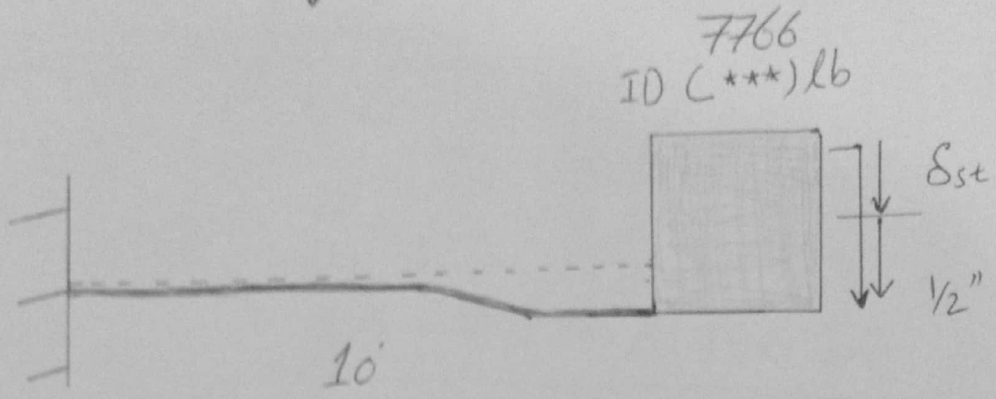
Q#



Figure

Ans:

Given Data:

$E = 29,000$ Ksi

$I = 150$ in

$\delta_{st} = 7766$

Solution:

The general E.o.M for S.DF systems is,

$$Ku + Cu + mu = P(t) \quad -(i)$$

in our case system is undamped ($c=0$) undergoing free vibration ($P(t)=0$) Hence general EoM becomes

$$Ku + mu = 0 \quad -(ii)$$

$K = 3EI/L^3$

So put value

$$= \frac{3 \times 29000\,ksi \times 150\,in^4}{10 \times 12\,in}$$

$K = 7.55\ k/in$

To eliminate mistake during calculation use fundamental units like lb, ft, sec etc.

So $K = 7.55\ k/in = \boxed{90625\ lb/ft}$

$$m = \frac{7766\ lb\ sec^2}{32.2\ ft}$$

$$\boxed{m = 241.180\ slug}$$

$$w_n = \sqrt{K/m} = \sqrt{\frac{96025}{241.180}}$$

$w_n = 19.953\ rad/sec$

$$T_n = 2\pi/\omega_n = 2\pi/19.953 = \boxed{0.314\ sec.}$$

Subsituting the corresponding values in eq (ii)

$$90625u + 241.180 = 0$$

Where "K" is the lb/ft and "m" is in lb sec/ft^2

Generally solution to EOM for undamped free vibration is;

$$u(t) = u(0)\cos(\omega_n t) + \frac{\dot{u}(0)}{\omega_n}\sin(\omega_n t)$$

$$u(0) = 1/2 = \frac{1}{24}\ ft \text{ and } \dot{u}(0) = 0$$

$$u(t) = \left(\frac{1}{24}\right) \times \cos(19.9t) + 0 =$$

equivalent, $\left(\frac{1}{24}\right) \times \cos(19.9t)$

"t" is

$$f_s(t) = K \cdot u(t) = \frac{90625 \times \cos(19.9t)}{24}$$

$$f_s(t) = 7552.08 \times \cos(19.9t)$$

P.T.O

Amplitude of dynamic displacement u_o for undamped free vibrations is;

$$u_o = \sqrt{\left[(u(0))^2 + \left(\frac{\dot{u}(0)}{\omega_n}\right)^2\right]} = \sqrt{\left(\frac{1}{24}\right)^2 + 0}$$

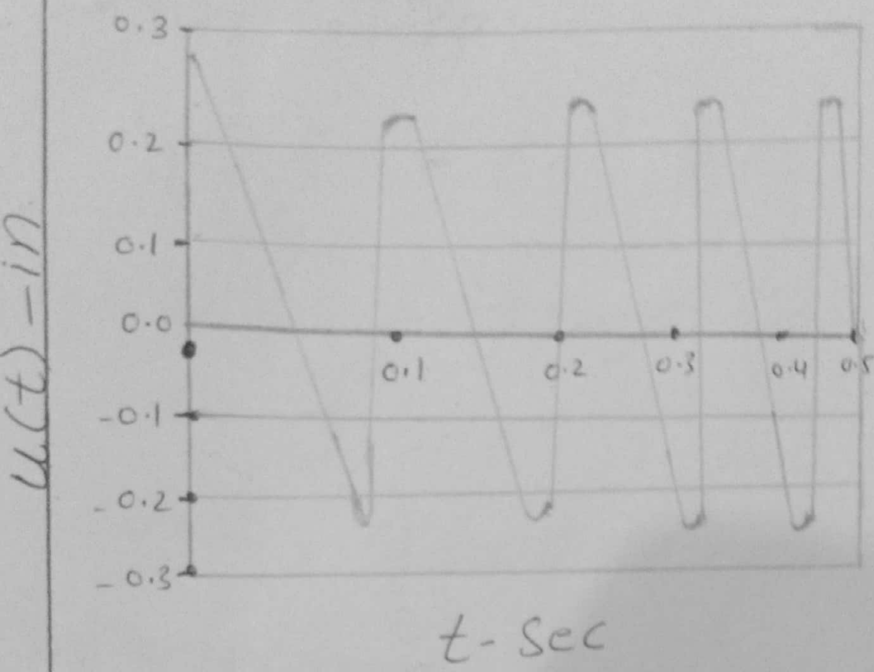
$$= \frac{1}{24} \text{ ft}$$

Amplitude of equivalent static force, is f_{so}

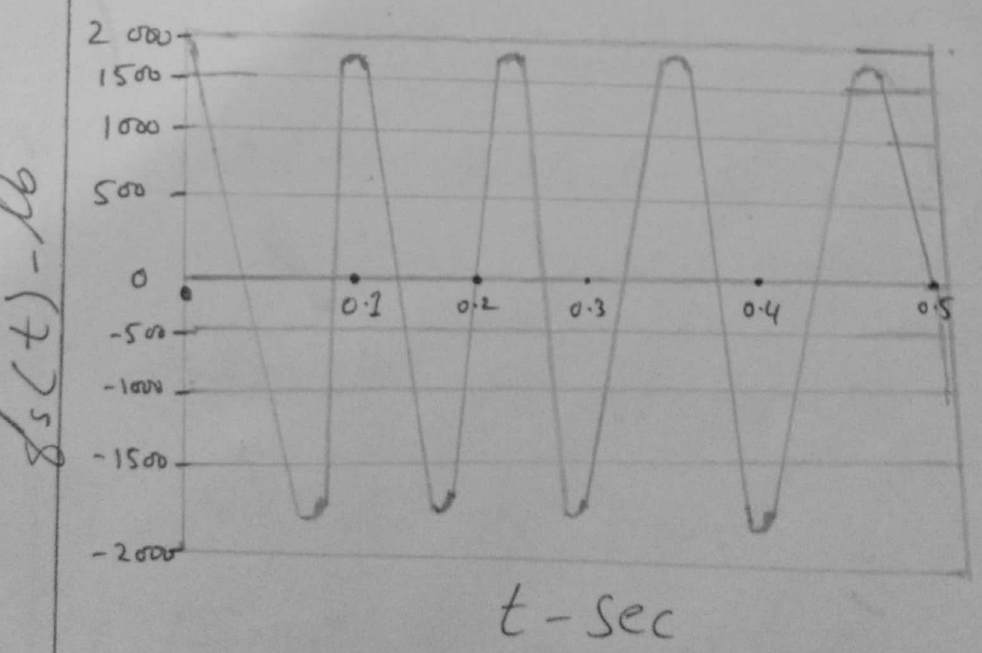
$$Ku_o = 90625 \times \frac{1}{24}$$

$$= \boxed{3776.04 \text{ Ans}}$$

undamped Free Vibration



⇒ Vibration of displacement with time.



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Problem: 3

Given Data:

- Force = 60 kips
- $u_1 = 7766/1000 = 7.766$
- After; j = 7 (cycles)
- Completed = 3.57 sec

Required Data:

(a) Dumping ratio
(b) Natural period of undamped vibration
(c) stiffness of structure
(d) weight of tank
(e) Dumping coeffient
(f) No of cycles to reduce the displacement amplitude to 0.5

Sol:

$u_1 = 7.7''$

after $j = 7$, $u_{j+1} = u_8 = 0.9''$

(a) Damping Ratio $= \zeta = ?$

$$j = \frac{1}{2\pi\zeta} \ln\left[\frac{u_1}{u_{j+1}}\right]$$

$$7 = \frac{1}{2\pi\zeta} \ln\left(\frac{7.7}{0.9}\right)$$

$$\zeta = 0.0488 = 4.88\%$$

(b) $T_n = ?$

7 cycles of vibration are completed in 3.57 seconds

⇒ Time required to complete one cycle $= 3.57/7$

$$T_n = 0.51 \text{ Sec}$$

Now,

$$\omega_D = \omega_n \sqrt{(1-\xi^2)}$$

$$\frac{2\pi}{\omega_D} = 2\pi / (\omega_n \sqrt{1-\xi^2})$$

$$\Rightarrow T_D = \frac{T_n}{\sqrt{1-\xi^2}}$$

$$T_n = T_D \times \sqrt{1-\xi^2}$$

$$T_n = 0.51 \times \sqrt{1-(0.488)^2}$$

$$\Rightarrow T_n = 0.445 = 0.46 \text{ sec.}$$

(C) Stiffness of structure = K = ?

$$K = \frac{F \cdot \cos\theta}{7.766} = \frac{60 \cos 60}{7.766}$$

$$\boxed{K = 46355.91 \text{ lb/ft}}$$

(d) Weight of the tank = W = ?

$$\omega_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{K}{(W/g)}} = \sqrt{\frac{K \times g}{W}}$$

$$\omega_n^2 = K \times g / W$$

$$\Rightarrow \quad W = K \times g / \omega_n^2$$

also

$$\omega_n = 2\pi / T_n$$

$$W = Kg \Big/ \left(\frac{4\pi^2}{T_n^2}\right) = Kg \times \frac{T_n^2}{4\pi}$$

$$W = \frac{46355.91 \, lb/ft \times 32.2 \, ft/sec \, (}{4\pi^2}$$

$$W = 46355.91 \times 32.2 \times \left(\frac{(0.46)^2}{4(3.14)^2}\right)$$

$$W = 8008.61 \, lb$$

$$\Rightarrow \boxed{W = 8.008 \, K}$$

(e) Dumping Coeffient:- $\dot{C} = ?$

we know that:

$$\zeta = \frac{C}{2m\omega_n}$$

$\Rightarrow$ $C = \zeta\,(2m\omega_n) = \zeta\left(2m\left(\frac{2\pi}{T_n}\right)\right)$

put values

$$C = \frac{0.462\left(2\left(\frac{8008.61}{32.2}\right)\right)}{0.46\ \text{sec}}$$

$C =$ $\boxed{49.959\ \text{lb sec/ft}}$

P.T.O.

(f) No of cycles to reduce the displacement amplitude to 0.5

$j = ?$

$$j = \frac{1}{2\pi\zeta} \ln\left(\frac{u_1}{a_{j+1}}\right)$$

$$\frac{1}{2(3.14)(0.0482)} \ln\left(\frac{7.766}{0.5}\right)$$

$= 9.1$

So $j = 9$ cycles.

Q# = 2

Given Data:

* Damping ratio of reinforce concrete with considdrable Cracking = 3-5%
* So we take $\xi = 3\%$
* other data are taken from question No: 1

Required value:

Develop and solve the eqn of motion for vibration at free end =?

Develop an equation showing variation in equivalent state forces with time =?

Sol:.

As we know that EOM (equation of motion) for damped free vibration is;

$$ku + c\dot{u} + m\ddot{u} = 0 \quad \text{---} (1)$$

As we know that from question no. 1 data

$K = 90625$ lb/ft

$m = 240.46$ rad/sec

$\omega_n = 19.983$

As we know that,

$c = \zeta \times 2 m \omega_n$

$c = 0.03 \times 2 \times 240.46 \times 19.98$

$c = 288.263$ lb sec/ft

P.T.O

By putting value in eq ①
we get.

$$90625\ddot{u} + 288.263\dot{u} + 240.4u = 0$$

Solution to the EOM for damped free vibration is,

$$u(t) = e^{-\zeta \omega_n t}\left[u(0)\cos(\omega_D t) + \rightarrow \frac{1}{\omega_D}\left[\dot{u}(0) + u(0)\zeta\omega_n\right]\sin\omega_D t\right]$$

Here;

$$\omega_D = 19.984 \text{ rad/sec}$$

$$u(t) = e^{-(0.03\times19.984\times t)}\left[\frac{1}{24}\times\cos(19.984t) \rightarrow + \frac{1}{19.984}\times\left[0 + \frac{1}{24}\times 0.03\times19.984\times \sin(19.984)\right]\right]$$

P.T.O.

$u(t) = e^{-(0.599t)}\left[0.0416 \times \cos(19.984t) + 0.024 \right.$
$\left. \sin(19.984)\right]$

we know that:

$f(t) = k \cdot u(t)$

$$fs(t) = 90625 \times u(t)$$

$fs(t) = e^{-0.599t}\left[3806.25 \cos(19.984t) + \right.$
$\left. 2175 \sin(19.983t)\right]$

$\Longrightarrow$ X $\Longrightarrow$ Ans

Damped Free vibration.