IQRA NATIONAL UNIVERSITY PESHAWER

# PAPER

# INTRODUCTION TO EARTHQUAKE ENGINEERING

**B-tech(civil)**

**6th semester**


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**Q.NO.**

**(a)**

(Q No: 1)

(a) Given :-

$E = 28000$ ksi

$I = 1400$ $in^4$

$d = 20ft$

$h_1 = 17ft = 17 \times 12 = 204in$

$h_2 = 14ft = 14 \times 12 = 168in$

~~Equiv~~

Required:-

lateral stiffness of the frame.

Solution :-

Equivalent stiffness of system

$k_{eq} = k_1 + k_2$

$$k = \frac{12EI}{h_1^3} + \frac{12EI}{h_2^3}$$

$$k = 12EI\left[\frac{1}{h^3} + \frac{1}{h^3}\right]$$

$$= 12 \times \left(28000\ \text{k/in}^2\right) \times 1400) \left[\frac{1}{(204)^3} + \frac{1}{(168)^3}\right]$$

$$= 470{,}400{,}000 \times 3.286 \times 10^{-7}$$

$$K = 154.61\ \text{k/in}$$

$$\boxed{K = 1855.32\ \text{k/ft}}$$

**Q.NO.1**

**(b)**

Q # 1

(b) Given:-

$E = 29000$ ksi

$K_{spring} = 300$ lb/ft

$l = 12$ ft

dia $= 4$ in

Required:

Equivalent ~~lateral~~ stiffness $K_{eq} = ?$

Solution.

$\therefore k_1 = 300$

$$k_2 = \frac{3EI}{l^3}$$

$$= \frac{(29000\ k/in^2)\left(\frac{\pi}{64} \times (4)^4\right)}{(12 \times 12)^3}$$

$$= \frac{87000 \times \frac{3.142}{64} \times 256}{(144)^3}$$

$$= \frac{109270}{2985984}$$

$$K_2 = 0.365 \ K/in^2$$

$$0.365 \times 1000 \times 12$$

$$K_2 = 4391 \ lb/ft$$

Equivalent stiffness of system

$$K_{eq} = \frac{K_1 * K_2}{K_1 + K_2}$$

$$= \frac{300 \times 4391}{300 + 4391}$$

$$= \frac{1317300}{4691}$$

$$\boxed{K_{eq} = 280.81 \ lb/ft}$$

**Q.NO 2:**

Given: mass = 500 kg

Halmoni Force = $p(t) = 5000 \times \sin \times 150 \times t$ in N

Damping Ratio, $\xi = 7\% = 0.07$

Force Frequency = $w = 150$ rad/sec

Amplitude, $p_0 = 5000$ N

Transmissibility = $T_R = 0.15$

Require.

Force Transmitted: Amplitude $= (f_{T0}) = ?$

Stiffness = $k = ?$

Solution:

$$T_R = \frac{f_T}{P_0} = \sqrt{\frac{1 \times (2\xi r w)^2}{(1-rw^2)^2 + (2\xi rw)^2}} \quad (1)$$

$$T_R = \sqrt{\frac{1 + (2\xi rw)^2}{(1+rw^2)^2 + (2 \times \xi \times rw)^2}}$$

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(2)

$$(0.15)^2 = \left(\sqrt{\frac{1+(2\times0.07\times r\omega)^2}{(1-r\omega^2)^2+(2\times0.07\times r\omega)^2}}\right)^2$$

$$0.0225 = \frac{1+(2\times0.07\times r\omega)^2}{(1-r\omega)^2+(2\times0.07\times r\omega^2}$$

$$0.0225 = \frac{1+0.0196\times r\omega^2}{(1-r\omega^2)^2+0.0196\times r\omega^2}$$

Put $= r\omega^2 = x$

$$0.0225 = \frac{1+0.0196\times x}{(1-x)^2+0.0196x}$$

$$0.0225 = \frac{1+0.0196x}{1+x^2-2x+0.0196x}$$

$$0.0225 = \frac{1+0.0196x}{x^2-1.9804+1}$$

$$x^2 - 1.9804x + 1 = \frac{1 + 0.0196x}{0.0225}$$

$$x^2 - 1.9804x + 1 = \frac{1}{0.0225} + \frac{0.0196x}{0.0225}$$

$$x^2 - 1.9804x + 1 = 44.43 + 0.8711x$$

$$x^2 - 1.9804 - 0.8711x + 1 - 44.43 = 0$$

$$x^2 - 2.8514x - 43.44 = 0$$

<u>Now</u> used quadratic formula

$$= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$a = 1$

$b = -2.8514$

$c = 43.44$

$$= \frac{-(-2.8514) \pm \sqrt{-(-2.8514)^2 - 4(1)(-43.44)}}{2(1)}$$

$$x_1 = \frac{2.8514 + 13.47}{2}$$

(4)

$$= \frac{16.33}{2}$$

$$\boxed{x = 8.16}$$

$$r\omega^2 = 8.16$$

$$\sqrt{r\omega^2} = \sqrt{8.16}$$

$$r\omega = 2.85$$

$$r\omega = \frac{\omega}{\omega_n}$$

$$2.85 = \frac{150}{\sqrt{\frac{k}{m}}}$$

$$\sqrt{\frac{k}{m}} = \frac{150}{2.85}$$

$$\left(\sqrt{\frac{k}{500}}\right)^{\cancel{2}\,2} = (52.26)^2$$

$$K = 273.1 \times 500$$

$$\boxed{K = 13638966\ N/m}$$

Put all the values in eq (1)

$$0.15 = \frac{(f_{TO})}{5000}$$

$$f_{TO} = 0.15 \times 5000$$

$$\boxed{f_{TO} = 750}$$

**Q.NO.3**

Q#3. (1)

Given:

Mass = m = 3kg

Harmonic Force = P(t) = 25 sin 75t N

$U_o$ = 0.005m

Modulus of Elasticity $E_{AL}$ = 70 Gpa

$70 \times 10^9$ pa

Amplitude = $P_o$ = 25N

Force Frequency = 75 rad/sec.

Required- diameter = d = ?

Solution

For Undamped Structure

$$R_d = \frac{U_o}{(U_{st})_o} = \frac{1}{1-r_\omega^2} \quad \text{— (1)}$$

$$(U_{st})_o = \frac{P_o}{k} \Rightarrow U_{st_o} = \frac{25}{K}$$

$$\omega_n = \sqrt{\frac{k}{m}} = \omega_m = \frac{k}{3}$$

Natural Frequency.

$$\text{Frequency Ratio} = r_w = \frac{\omega}{\omega_n} = \frac{75}{\sqrt{\frac{k}{m}}}$$

$$= \frac{75 \times \sqrt{3}}{\sqrt{3}}$$

Put the value of $(u_{st})_0$ and $r_w$ in eq ①

$$\frac{U_0}{U_{st_0}} = \frac{1}{1 - r_w^2}$$

$$\frac{0.005}{\frac{25}{k}} = \frac{1}{1 - \left(\frac{75 \times \sqrt{3}}{\sqrt{k}}\right)^2}$$

$$0.005\left(1 - \frac{75 \times \sqrt{3}}{k}\right)^2 = \frac{25}{k}$$

$$0.005 \times \left(1 - \left(\frac{16875}{k}\right)\right) = \frac{25}{k}$$

$$0.005 - \frac{84.375}{k} = \frac{25}{k}$$

$$= \frac{84.375}{k} + \frac{25}{k}$$

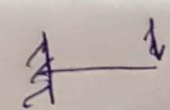
$$0.005 = \frac{109.375}{k}$$

$$k = \frac{109.375}{0.005}$$

$$\boxed{k = 21875\ N/m}$$

Now :

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



$$I = \frac{kL^3}{3E}$$

$$I = \frac{21875 \times (0.5)^3}{3 \times 70 \times 10^9}$$

(14)

$$I = \frac{2734.375}{2.1 \times 10^{11}}$$

$$\boxed{I = 1.30 \times 10^{-8} \, in^4}$$

So:

$$I = \frac{\pi}{64} \times d^4$$

$$d = \left(\frac{I \times 64}{\pi}\right)^{\frac{1}{4}}$$

$$= \left(\frac{(1.30 \times 10^{-8})(64)}{3.14}\right)^{\frac{1}{4}}$$

$$d = 0.0221 \, m$$

$$d = 0.022 \times 1000$$

$$\boxed{d = 22 \, mm}$$

Q.NO.(04)

What is meant by Plate boundaries and explain different types of Plate boundaries along with diagrams.

**Plate boundaries**

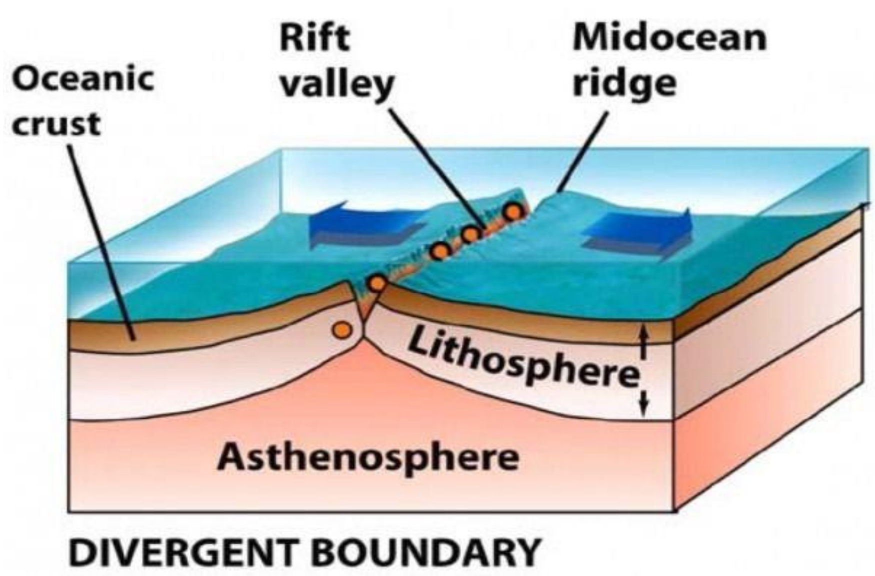
Plate boundaries are the edges where two plates meet. Most geologic activities, including volcanoes, earthquakes, and mountain building, take place at plate boundaries

There are three types of plate tectonic boundaries: divergent, convergent, and transform plate boundaries.

1. Divergent plate boundaries: the two plates move away from each other.
2. Convergent plate boundaries: the two plates move towards each other.
3. Transform plate boundaries: the two plates slip past each other.

## 1. Divergent plate boundaries

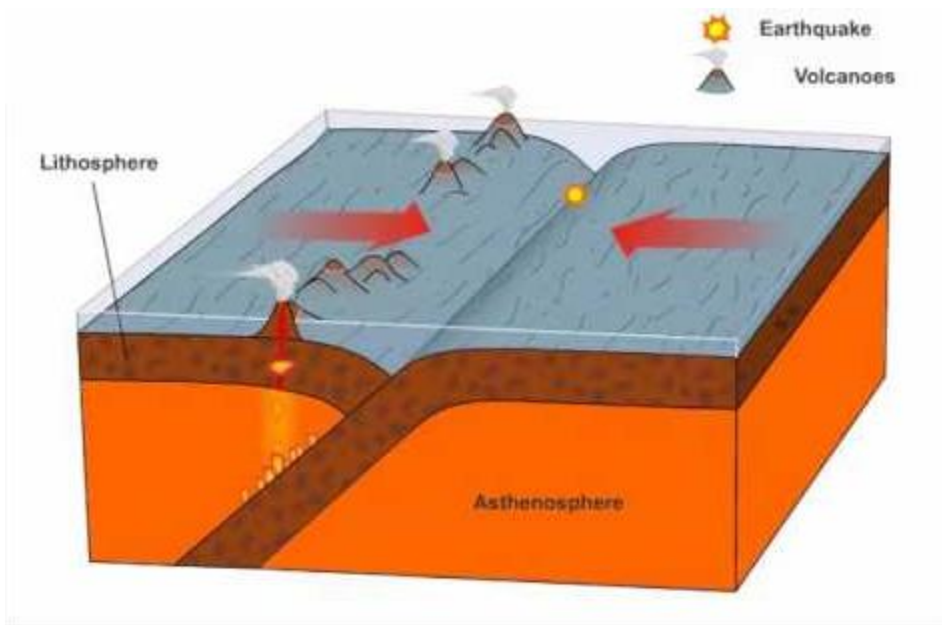
A **divergent boundary** occurs when two tectonic plates move away from each other. Along these boundaries, earthquakes are common and magma (molten rock) rises from the Earth's mantle to the surface, solidifying to create new oceanic crust.




## 2. Convergent plate boundaries

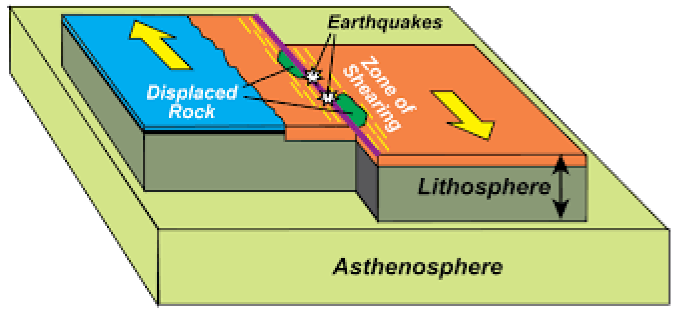
When two plates come together, it is known as a **convergent boundary**. The impact of the colliding plates can cause the edges of one or both plates to buckle up into a mountain ranges or one of the plates may bend down into a deep seafloor trench. A chain of volcanoes often forms parallel to convergent plate boundaries and powerful earthquakes are common along these boundaries.

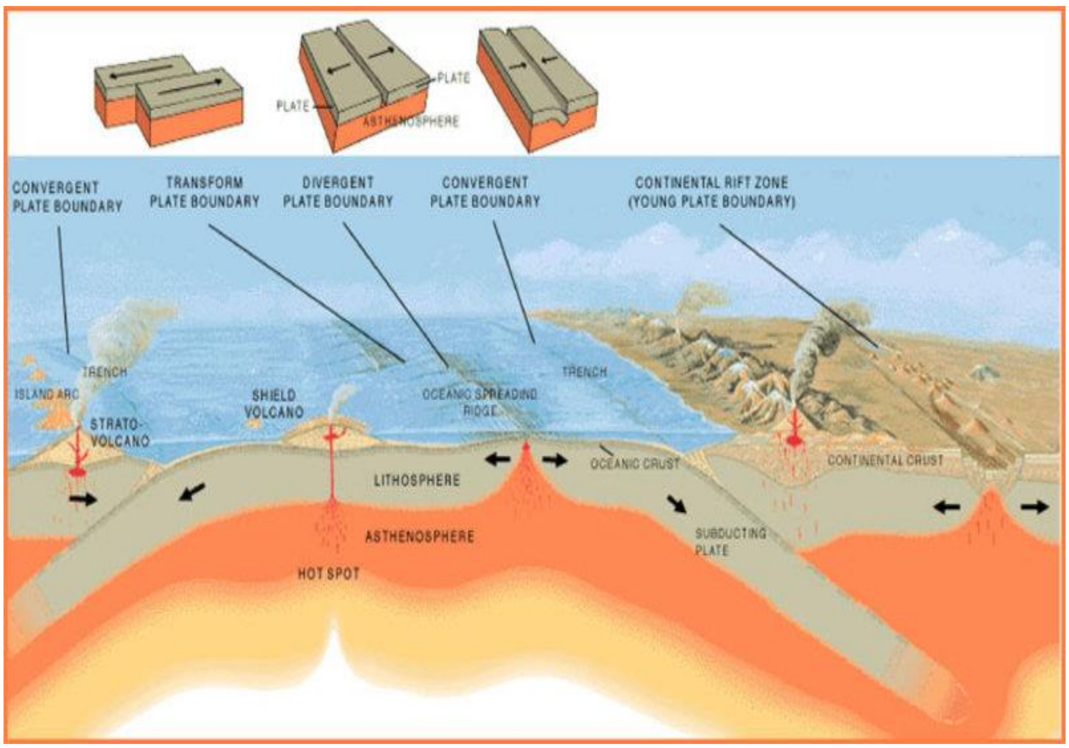
At convergent plate boundaries, oceanic crust is often forced down into the mantle where it begins to melt. Magma rises into and through the other plate, solidifying into granite, the rock that makes up the continents. Thus, at convergent boundaries, continental crust is created and oceanic crust is destroyed.




3. **transform plate boundary**

Two plates sliding past each other forms a **transform plate boundary**. Natural or human-made structures that cross a transform boundary are offset—split into pieces and carried in opposite directions. Rocks that line the boundary are pulverized as the plates grind along, creating a linear fault valley or undersea canyon. Earthquakes are common along these faults. In contrast to convergent and divergent boundaries, crust is cracked and broken at transform margins, but is not created or destroyed.



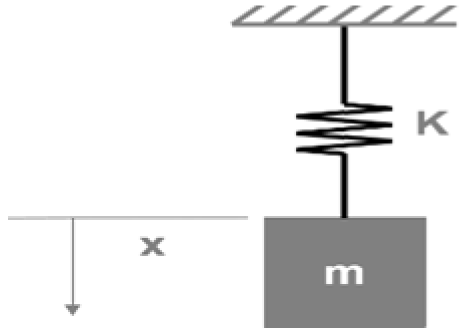

Q.NO.(05)

What is meant by degree of freedom and differentiate between continuous and discrete systems.

**Degrees of freedom (DOF)**

Degrees of freedom (DOF) of a system is defined as the number of independent variables required to completely determine the positions of all parts of a system at any instant of time.

It is defined as minimum number of parameters used to define a system.




## Continuous system

Some systems, especially those involving continuous elastic members, have an infinite number of DOF. As an example of this is a cantilever beam with self-weight only. This beam has infinites mass points and need infinites number of displacements to draw its deflected shape and thus has an infinite DOF. Systems with infinite DOF are called Continuous or Distributed systems.

## Discrete system

Systems with a finite number of degree of freedom are called Discrete or Lumped mass parameter systems