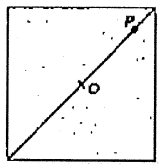
11 CHAPTER

Theory of Columns

Q.1 A load P is acting on the diagonal of a square column of size D, as shown in figure below. For no tension, the maximum distance of the load from the centre O is



(a) $D/8$ (b) $D/6$

(c) $D\sqrt{2}/6$ (d) $D\sqrt{2}/12$

Q.2 Match List-I (Euler's crippling load) with List-II (End conditions of column) and select the correct answer by using codes given below the lists:

List-I	List-II
A. $\frac{\pi^2 EI}{L^2}$	1. Both ends hinged
B. $\frac{\pi^2 EI}{4L^2}$	2. Both ends fixed
C. $\frac{2\pi^2 EI}{L^2}$	3. One end fixed, other end free
D. $\frac{4\pi^2 EI}{L^2}$	4. One end fixed, other end hinged

Codes:

	A	B	C	D
(a)	1	3	2	4
(b)	4	1	3	2
(c)	1	3	4	2
(d)	4	1	2	3

Q.3 Consider the following statements :

1. The buckling load is less than the crushing load in long columns.
2. The buckling load is more for long columns and relatively less for short columns.
3. When an axially loaded compression member just buckles, it is said to develop an elastic instability.

Which of the above statements are correct?

(a) both 1 and 2 (b) both 2 and 3

(c) both 1 and 3 (d) all 1, 2 and 3

Q.4 Euler's formula is based on the following assumptions:

1. The column is initially perfectly straight and is axially loaded.
2. The column will fail by bucking only.
3. The length of the column is very large in comparison to the lateral dimension.

Which of the above statements is/are correct?

(a) only 3 (b) both 1 and 3

(c) both 2 and 3 (d) 1, 2 and 3

Q.5 Consider the following statements:

1. Euler's formula for columns is valid when the slenderness ratio is less than 80.
2. Rankine formula for column is valid for any value of slenderness ratio.
3. The effective length of the column becomes half when both its ends are fixed.

Which of the above statements are correct?
(a) both 1 and 3 (b) both 1 and 2
(c) both 2 and 3 (d) 1, 2 and 3

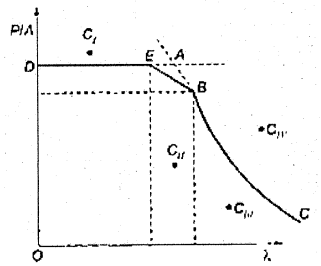
Q.6 A column of length 2.4 m, area of cross-section 2,000 mm^2 and moment of inertia of $I_{xx} = 720 \times 10^4\ mm^4$ and $I_{yy} = 80 \times 10^4\ mm^4$ is subjected to buckling load. Both the ends of the column are fixed. What is the slenderness ratio of column?
(a) 120 (b) 80
(c) 60 (d) 40

Q.7 The Rankine's constant in the formula for axial loads on column made of material of crushing strength f_c and modulus of elasticity E is

(a) $\frac{f_c}{\pi^2 E}$ (b) $\frac{f_c}{2\pi^2 E}$

(c) $\frac{f_c}{8\pi^2 E}$ (d) $\frac{\pi^2 E}{f_c}$

Q.8 The curve shown below is the Euler's curve for stability of column. With reference to the figure, match List-I with List-II and select the correct answer using the codes given below:



List-I	List-II
A. C_I	1. Long, unsafe
B. C_{II}	2. Long safe
C. C_{III}	3. Short, unsafe
D. C_{IV}	4. Intermediate, safe

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	2	4	3	1
(c)	3	1	4	2
(d)	3	4	2	1

Q.9 Four columns of same material and same length are of rectangular cross-section having same breadth 'b'. The depth of the cross-section and the end conditions are as given below:

Column	Depth	End conditions
1.	0.6 b	Fixed-Fixed
2.	0.8 b	Fixed-Hinged
3.	1.0 b	Hinged-Hinged
4.	2.6 b	Fixed-Free

Which of the above column will have maximum Euler's buckling load.
(a) Column-1 (b) Column-2
(c) Column-3 (d) Column-4

Q.10 Match List-I (shape of column) with List-II (shape of kern) and select the correct answer using the codes given below:

List-I	List-II
A. Rectangular	1. Square
B. Square	2. Circle
C. I-section	3. I-section
4. Hollow circular section	4. Rhombus

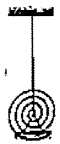
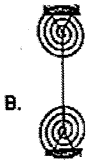
Codes:

	A	B	C	D
(c)	4	1	3	2
(d)	4	2	3	1
(c)	1	4	2	3
(d)	4	1	4	2

Q.11 Consider the following statements about Rankine's theory of columns.
1. It is applicable for long columns only.
2. It assumes buckling and crushing modes of failure.
3. It takes into account the initial crookedness of column and imperfections in loading

Which of the above statement(s) is(are) correct?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.12 Match List-I (Columns with length L having partially restrained end conditions) with List-II (Range of effective length) and select the correct answer using codes given below:

List-I	List-II
A. 	1. $\frac{L}{2} < l_{eff} < L$
B. 	2. $\frac{L}{2} < l_{eff} < \frac{L}{\sqrt{2}}$
C. 	3. $2L < l_{eff} < \infty$

Codes:

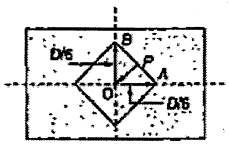
	A	B	C
(a)	1	2	3
(b)	2	1	3
(c)	2	3	1
(d)	1	3	2

Answers Theory of Columns

1. (d) 2. (c) 3. (c) 4. (d) 5. (c) 6. (c) 7. (a) 8. (d) 9. (b) 10. (d)
11. (c) 12. (b)

Explanations Theory of Columns

1. (d)



Core of section for no tension is having half diagonal

$$= \frac{D}{6} \text{ from } OA \text{ or } OB$$

$$\angle OAB = 45°$$

Hence $$OP = OA \cos 45 = \frac{D}{6} \times \frac{1}{\sqrt{2}}$$

$$OP = \frac{D\sqrt{2}}{12}$$

5. (c)
Euler's buckling formula is based on Euler-Bernoulli's theorem and does not account for effect of transverse shear deformation. It is valid for long column range $L/h > 80$, the failure is elastic and Euler's equation is valid.

6. (c)
Slenderness ratio of column is given by

$$\lambda = \frac{l_{eff}}{r_{min}}$$

$$l_{eff} = \frac{1}{2} \times 2.4$$

(for both ends fixed)

$$= 1.2 \text{ m} = 1200 \text{ mm}$$

$$r_{min} = \sqrt{\frac{I_{min}}{A}}$$

where, $I_{min} = I_{yy} = 80 \times 10^4 \text{ mm}^4$

$$\therefore \quad r_{min} = \sqrt{\frac{80 \times 10^4}{2000}} = 20 \text{ mm}$$

$$\therefore \quad \lambda = \frac{1200}{20} = 60$$

7. (a)

$$P = \frac{f_c A}{1 + \left(\frac{f_c}{\pi^2 E}\right)\left(\frac{L}{r}\right)^2}$$

Here, $\frac{f_c}{\pi^2 E}$ = Rankine constant

9. (b)

$$P_{cr_1} = \frac{\pi^2 EI}{L_{eff}^2} = \frac{\pi E\left(\frac{b \times (0.6b)^3}{12}\right)}{\left(\frac{L}{2}\right)^2}$$

$$= \frac{4\pi^2 Eb^4}{12L^2} \times 0.6^3 = 0.864 \frac{\pi^2 Eb^4}{12L^2}$$

$$P_{cr_2} = \frac{\pi^2 E\left(\frac{b \times (0.8b)^3}{12}\right)}{\left(\frac{L}{\sqrt{2}}\right)^2}$$

$$= \frac{2\pi^2 Eb^4}{12L^2} \times 0.8^3 = 1.024 \frac{\pi^2 Eb^4}{12L^2}$$

$$P_{cr_3} = \frac{\pi^2 Eb^4}{12L^2}$$

$$P_{cr_4} = \frac{\pi^2 E \times \left(\frac{2.6b \times b^3}{12}\right)}{(2L)^2}$$

$$= \frac{\pi^2 Eb^4}{12L^2} \times \frac{2.6}{4} = \frac{0.65\pi^2 Eb^4}{12L^2}$$

11. (c)
Rankine's theory is applicable for short and long columns.

■■■■