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Question = 1 :

ANSWER :

GIVEN DATA:

-> length of beam = L = 16'
-> beam pulled in downward direction = 1/2"
-> E = 29000 Ksi
-> I = 150 in"
-> f_{st} = 7690 lb
- Ignore self weight and damping effects

REQUIRED:

① Natural time period = ?
② develop & solve equation of motion for vibrations at free end = ?
③ Develop equation showing variation in the equivalent static force with time = ?
④ Camplitude of equivalent ~~of~~ static force = ?

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(3) Graph = ?

SOLUTION:

The general E.O.M for SDOF system is

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

undamped system (c=0) undergoing free vibration P(t) = 0

So general E.O.M become

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

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

$$K = \frac{3 \times 29000 \times 150}{(10 \times 12)^3}$$

$$\boxed{K = 7.55 \text{ K/in}}$$

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In order to eliminate the chances of mistakes during calculation, it is more apropriote to use fundamental unit like lb, ft or Kg, m, sec

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

$$m = \frac{7690\ lb\ sec^2}{32.2} = 238.20\ slug$$

$$\omega_n = \sqrt{K/m} = \sqrt{\frac{90625}{238.20}}$$

~~$\omega_n = 20$ rad/sec~~

$$\boxed{\omega_n = 19.5\ rad/sec}$$

$$\tau_n = 2\pi/\omega_n = 2\pi/19.5 = 0.318\ sec$$

Putting value in eq (i)

$$\boxed{90625\,u + 238.20\,\ddot{u} = 0}$$

Where K is in lb/ft and m is in lb sec/ft

General solution to the E.O.M for undampled free vibration is,

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

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

$u(t) = (1/24) \times \cos(20t) + 0$

$u(t) = (1/24) \times \cos 20t$

Equivalent static force of any time "t" is

$f_s(t) = K \cdot u(t) = \frac{90625 \times \cos(20t)}{24}$

$f_s(t) = 3776 \cos(20t)$

Amplitude of dynamic displacement, U_0 for undamped free vibration is

$U_0 = \sqrt{(u(0))^2 + (\dot{u}(0)/\omega_n)^2}$

$$u_0 = \sqrt{\left((1/24)^2 + 0 \right)}$$

$$\boxed{u_0 = 1/24 \text{ ft}}$$

Amplitude of equivalent static force

f_{s0}

$$K u_0 = 90625 \times 1/24$$

$$\boxed{K u_0 = 3776 \text{ lb}}$$

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Question = 2:

ANSWER:

GIVEN : DATA:

Use required data from question "01"

REQUIRED : DATA:

① develop and solve the eq of motion for vibration resulting at free end.

② Develop eqs showing variation in equivalent static force with time.

③ Draw Graph to show the variation of displacement with time and variation of equivalent static for with time

SOLUTION:

Damping ratio of Rec.

Min = 0.80 %, Average = 1.3 %

So we consider 1.3 %

ξ = 0.M for damped free vibration.

$Ku + C\dot{u} + m\ddot{u} = 0$ → eq ①

from prob Ⓐ

K = 90,625 lb/ft

m = 238.20 $lb \cdot sec^2/ft$

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

C = 2 × 238.20 × 20 ~~.5~~ × 0.013

$c = 124.86$ lb/ft

Putting value of k, m and c in eq (A)

(A) = $90625u + 124.86\dot{u} + 238.20\ddot{u} = 0$

Solution to the E.O.M. for damped free vibration

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

~~u(t) = e^{-ζωnt}~~ $\omega_D = 20$ rad/sec

$$u(t) = e^{-0.013\times 20t}\left[\frac{1}{24}\times\cos(20t) + \frac{1}{20}\times\left[0 + \frac{1}{24} + 0.013\times 20\times \sin(20t)\right]\right]$$

$$u(t) = e^{-0.26t}\left[0.041\times\cos(20t) + 0.00054\,\sin 20t\right]$$

$V_s(t) = k \cdot u(t) = 90{,}625 \times u(t)$

$V_s(t) = e^{-0.2\alpha}\left[3715 \cos(20t) + 49.08 \sin(20t)\right]$

QUESTION = 3 :

ANSWER:

GIVEN DATA:

* Displacement = 7690/1000 = 7.69"
* Force = F = 60 kips
* [illegible]
* no of cycle 7 are complete in 3.57 sec.
* Amplitude = 2.286 cm = 0.9"
* Iguore vertical vibration.

REQUIRED DATA:

a, Damping ratio
b, Natural period of un damped vibration
c) stiffness of structures
d, Weight of tank
e, Damping co-efficient.
f). No of cycles to reduce displacement to 0.5"

SOLUTION:

$u = 7.73''$

After $j = 7$, $u_{j+1} = 48 = 0.9''$

(a) δ = damping ratio = ?

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

$$7 = \frac{1}{2\pi\delta} \ln(7.73/0.9)$$

$$\delta = \frac{2.15}{2\pi(7)}$$

$$\boxed{\delta = 0.0488 = 4.88\%}$$

(b) $T_n = ?$

7 cycles of vibration are completed in 3.57 sec.

Now

Time required to 1 cycle = T_D

$= 3.57/7$

$T_D = 0.51$ sec

Now

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

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

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

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

$T_n = 0.51 \times \sqrt{1-(0.0488)^2}$

$\boxed{T_n = 0.5093 = 0.51 \text{ sec}}$

c) $K = ?$

$K = \dfrac{60 \times \cos 60^\circ}{2} = 15$ k/u

$K = 13600$ lb/ft.

(2) Weight of tank, w = ?

$\omega_n = \sqrt{K/m} = \sqrt{\frac{K}{w/g}} = \sqrt{\frac{K \times g}{w}}$

$\omega_n^2 = \frac{K \times g}{w}$

$W = \frac{K \times g}{\omega_n^2}$

Also $\omega_n = 2\pi / T_n$

$W = \frac{K \times g}{4\pi^2 / T_n^2}$

$W = K \times g \times \frac{T_n^2}{4\pi^2}$

$W = 13600 \times 32.2 \times \frac{(0.51)^2}{4\pi^2}$

$W = 3218.64$ lb $= 3.21$ k

(e) $c = ?$

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

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

$c = \zeta \times 2m\,(2\pi / T_n)$

$c = 0.0488 \times 2 \times \left(\frac{3818.64}{32.2}\right)\left(\frac{2\pi}{0.5}\right)$

$c = 142.59$ lb·sec/ft

(f) No of cycle to reduce displacement amplitude from 7.69" to 0.5", $j = ?$

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

$j = \frac{1}{2\pi \times 0.0488} \ln \left[\frac{7.69}{0.5}\right]$

$j \doteq 8.93$ or 9 cycles