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Sec :- "A"

Subject :- Intro to Structure Dynamic & Earthquake Engg:

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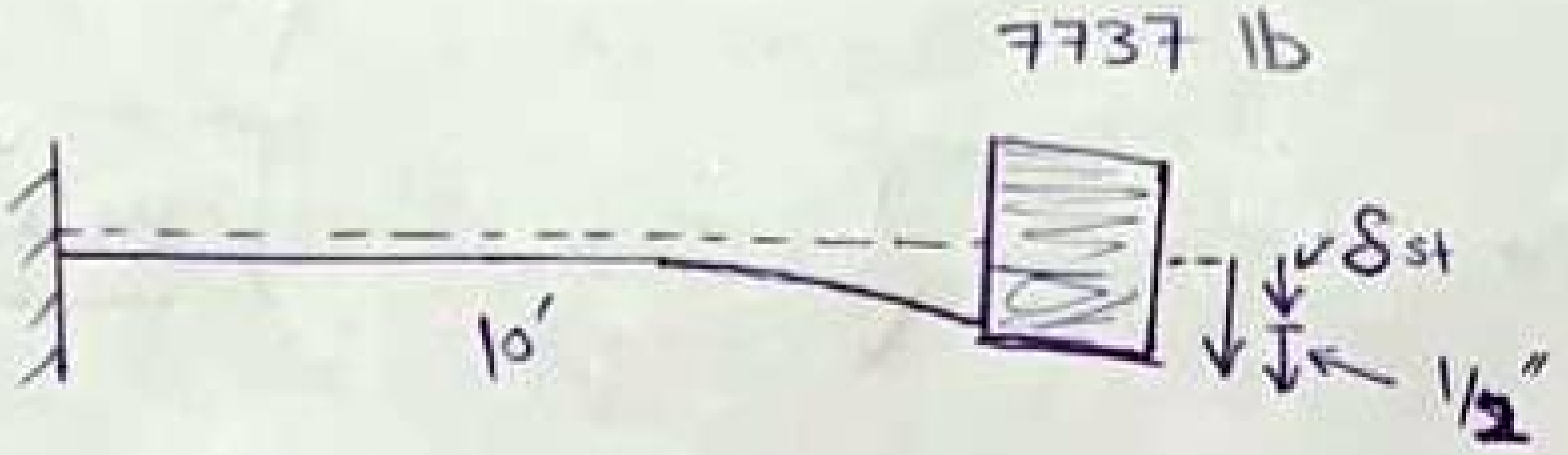
QNo 1 :-

Given Data :-



$L = 10'$

$E = 29000$ Ksi

$I = 150 \ in^4$ δ_{st}

Deflection due to 7737 lb

Solution :-

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

In our case System is undamped $(c=0)$ undergoing free Vibration. $P(t) = (0)$

Hence General EOM become $Ku + m\ddot{u} = 0 \rightarrow (1)$

$$K = 3EI/L^3$$

$$= \frac{3 \times (29000 \frac{k}{in^2})(150) in^4}{(10 \times 12 \ in)^3}$$

$$= 7.55 \ k/in$$

In order to eliminate the chances of mistakes of during Calculation, it is appropriate to use fundamental units like lb, ft Sec or kg, m, Sec

$$K = 7.55 \ k/in = (7.55) \times (1000)(12)$$

$$\boxed{K = 90625 \ lb/ft}$$

P(2)

$m = \frac{w}{g} = \frac{7737}{32.2} = $ **240.28 Slug**

$w_n = \sqrt{K/m} = \sqrt{\frac{90625}{240.28}}$

$w_n = 19.42$ rad/sec

$T_n = \frac{2\pi}{w_n} = \frac{2\pi}{19.425} = $ **0.323 Sec**

Put m & K in eq (1)

where K is in lb/ft & m is

lb Sec/ft

⇒ General Solution to EOM for undamped free Vibration,

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

$u(t) = \frac{1}{24} \cos(19.425 t) + 0 =$

$= 1/24 \times \cos 19.42 t$

Equivalent Static force at any time is

$f_s(t) = K \cdot u(t) = \frac{90625 \times \cos(19.425 t)}{24}$

$= 3776 \cos(19.25 t)$

Amplitude of dynamic displacement u_0 for undamped free Vibration is

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

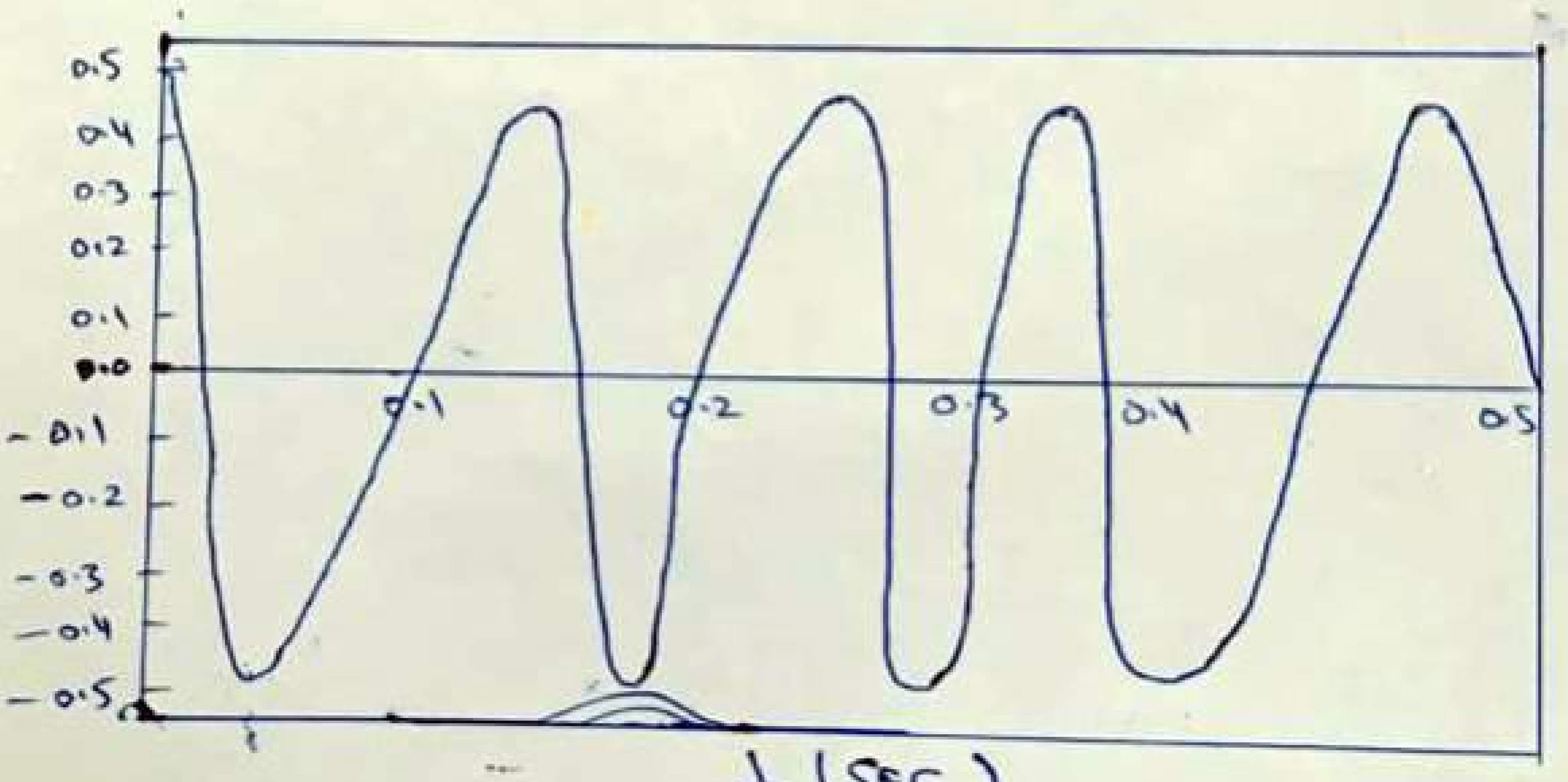
$$= \sqrt{(1/24)^2 + 0}$$

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

Amplitude of Equivalent Static force f_{s0}.

$$Ku_0 = 90625 \times \frac{1}{24}$$

$$\boxed{Ku_0 = 3776}$$



Variation of displacement

Q No 2 P(4)

Given Data

ξ (Damping ratio) of reinforced Concrete with Considered Craking $= 3-5\% = 3\%$

Required Data :-

Develop and Solve the Equa Showing Variation in equivalent Static force with time.

→ Draw graph to Show the Variation of displacement with time the Variation of equivalent Static force with time.

Solution :-

EOM for damped force Vibration

$$Ku + C\dot{u} + m\ddot{u} = 0 \longrightarrow (1)$$

from data,

$K = 90625$ lb/ft

$\omega_n = 19.36$ or 20 rad/sec

$m = 240.28$

We know that

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

$$= (0.03) \times 2(240.28)(19.42)$$

$$\boxed{C = 279.97} \text{ or } 280 \text{ lb-Sec/ft}$$

Put the Value of Eq (1)

$9\,0625u + 280.76u + 240.28$

Solution to the EOM from damped free Vibration is.

$$u(t) = e^{\zeta w_n t}\left[u(0)\cos(w_D t) + \frac{1}{w_D}\left[\dot{u}(0) + u(0)\,\zeta' w_n\right] \sin w_D t\right]$$

$$\boxed{w_D = 19.36 \text{ rad/sec}}$$

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

$$u(t) = e^{-0.50808t}\left[0.041 \times \cos(19.36) + 0.0516 \times \sin(19.36t)\right]$$

$$f_s(t) = K \cdot u(t) \Rightarrow 90625 \times u(t)$$

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

$$f_s(t) = e^{-0.5808}\left[3715.62 \cos(19.36t) + 90625 \cdot 0516 \sin 19.36t\right]$$

Q No3

Given Data :-

Force = 60 Kips

U_s = 7737/1000 = 7.737 in

After J = 7 (Cycles)

Completed = 3.57 Sec

U_{J+1} = 2.286 cm = 0.9 in

Ignore the Vertical Vibration

Required :-

→ Damping ratios
→ Natural Period of undamped Vibration
→ Stiffness of Structure
→ Weight of tank
→ Damping Coefficient

etc

Solution

(a) ζ = Damping ratio = ?

As: $\delta = \frac{1}{2\pi\zeta} \ln\left|\frac{u_1}{u_{j+1}}\right|$

By Putting Value

$$7 = \frac{1}{2(3.14)\zeta} \ln\left|\frac{7.737}{0.9}\right|$$

$$\zeta(7 \times 2 \times 3.14) = 2.151$$

$$\zeta(43.96) = 2.151$$

$$\zeta = 2.151/43.96$$

$$= 0.0489$$

$$\zeta = 4.89\%$$

(b) $T_n = ?$

As 7 Cycle completed in 3.57 Sec
thus time required to Complete
one Cycle = 7/3.57 = 1.96 Sec

$$T_D = 1.96 \text{ Sec}$$

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

$$= 1.96(\sqrt{1-(0.0489)^2})$$

$$T_n = 1.957 \text{ Sec}$$

Natural Period of undamped Vibration

(c) Stiffness of Structure
"K=?"

As = $K = \frac{F \cdot \cos\theta}{2}$

$$K = \frac{60 \cos 60^\circ}{2}$$

$= 15K/in$

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

(d) weight of tank "W=?"

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

$$\omega^2 = k \cdot g / W \Rightarrow W = k \cdot g / \omega_n^2$$

By Putting Value of $\omega_n = 2\pi / T_n$

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

$$W = 12000 \frac{lb}{ft} \quad 32.2 \frac{ft}{sec} \left(\frac{(1.957)^2}{4(3.14)^2} \right)$$

$$W = 56284.75 \ lb = \boxed{56.284 \ klb}$$

(e) Damping Coefficent "C=?"

It is know that

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

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

By Putting Value

$$C = 0.0489 \frac{\left(2\left(\frac{56284}{32.2}\right)\right)\left((2)(3.14)\right)}{1.957}$$

$$\boxed{C = 548.57 \ lb\text{-}sec/ft}$$

(f) "No of Cycles to reduce displacement altitude from "7.737 In to 0.5 In"

$J = ?$

$$J = \frac{1}{2\pi \zeta} \ln \left| \frac{u_1}{u_{J+1}} \right|$$

$$= \frac{1}{2(3.14)(0.0489)} \ln \left| \frac{7.737}{0.9} \right|$$

$$= (3.256)(2.151)$$

$$= 7.004 \quad \text{OR}$$

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