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Section = "A"

Subject =

Intro To Structural Dynamic

&

Earthquake

Engg.

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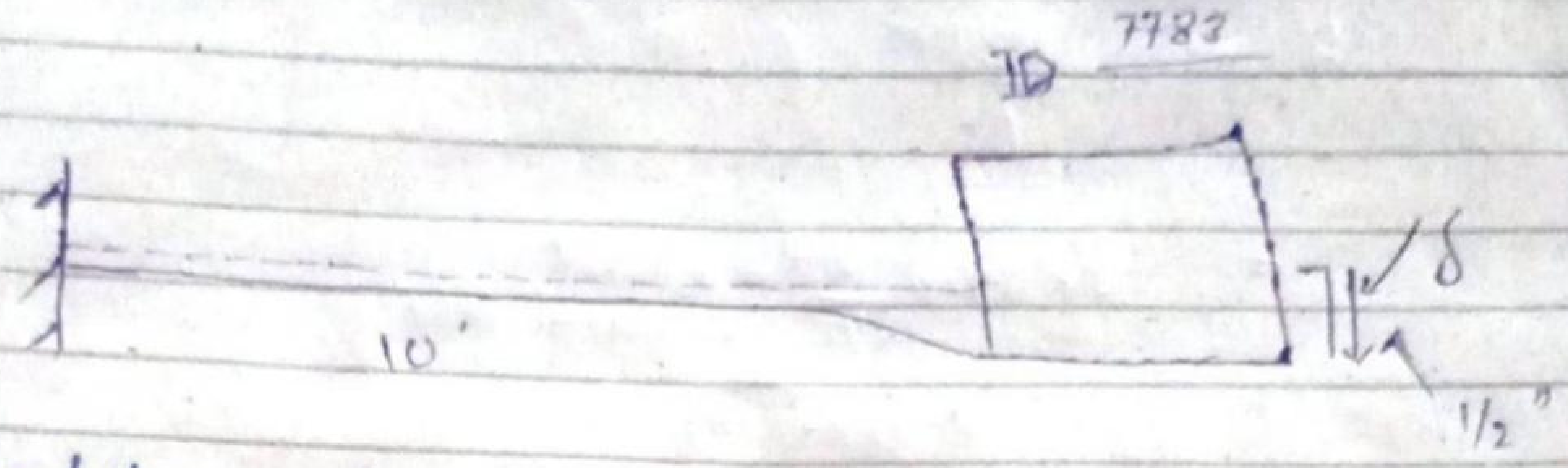
QNo1: Problem.



Givendata: $E = 29{,}000\,ksi$

$I = 150\,in^4$

δ_{st} = Deflection due to 7783lb static load.

Beam is pulled 1/2" downwords.

R.D: Natural time periods of system develop and solve the equation of motion.

Draw graph to show the vaibration of displacement with time & the vibration of equlivent static force with time.

Solution:

General EOM for SDOF system is;

$$Ku + C\dot{u} + m\ddot{u} = P(t)$$

Since system is undamped = $(C = 0)$.
undegoing free vibration $P(t) = 0$

Hence genral EOM becomes

$$Ku + m\ddot{u} = 0 \rightarrow ①$$

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$$K = \frac{3EI}{l^3}$$

$$= \frac{3 \times 2900 \frac{K}{in^2} \times 150\, in^4}{(10 \times 12in)^3}$$

$$\boxed{K = 7.55208\, K/in}$$

⇒ In order to eliminate chances of mistake during calculation, it is more appropriate to use fundamental unit like lb, ft, sec or kg, m, sec.

$$K = 7.55208\, K/in \Rightarrow 90625\ lb/ft.$$

$$m = w/g = \frac{7783}{32.2} \Rightarrow$$

$$m = 241.708\ slug.$$

$$\omega_n = \sqrt{\frac{K}{m}} \Rightarrow \sqrt{\frac{90625}{241.708}}$$

$$\omega_n = 19.36\ rad/sec.$$

$$T_n = \frac{2\pi}{\omega_n} = \frac{2\pi}{19.36} = \boxed{0.3243 sec}$$

put m & k in eqn (1).

$$90625u + 241.708\ddot{u} = 0.$$

where K is in lb/ft is lbsec/ft²

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General solution to EOM for undamped free vibration is

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

$u(0) = \frac{1}{2}'' = \frac{1}{24}$ ft & $\dot{u}(0) = 0$

$$u(t) = \left(\frac{1}{24}\right) \times \cos(19.36) + 0 = \left(\frac{1}{24}\right) \times \cos(19.36)$$

Equivalent static force at any time 't' is

$$f_s(t) = k \cdot u(t) = \frac{90625 \times \cos(19.36t)}{24}$$

$$= \boxed{(85.5054\ t)}$$

Amplitude of dynamic displacement, u_0 for undamped free vibration is

$$u_0 = \sqrt{(u(0))^2 + \left(\frac{v(0)}{\omega_n}\right)^2}$$

$$\sqrt{\left(\frac{1}{24}\right)^2 + 0}$$

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

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(4)

Amplitude of equilvent static force, f_{so}

$K u_0 = 90625 \times 1/24$

$K u_0 = 3776$

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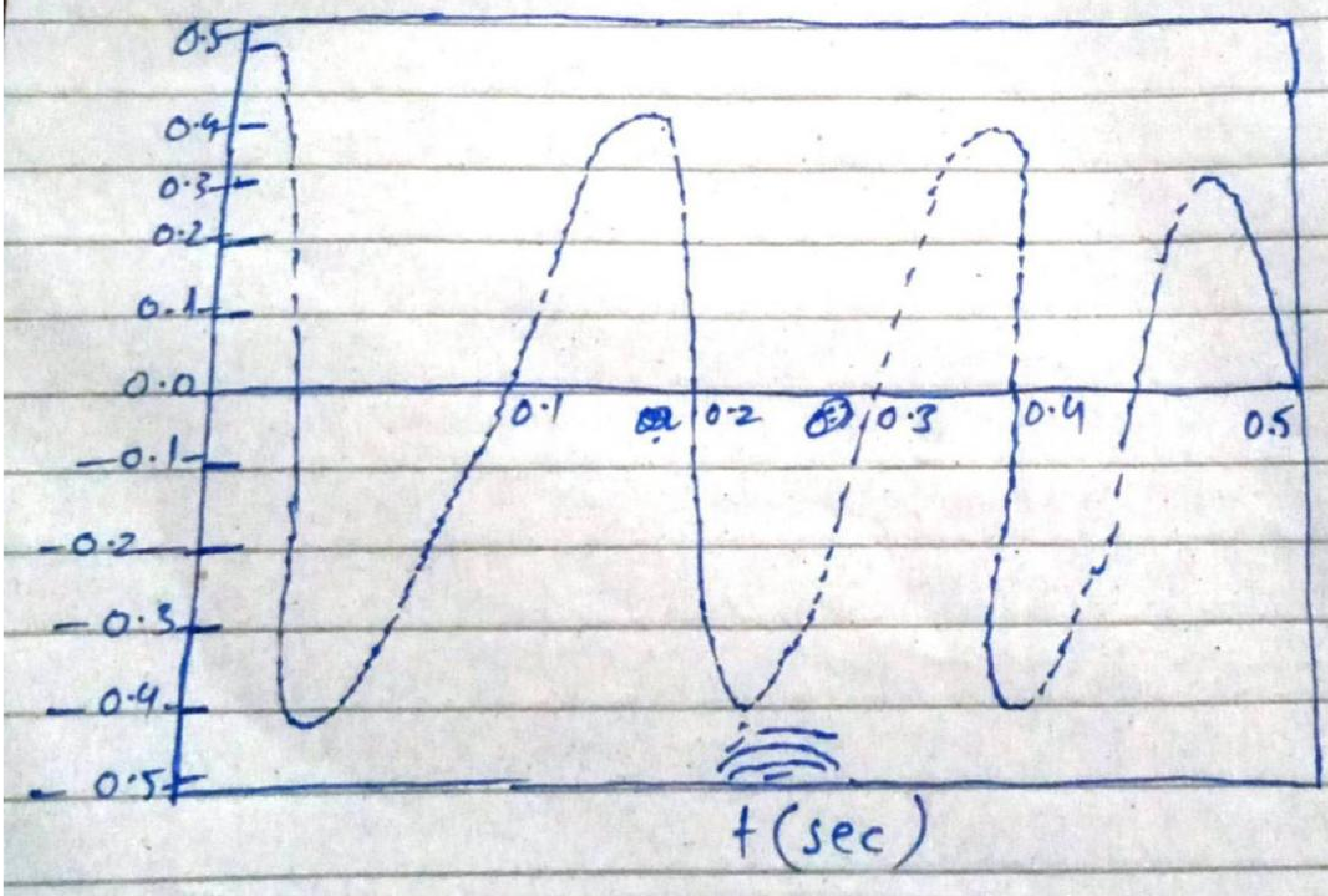
(4)

(5)



varation of displacement.

QNo2: ①

Givendata:

ξ (Damping ratio) of Reinforced Concrete with considered cracking = 3-5%

= 3%

(Required Data):-

Develop and solve the equation showing variation in equivalent static force with time.

→ Draw graph to show the varition of displacement with time & the variation of equivlant static force with time.

Solution:-

EOM for damped force vibration is

$$Ku + cv + m\ddot{u} = 0 \quad \text{—} ①$$

form data.

$K = 90625$ lb/ft

$\omega_n = 19.36$

$m = 241.708$.

We know That

$$C = \xi \times 2m\omega_n$$

$$= (0.03) \times 2(241.708)(19.36).$$

$$C = \boxed{280.76} \text{ lb.sec/ft}.$$

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Put the value of eq ①.

$90625u + 280.76u + 241.708u = 0$

Solution to The EOM form damped free vibration is

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

$\boxed{\omega_D = 19.36}$ rad/sec

$$u(t) = e^{-0.03(19.36)}\left[\tfrac{1}{24}\times\cos(19.36t) + \frac{1}{19.36}\times\left[0 + \tfrac{1}{24}\times 0.03\times 19.36\times\sin(19.36t)\right.\right.$$

$$u(t) = e^{-0.5808t}\left[0.041\times\cos(19.36) + 0.0516\times\sin(19.36t)\right]$$

$fs(t) = K.u(t) \Rightarrow 90625\times u(t).$

$$fs(t) = e^{-0.5808t}\left[90625\times 0.041)\cos(19.36t) + 90625\times 0.0516\times \sin(19.36t)\right.$$

$$fs(t) = e^{-0.5808t}\left[3715.62\cos(19.36t) + 90625.0516\sin 19.36t\right].$$

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CON03

Problem

Givendata:-

- Force = 60 kips
- $u_1 = \frac{7783}{1000} = 7.783$
- After, $j = 7$ (cycle).
- Completed = 3.57 sec.
- $u_{j+1} = 2.286\,cm = 0.9\,in.$
- Ignore the vertical vibration.

Req: (a) Damping ratios.
(b) Natural periods of undamped vibration
(c) Stifness of structural.
(d) weight of tank.
(e) Damping co-effecient.
(f) Number of cycles to reduce the displacement amplitude to 0.5".

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

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

putting value.

$= 7 = \frac{1}{2(3.14)\zeta} \ln\left[\frac{7.783}{0.9}\right]$

$\zeta = (7 \times 2 \times 3.14)\zeta = (2.157).$

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$\zeta\ (43.96) = (2.157)$

$\zeta = \frac{2.157}{43.96}$

$\boxed{\zeta = 0.049}$

$\boxed{\zeta = 4.9\ \%}$

(b) $T_n = ?$

As "Seven" cycles are completed in "3.57" sec.

Thus time required to completed one cycle $= 7/3.57 = 1.96$ sec.

$\boxed{T_D = 1.96 sec}$

Now $\omega_D = \omega_n\sqrt{1-\zeta^2}$

$= \frac{2\pi}{\omega_D} = \frac{2\pi}{\omega_n}\left(\sqrt{1-\zeta^2}\right)$

As $T_D = \frac{T_n}{\sqrt{1-\zeta^2}}$

$T_n = T_D\left(\sqrt{1-\zeta^2}\right)$

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③

$= 1.96\sqrt{1-(0.049)^2}$

$\boxed{T_n = 1.9576}$ sec.

Natural period of undamped vibration.

(C) Stiffness of Structure? K = ?

As $K = \frac{F.\cos\alpha}{2}$.

$= K = \frac{60, \cos(60^\circ)}{2}$ | F = 60 kips, $\theta = 60^\circ$

$K = 15K/in$

$\boxed{K = 18000 \text{ lb/ft}}$

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(d) Weight of Tank, $w = ?$

As

$$\omega_n = \sqrt{k/m} = \sqrt{\frac{k}{(w/g)}} = \sqrt{\frac{k \cdot g}{w}}$$

$$= \omega_n^2 = \frac{k \cdot g}{w} \Rightarrow \left(W = k \cdot g / \omega_n^2 \right)$$

By putting value of $\omega_n = 2\pi / T_n$.

$$W = k \cdot g \Big/ \left(4\pi^2 / T_n^2 \right) = k \cdot g \left(\frac{T_n^2}{4\pi^2} \right)$$

$$W = \frac{18000\,lb}{ft} \cdot \frac{32.2}{sec} \left(\frac{(1.9576)^2}{(4(3.14)^2} \right)$$

$$\boxed{W = 56319.268}\ klb$$

"e"

Damping Co-efficient : $C = ?$

It is know that $\zeta = \frac{c}{2m\omega_n}$

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

By putting value.

$$C = 0.049\left(2\left(\frac{56319.26}{32.2}\right)\frac{\left(2\cdot(3.14)\right)}{1.9576}\right)$$

$$\boxed{C = 594.87} \text{ lb.sec/ft.}$$

(f) No of cycle to reduce displacement altitude form 7.783 to 0.5 in

$j = ?$

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

$$= \frac{1}{2(3.14)(0.049)}\ln\left(\frac{7.783}{0.5}\right)$$

$$= 7.01 \quad \text{"OR"}$$

$$\boxed{J = 7\text{cycle}}$$

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