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SECTION = A

SUBJECT = Earth Quake Engineering

Date = 28/06/2020

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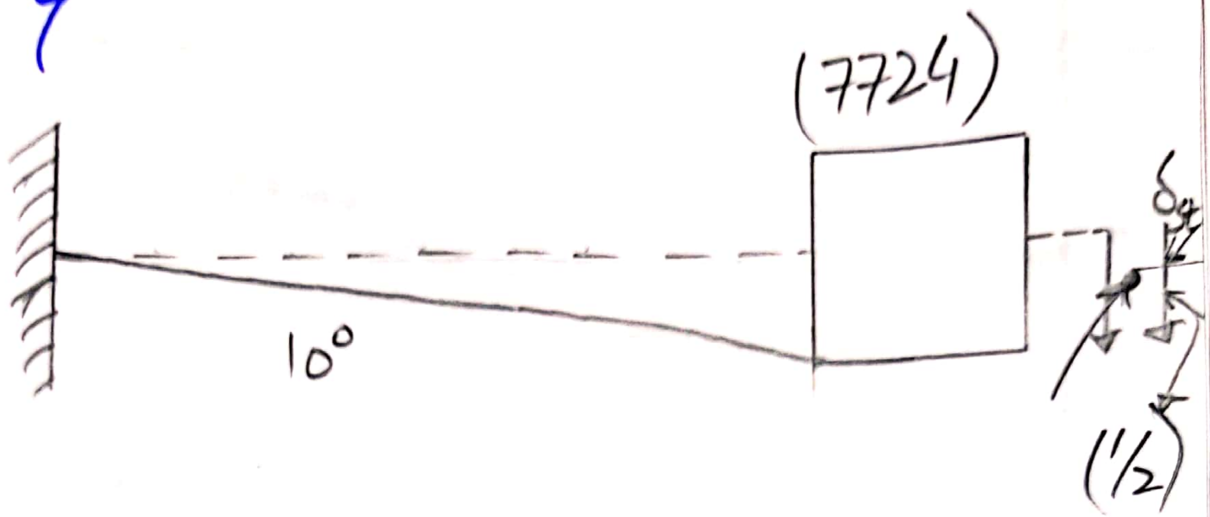
#01

Q No. #01:-



GIVEN DATA:-

$E = 29,000$ ksi

$I = 150$ in^4

δ_{st} = deflection (7724) lb

SOLUTION:-

The General E.O.M for SDOF System is.

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

#02

In our system it's undamped ($c = 0$) undergoing free vibration ($P(t) = 0$)

→ Hence General E.O.M becomes

$k u + m \ddot{u} = 0$ ——→ (ii) ——— (1)

→ $K = 3EI/L^3$

→ $K = \dfrac{3 \times 29{,}000 \frac{K}{in^2} * 150\ in^4}{(10 \times 12\ in)^3}$ $K = 7.55\ K/in$

In Order to eliminate the chances of mistakes during calculation it is more appropriate to use fundamental units like lb, ft sec or kg, m, sec.

→ $K = 7.55\ K/in = 90625\ lb/ft$ ~~90625 lb/ft~~

→ $m = \dfrac{7724\ lb\,sec^2}{32.2\ ft} = 239.875\ Slug$

Abasusey

③

#03

$$\omega_n = \sqrt{K/m} = \sqrt{\frac{90625}{239.875}}$$

$$\omega_n = 19.437 \text{ rad/sec}$$

$$\Rightarrow T_n = 2\pi/\omega_n \Rightarrow 2\pi/19.437$$

$$\Rightarrow T_n = 0.323 \text{ Sec}$$

⇒ Substituting the Corresponding value in eq # (ii)

~~⇒ 90625u + 240.44 =~~

$$\Rightarrow 90625u + 239.87\ddot{u} = 0$$

⇒ Where K is in lb/ft & (m) is in lb Sec/ft².

General Solution to the E.O.M

4

#04

For undamped Free Vibration is;

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

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

$$u(t) = \frac{1}{24} \times \cos(19.437t) + 0$$

$$= \frac{1}{24} \times \cos(19.437t)$$

Equivalent Static Force at any Time (t) is;

$$f_s(t) = K.u(t) = \frac{90625 \times \cos(19.437t)}{24}$$

$$f_s(t) = (3776.04 \times \cos 19.437t)$$

$$f_s(t) = 3560$$

S

#05

* Amplitude of dynamic displacement u_0 for undamped free vibration is.

$$u_0 = \sqrt{(u(0))^2 + \left(\frac{\dot{u}(0)}{\omega_n}\right)^2} = \sqrt{\left(\frac{1}{24}\right)^2 + 0}$$

$$\boxed{u_0 = \frac{1}{24}\ ft}$$

* Amplitude of equivalent static force. f_{so}.

$$\Rightarrow K u_0 = 90625 \times \frac{1}{24}$$

$$\boxed{3776.04}$$

END #Q01

#06

Q#02

ζ (Damping ratio) of Reinforced Concrete with Considerable Cracking?

⇒ 3-5%

⇒ 3%

using Data of beam given in Q#01

Required: ⇒ Develope & Solve the equation showing variation in Equivalent Static Force with time

⇒ Draw graph to show the variation of displacement with time & the variation.

#07

Q Equivalent Static Force with time.

Solution: E.O.M for Damped free variation is

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

For Question (1)

$K = 90625$ lb/ft

$m = 239.875$ slug

$\omega_n = 19.437$ rad/sec

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

$C = (0.03) \times 2 (239.875) \times (19.437)$

$$C = 279.747 \text{ lb sec/ft}$$

Put value in eq → (1)

#08

⇒ $Ku + C\dot{u} + m\ddot{u} = 0$ — ① put value

⇒ $9062.5u + 279.747 + 239.875 = 0$

~~⇒ $f_s(t) = K.u(t)$~~

Solution to the EOM for Damped free vibration is

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

~~ω_D~~ ⇒ $\omega_D = 19.437$ rad/sec

$u(t) = e^{-0.03 \times 19.425t}\left[\frac{1}{24} \times \cos(19.425t) + \frac{1}{19.425} \times \left[0 + \frac{1}{24} \times 0.03 \times 19.425\right] \times \sin(19.425t)\right]$

$u(t) = e^{-0.0582t}\left[0.041 \times \cos(19.425t) + 0.00125 \times \sin(19.425t)\right]$

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#09

$\Rightarrow f_s(t) = e^{-0.582t}\left[(90625 \times 0.041)\cos(19.425t) + (90625 \times 0.00125)\sin(19.425t)\right]$

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

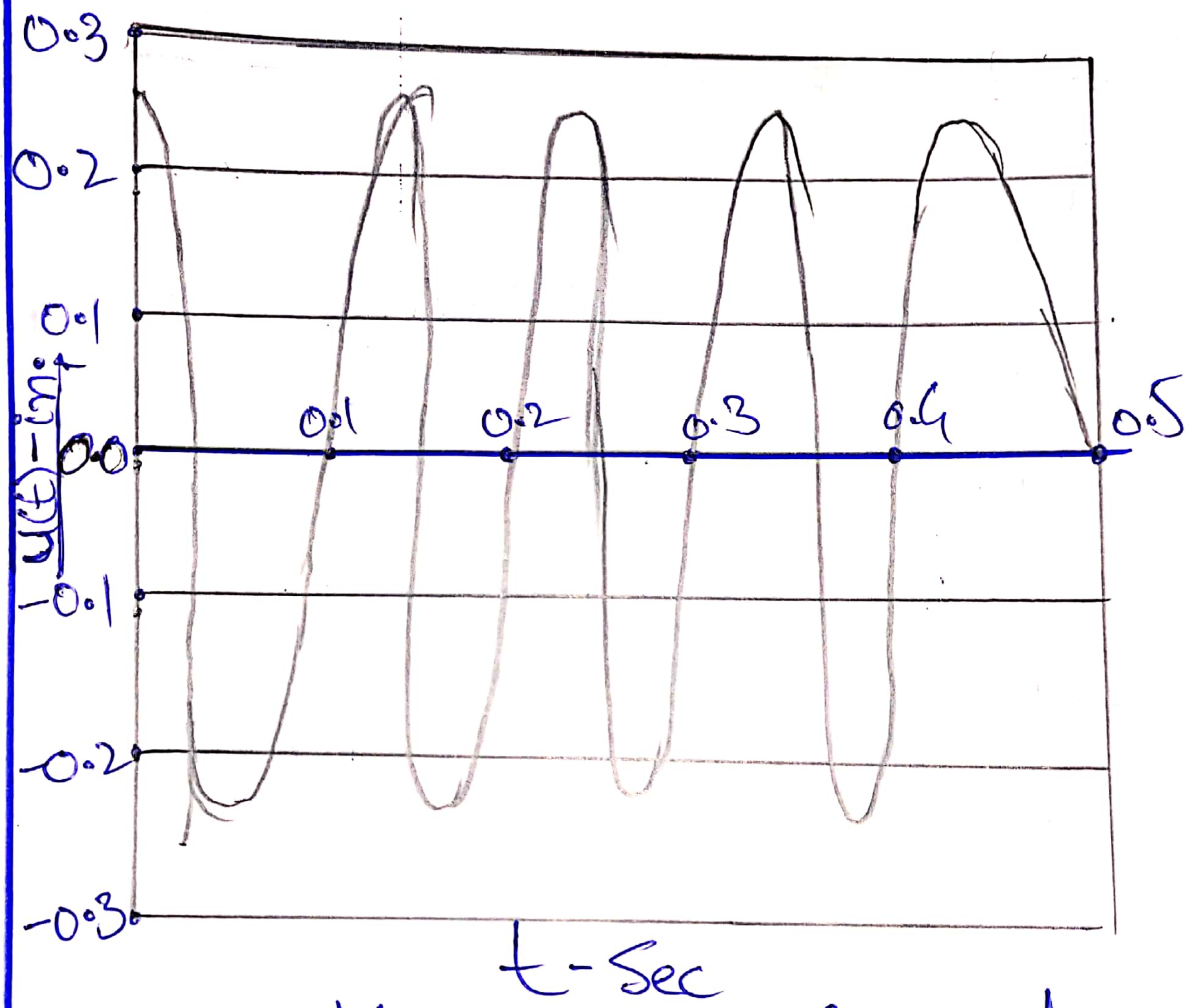
$\Rightarrow f_s(t) = e^{-0.582t}\left[(90625 \times 0.04)\cos(19.425t) + (90625 \times 0.00125)\sin(19.425t)\right]$

$\Rightarrow f_s(t) = e^{-0.582t}\left[3715.62\cos(19.425t) + 113.28\sin(19.425t)\right]$

(END #09)

#Q10

Undamped Free Variation:-

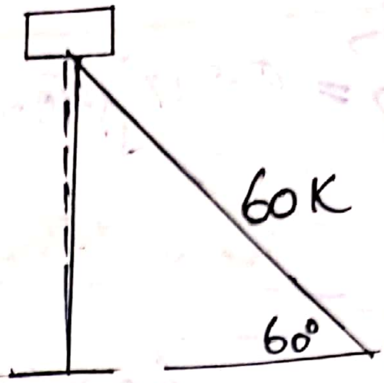


Variation Displacement with Time.

01

#011

Q#03



Given DATA:-

Force of = 60 Kips

displace The Tank by = 7.74 in

ate the end of = 7 cycle

which Complete of = 3.57 sec

Amplitude of displacement = 2.286 cm → 0.9 in

Required DATA:-

↳ Complete the following

1. Damping ratios.
2. Natural periods of undamped vibrations.
3. Stiffness of Structures.

#12

4 → weight of Tank.

5 → Damping Co-efficient.

6 → Number of Cycles to reduce the displacement amplitude 0.5"

8 →

Solutions:→ It given in eq,

$u_1 = 7.724$ in

after $J = 7$,

$u_{j+1} = u_B = 2.286$ cm $= 0.9$ in

3(A) → Damping Ratio:→

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

→ By puttings values we get;

→ $7 = \frac{1}{2\pi 7} \ln\left(\frac{7.724}{0.9}\right)$

03

#13

$\zeta = 0.0488 = 4.88\%$

$\zeta = 4.88\%$ Answer.

3 (B) Natural of period of undamped vibrations $T_n = ?$

⇒ 7 Cycle of Vibration = 3.57 Sec

⇒ Time required to complete on cycle = 3.57/7

⇒ $T_D = 0.51$ Sec Damping Time Period.

Now:

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

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

(3) ⇒ $T_D = \frac{T_n}{\sqrt{(1-\zeta^2)}}$ (4) ⇒ $T_n = T_D \times \sqrt{1-\zeta^2}$

(5) ⇒ $T_n = 0.51 \times \sqrt{1 - \frac{(0.0488)^2}{4\pi^2}}$

#04

$T_n = 0.51 \times \sqrt{1-(0.0488)^2}$ $\boxed{T_n = 0.5093 \text{ second}}$ Answer.

3(C) ⇒ Stiffness Of Structure; (K) = ?

$$K = \frac{60 \times \cos 60^\circ}{7.724}$$

$K = 3.883$ K/in

$K = 46596$ lb/ft Answer.

3(D) ⇒ Weight of Tank; (W) = ?

$$\Rightarrow \omega_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{K}{\left(\frac{W}{g}\right)}} = \sqrt{\frac{K \cdot g}{W}}$$

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

$\Rightarrow W = K \times g / \omega_n^2$ ⇒ Also $\left(\omega_n = 2\pi / T_n\right)$

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

$$\Rightarrow W = Kg \times \frac{T_n^2}{4\pi^2}$$

05/

15

$\Rightarrow W = \frac{46596}{ft} \times \frac{32.2\,ft}{sec^2} \times \frac{(0.51\,sec)^2}{4\pi^2}$

$\Rightarrow W = 19882.73\,lb \Rightarrow$ 19.88 Answer.

#3(E): Damping Coefficient: (c = ?)

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

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

$$\Rightarrow c = \frac{0.0488 \times 4 \times \pi \times \frac{19882.73}{32.2}}{0.51}$$

$\Rightarrow c = 594002.496\,lb.sec/ft$ Answer.

#3(F): No. of Cycle to reduce the displacement amplitude from (7 in) to (0.5 in). (J = ?)

8 # 16

$$\to T = \frac{1}{2\pi\tau} \ln\left[\frac{U_1}{U_{j+1}}\right]$$

$$\to T = \frac{1}{2\times\pi\times 0.0488} \ln\left[\frac{7.724}{0.5}\right]$$

$$\to T = 8.90 \text{ or } 9 \text{ cycle.}$$

(End #03)