5 CHAPTER

Compression Members

Q.1 For design of compression member,
(a) Slenderness ratio should be minimum
(b) Radius of gyration should be large
(c) Both (a) and (b)
(d) None of these

Q.2 A column has effective length l, when both ends are fixed. What will be the new effective length if one end become hinged?
(a) l (b) $0.5l$
(c) $1.41l$ (d) $2l$

Q.3 If a laced column is designed to carry 500 kN axial load, then total transverse shear resisted by lacing will be
(a) 6.25 kN (b) 12.5 kN
(c) 15 kN (d) 25 kN

Q.4 Slenderness ratio of lacing bars should not exceed
(a) 100 (b) 120
(c) 180 (d) 145

Q.5 In design of compression member
(a) Lacing are not used with batten
(b) Batten are acted by longitudinal shear and moment both
(c) Lacing is generally preferred over battening in case of eccentric loading
(d) All of these

Q.6 If column has machined end, then connection between splice and column is designed to carry
(a) 25% axial load and any tension.
(b) 50% axial load and any tension.
(c) only tension
(d) only axial load

Q.7 The most critical consideration in the design of rolled steel columns carrying axial load is the
(a) Percentage elongation at yield and the net cross-sectional area.
(b) Critical bending strength and axial yield strength of the material.
(c) Buckling strength based on the net area of the section and percent elongation at ultimate load.
(d) Compressive strength based on slenderness ratio and gross sectional area of the member.

Q.8 The design of eccentrically loaded column needs revision when
(a) $\frac{f'_c}{f_c}+\frac{f'_b}{f_b}<1$ (b) $\frac{f'_c}{f_c}-\frac{f'_b}{f_b}<1$
(c) $\frac{f'_c}{f_c}-\frac{f'_b}{f_b}>1$ (d) $\frac{f'_c}{f_c}+\frac{f'_b}{f_b}>1$

Q.9 A circular column section is generally not used in actual practice because
(a) it is uncommercial
(b) it cannot carry the load safely
(c) it is difficult to connect beams to round sections.
(d) All of the above

Q.10 The slenderness ratio of a column supported throughout its length by a masonry wall is
(a) zero (b) 10
(c) 100 (d) infinity

Q.11 According to IS specifications, the effective length of a column effectively held in position at both ends and restrained against rotation at one end is taken as
(a) $0.67\,L$
(b) $0.707\,L$
(c) $0.8\,L$
(d) L

Q.12 The effective length of a battened strut, effectively held in position at both ends but not restrained in rotation is taken as
(a) 1.8 L (b) L
(c) 1.1 L (d) 1.5 L

Q.13 According to IS : 800, in the Merchant-Rankine formula the value of imperfection index (n) is
(a) 1.0 (b) 1.4
(c) 1.8 (d) 2.0

Q.14 If the 18 mm rivets are used in lacing bars, then the minimum width of lacing bar should be
(a) 40 mm (b) 60 mm
(c) 80 mm (d) 55 mm

Q.15 The use of tie plates in laced column is
(a) Prohibited
(b) Permitted
(c) Permitted at start and end of lacing system only
(d) Prohibited at start and end of lacing system only

Q.16 The maximum slenderness ratio of a compression member carrying both dead and superimposed load is
(a) 180 (b) 200
(c) 250 (d) 350

Q.17 The maximum slenderness ratio of a steel column, the design of which is governed by wind or seismic forces is
(a) 150 (b) 180
(c) 250 (d) 350

Q.18 Angle of inclination of the lacing bar with the longitudinal axis of the column should preferably be between
(a) 10° to 30° (b) 30° to 40°
(c) 40° to 70° (d) 90°

Q.19 A solid timber column is considered as long column when the slenderness ratio is
(a) less than 11
(b) 11
(c) between 11 and $0.702\sqrt{\frac{E}{f_{cp}}}$
(d) between $0.702\sqrt{\frac{E}{f_{cp}}}$ and 50

Q.20 The least dimension in case of a circular column of diameter D is taken as
(a) 0.5 D (b) 0.68 D
(c) 0.88 D (d) D

Q.21 The channels or angles in the compression chords of the steel truss girder bridges are turned outward in order to increase
(a) cross-sectional area
(b) section modulus
(c) torsional constant
(d) radius of gyration

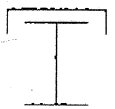
Q.22 A column splice is used to increase
(a) length of the column
(b) strength of the column
(c) cross-sectional area of the column
(d) none of these

Q.23 The value of FOS 'n' in the formula for safe compressive stress for a column is taken as

$$P_c = \frac{\frac{f_y}{n}}{1+0.20\sec\left[\left(\frac{1}{r}\right)n\sqrt{\frac{P_c}{4E}}\right]}$$

(a) 1.5 (b) 1.6
(c) 1.68 (d) 1.88

Q.24. The figure below shows a typical section of a crane girder.



Consider the following statements in this regard:
The function of the top channel is to
1. increase moment of inertia about vertical axis
2. reduce moment of inertia about horizontal axis
3 increase torsional stiffness
4. increase lateral buckling strength
Which of these statements are correct?
(a) 1 and 4 (b) 2 and 3
(c) 1, 2 and 4 (d) 1, 3 and 4

Q.25 Consider the following statements with reference to an encased column:
1. The member is a symmetrical I-shape or a single I-beam or channels placed back to back, with or with out flange plates.
2. The minimum width of solid casing is equal to $(b_0 + 150)$ where b_0 is the width of steel flanges.
3. The surface and edges of the steel column have a concrete cover of not less than 50 mm.
Which of these statements is/are correct?
(a) Only 2 (b) Both 1 and 2
(c) Both 2 and 3 (d) Both 1 and 3

Q.26 Secant formula for direct stress in compression, is applicable only for slenderness ratio upto
(a) 120 (b) 160
(c) 140 (d) 150

Q.27 Compression members composed of two channels placed back-to-back and separated by a small distance are connected together by riveting so that the minimum slenderness ratio of each member between the connections, does not exceed
(a) 40 (b) 50
(c) 60 (d) 70

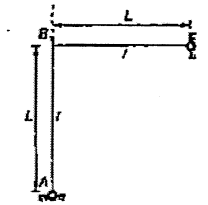
Q.28 Tacking rivets in compression plates not exposed to the weather, have a pitch not exceeding 300 mm or
(a) 16 times the thickness of outside plate
(b) 24 times the thickness of outside plate
(c) 32 times the thickness of outside plate
(d) 36 times the thickness of outside plate

Q.29 For a pair of identical steel channel sections, tack welded as a tension element, what is the net area of cross-section for design purposes?
(a) Net area of the webs only
(b) Net area of the flanges only
(c) Net area of the webs and flanges
(d) Web area plus a portion of the area of the flanges

Q.30 An electric pole 5 m high is fixed into the foundation. It carries a wire at the top and is free to move sideways. The effective length of the pole is
(a) 3.25 m (b) 4.0 m
(c) 5.0 m (d) 10.0 m

Q.31 A member is subjected to axial compression. Effective length is 3000 mm. Size of the angle used is 100 × 100 × 10 mm. What is the maximum capacity (if f_y = 250 MPa)?
(a) 101.2 kN (b) 81.7 kN
(c) 59.2 kN (d) 95.1 kN

Q.32 The effective length of column AB shown in figure below is



(a) 0.7L
(b) less than 0.7L
(c) greater than 0.7L but less than L
(d) L

Q.33 M 60 structural steel tube has a radius of gyration 20 mm. The unbraced length upto which the tube can be used as a compression member, is
(a) 3.6 m (b) 5.0 m
(c) 6.0 m (d) 7.2 m

Q.34 The effective length of the member as shown in the figure below is equal to

(a) 1.2L (b) 1.5L
(c) 2.0L (d) 3.0L

Q.35 Why are tie plates provided in laced columns?
(a) To check the buckling of column as a whole
(b) To check the buckling of the lacing flats
(c) To check the buckling of the component columns
(d) To check the distortion of the end cross sections

Q.36 Consider the following statements:
1. The two angle sections placed back to back are most frequently used in roof trusses.
2. A built-up section consisting of two channel sections back to back is occasionally used.
3. The local buckling of a compression member limits its size.

Which of these statements are correct?
(a) Both 1 and 2 (b) Both 1 and 3
(c) Both 2 and 3 (d) 1, 2 and 3

Q.37 Consider the following stipulations in designing a laced column.
1. Single lacing systems on opposite planes shall preferably be in the same direction so that one is the shadow of the other.
2. Lacing bar should be a flat section.
3. The slenderness ratio of the lacing bars for compression shall not exceed 180.
4. Laced compression members are to be provided with tie plates at ends.

Which of these observations is/are correct?
(a) 1 only (b) 1 and 3
(c) 2 and 4 (d) 1 and 4

Q.38 Battening is preferable when the
1. Column carries axial load only
2. Space between the two main components is not very large
3. Column is eccentrically loaded.

The correct answer is
(a) 1 only (b) 2 only
(c) 1 and 2 (d) 1, 2 and 3

Q.39 The overlap of batten plates with the members in welded connections should be more than
(a) $3t$ (b) $4t$
(c) $6t$ (d) $8t$
where, t = thickness of the batten plate.

Q.40 For a compression member with double angle section, which of the following section will give larger value of minimum radius of gyration?
(a) Equal angles back to back
(b) Unequal angles with long leg back to back
(c) Unequal angle with short leg back to back
(d) Both (b) are (c)

Q.41 A strut 1 m long consists of two angles ISA 90 × 90 × 6 mm connected on both sides of 10 mm gusset plate by one bolt. The design strength of strut weld be (f_y = 250 MP)
Given data [Area = 2055 mm^2,
$C_{xx} = C_{yy}$ = 23.5 mm
r_{xx} = 30.9 mm for double ISA 90 × 90 × 6 r_{yy} = 34.32 mm]

	Yield Stress (MPa)						
KL/r	200	210	220	230	240	250	260
20	182	190	199	207	216	224	233
30	172	180	188	196	204	211	209
40	163	170	177	184	191	198	205

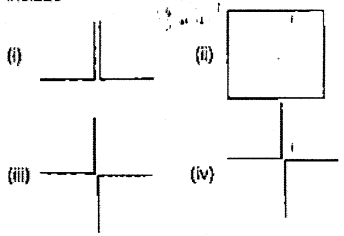
(a) 259 KN (b) 330 kN
(c) 410 kN (d) 440 kN

Q.42 For economical consideration, a compound column shall have

(a) $r_{xx} = r_{yy}$ (b) $r_{xx} = \frac{r_{yy}}{2}$

(c) $r_{xx} > r_{yy}$ (d) $r_{xx} > 2\,r_{yy}$

Q.43 Two equal angles form a compound column cross-section as shown in figure, among these, those which have the same [illegible] carrying capacity could include

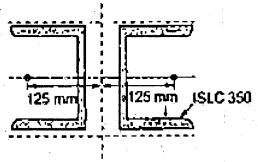


Choose the correct answer :
(a) (i) and (ii) (b) (i) and (iii)
(c) (ii) and (iii) (d) (ii) and (iv)

Q.44 A compound column had been fabricated with 4 angles of ISA 60 × 60 × 8 mm placed at corners of a square 850 mm × 350 mm. The radius of gyration of the angle is 15 mm. For the fabricated column overall slenderness ratio is 45. What is the maximum distance between lacing bar attached at the fabricated column?
(a) 475 mm (b) 470 mm
(c) 435 mm (d) 410 mm

Q.45 Two identical I-sections form a compound column section. For most economical section, distance between web of I-section will be
(a) $r_{xx} + g_{yy}$ (b) $2(r_{xx} - r_{yy})$
(c) $2\sqrt{r_{xx}^2 - r_{yy}^2}$ (d) $2\,r_{xx}$

Q.46 Figure below shows a double channel section. What will be the design compressive capacity of the column? (L_{eff} = 3 m)
Properties of ISLC 350
Area = 4947 mm^2
I_{xx} = 394.6 × 10^4 mm^4
I_{yy} = 394.6 × 10^4 mm^4
r_{cx} = 137.2 mm
c_{yy} = 24.1 mm
f_y = 250 MPa



λ	10	20	30	40	50	60	70
f_{cd}(MPa)	228	226	220	213	205	195	182

(a) 224.76 kN (b) 2224.7 kN
(c) 3598.2 kN (d) 417.5 kN

Q.47 Which one of the following pair is correctly matched?
(a) Truss : Bending
(b) Beam : Twisting
(c) Column : Buckling
(d) Shaft : Shortening

Q.48 Slenderness ratio of the splices for compression members is
(a) 0 (b) 145
(c) 180 (d) 350

Q.49 The thickness of lacing bars for single lacing system should not be less than
(a) $l/40$ (b) $l/50$
(c) $l/60$ (d) $l/70$
where l = length between the inner end of connections.

Q.50 What is the maximum permissible slenderness ratio for steel ties likely to be subjected to compression?
(a) 400 (b) 350
(c) 250 (d) 180

Q.51 The non-dimensional effective slenderness ratio for column ISHB 300 (r_{yy} = 51.8 mm) of length 3 metre and its both ends pinned is
($E = 2 \times 10^5$ N/mm^2, f_y = 250 N/mm^2, f_u = 410 N/mm^2)
(a) 0.3216 (b) 0.6518
(c) 0.4322 (d) 0.7314

Q.52 A column of 4 m long has to support a factored load of 6000 kN. The column is effectively held at both ends and restrained in direction at one end. Assume 20 mm plate, f_{cd} = 200 N/mm^2, ISHB area = 11789 mm^2, b_f = 250 mm the breadth of plate is;
(a) 500 mm (b) 390 mm
(c) 410 mm (d) 430 mm

Q.53 A battened column with two channels back to back length of 10 m to carry an axial factored load of 1400 kN. The column may be assumed to have restrained in position but not in direction at both ends. Assuming spacing of battens = 1200 mm, distance b/w centres of channel, S = 268.8 mm. The design shear force for batten plates is;
(a) 48 kN (b) 68 kN
(c) 79 kN (d) 58 kN

Q.54 A bearing plate having width b and thickness$t$ having design bending stress is subjected to bending moment M. The thickness is:

(a) $\frac{6M}{bf_{bs}}$ (b) $\frac{12M}{bf_{bs}}$

(c) $\sqrt{\frac{6M}{bf_{bs}}}$ (d) $\sqrt{\frac{12M}{bf_{bs}}}$

Q.55 As per IS: 800-2007, the stress reduction factor for an axially loaded compression member depends upon which of following factors for design strength criteria?

1. Initial crookedness
2. Accidental eccentricities of load
3. Type of cross-section
4. Residual stresses

Of the above factors, the influencing factors are:

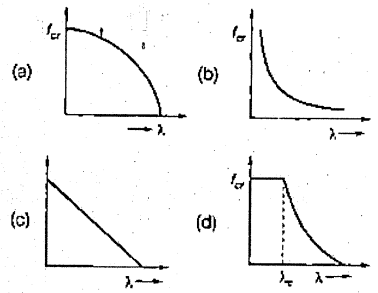
(a) 1, 2 and 3 are correct
(b) 1, 3 and 4 are correct
(c) 2, 3 and 4 are correct
(d) 1, 2, 3 and 4 are correct

Q.56 Which of the following statements are correct?

(*i*) The effective slenderness ratio of the laced column should be increased by 5%.
(*ii*) The effective length of a single-angle discontinuous strut connected by more than are bolt or weld is the same.
(*iii*) The slenderness ratio of compression members is limited to take into account unexpected vibrations.
(*iv*) Compression members are designed using Merchant Rankine formula.

(a) (*i*), (*ii*) and (*iii*) only
(b) (*ii*), (*iii*) and (*iv*) only
(c) (*i*) and (*ii*) only
(d) All of the above

Q.57 The relationship between buckling stress (f_{cr}) and the slenderness ratio (λ) for elastic column is expressed as



Q.58 What are following factors that are considered in design criteria of latticed column?

(*i*) Buckling of column as whole.
(*ii*) Buckling of component column.
(*iii*) Buckling of individual rolled sections constituting column.
(*iv*) Buckling of lattice member.

(a) (*i*) and (*iv*) only
(b) (*i*), (*ii*) and (*iii*) only
(c) (*i*), (*ii*) and (*iv*) only
(d) All of the above

Answers Compression Members

1. (c)	2. (c)	3. (b)	4. (d)	5. (d)	6. (b)	7. (d)	8. (d)	9. (c)	10. (a)
11. (c)	12. (c)	13. (b)	14. (d)	15. (c)	16. (a)	17. (c)	18. (c)	19. (d)	20. (c)
21. (d)	22. (a)	23. (c)	24. (a)	25. (d)	26. (b)	27. (b)	28. (c)	29. (c)	30. (b)
31. (b)	32. (c)	33. (a)	34. (c)	35. (d)	36. (d)	37. (d)	38. (c)	39. (b)	40. (b)
41. (d)	42. (a)	43. (c)	44. (b)	45. (c)	46. (a)	47. (c)	48. (a)	49. (a)	50. (b)
51. (b)	52. (a)	53. (c)	54. (c)	55. (d)	56. (a)	57. (b)	58. (c)		

Explanations Compression Members

3. (b)
Total load on lacing column = 500 kN
We know that the transverse shear resisted by lacking is 2.5% of total vertical load.

So, load resisted by lacing = $\frac{2.5}{100} \times 500$

= 12.5 kN

12. (c)
For battened struts, the effective length is increased by 10%.

14. (d)
Minimum width of lacing bars in revetted construction should be as follows:

Nominal rivet dia(mm)	Width of lacing bar (mm)
22	65
20	60
18	55
16	50

24. (a)
Under normal circumstances, the crane girder is designed as laterally unsupported beam carrying vertical and horizontal load at the level of top flange. The channel at top flange.
(i) increases moment of inertia about vertical axis.
(ii) improves lateral buckling strength.

25. (b)
In the direction of wire, the pole is hinged at wire end so effective length = $0.8L = 4.0$ m.

31. (b)
Area of section
$= (100-5) \times 10 + (100-5) \times 10$
$= 1900\ mm^2$
Radius of gyration = 19.4 mm
∴ Slenderness ratio,

$\lambda = \frac{3000}{19.4} = 154.6$

Allowable strength = 43 MPa
∴ Capacity of section
$= 43 \times 1900 = 81700\ N = 81.7\ kN$

37. (d)
The lacing bar may be a flat or angle section. The purpose of lacing is to hold the various parts of a column straight, parallel at a correct distance apart and to equalize the stress distribution between its various parts. The slenderness ratio of the lacing bars for compression shall be less than 145.

41. (d)
Since $r_{yy} > r_{uu}$
Thus, minimum radius of gyration r_{yy} will be used for slenderness ratio λ

$\frac{KL}{r} = \frac{1000}{r_y}$

$= \frac{1000}{30.9} = 32.36$

From table corresponding to

$f_y = 250$ MPa and $\frac{KL}{r_y} = 32.36$

$f_{cd} = 211 + \frac{2.36}{10}(211-198)$

$f_{cd} = 214.068$ MPa

Thus, design strength of strut
$= A_e + f_{cd}$
$= 2055 \times 214.068\ N$
$= 440\ kN$

43. (c)
Almost equal radius of gyration.

44. (b)
Let spacing between lacing bars is S

Thus, $\frac{S}{r} \le 0.7 \times$ overall slenderness ratio.

or, $\frac{S}{15} \le 0.7 \times 45$

or, $S \le 472.5$ mm

Thus, maximum spacing, $S = 470$ mm.

45. (c)

Let, A = area of one I-section.

I'_{xx} = moment of inertia of one I-section about xx axis.

S = distance between yy_{axis} of two I-section.

I'_{yy} = moment of inertia of one I-section about yy axis.

For compound section, due to symmetry,

$$I_{xx} = 2I'_{xx}$$

$$I_{yy} = 2\left[I'_{yy} + A\left(\frac{S}{2}\right)^2\right]$$

(by parallel axis theorem)

For most economical arrangement,

$$I_{xx} = I_{yy}$$

or $$2I'_{xx} = 2\left[I'_{yy} + A\left(\frac{S}{2}\right)^2\right]$$

or, $$\left(\frac{S}{2}\right)^2 = \frac{I'_{xx}}{A} - \frac{I'_{yy}}{A}$$

So, $$S = 2\sqrt{r_{xx}^2 - r_{yy}^2}$$

46. (a)

For compound section

$$I_{xx} = 2I_{xx} \qquad A = 2A_0$$

[where A_0 = is sectional area of single channel]

Thus, $$r_{xx} = \sqrt{\frac{2I_{xx}}{2A_0}} = \sqrt{\frac{I_{xx}}{A_0}}$$

$$= \sqrt{\frac{9312.6\times10^4}{4947}}$$

$$= 137.2 \text{ mm}$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}}$$

$$r_{yy} = \sqrt{\frac{I_{yy}}{2A_0}}$$

Moment of inertia about yy axis

$$I_{yy} = 2\left[I_{yy} + A\left(\frac{S}{2}\right)^2\right]$$

where S is distance of CG of one I-section to the yy axis

i.e., $$S = 125 + C_{yy}$$

$$= 125 + 24.1 = 149.1 \text{ mm}$$

Thus, $I_{yy} = 2[394.6\times10^4 + 4947(149.1)^2]$

$$= 22784.2\times10^4 \text{ mm}^4$$

$$r_{yy} = \sqrt{\frac{I_{yy}}{2A_0}} = \sqrt{\frac{22784.2\times10^4}{2\times4947}}$$

$$= 157.75 \text{ mm}$$

48. (a)

Splices used in compression members are assumed to act as short columns with zero slenderness ratio.

49. (a)

Minimum thickness of lacing bars

$t \ge l/40$ for single lacing

$t \ge l/60$ for double lacing riveted or welded at intersection

51. (b)

We know

$$f_{cc} = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = \frac{\pi^2\times2\times10^5}{\left(\frac{3000}{51.8}\right)^2}$$

$$= 588.5 \text{ N/mm}^2$$

Non-dimensional effective slenderness ratio,

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = \sqrt{\frac{250}{588.5}} = 0.6518$$

52. (a)

$$f_{cd} = 200 \text{ N/mm}^2$$

Area required

$$= \frac{6000\times10^3}{200} = 30000 \text{ mm}^2$$

Area provided

$$= 11789 \text{ mm}^2$$

Width of flange = 250 mm

$\therefore$ Area to be provided by plates

$$= 30000 - 11789 = 18211 \text{ mm}^2$$

Given 20 mm plate, b be breadth required

$2b\times20 = 18211$

$\Rightarrow$ $b = 455.3$ mm use $b = 500$ mm.

53. (c)

$C = 1200$ mm

$$V_f = \frac{2.5}{100}\times1400\times10^2 = 35000 \text{ N}$$

$$V_b = \frac{V_f C}{NS} = \frac{3500\times1200}{2\times268.8}$$

$\Rightarrow$ $V_b = 78.125$ kN

54. (c)

Thickness of bearing plate required, t is given by

$$\Rightarrow \frac{1}{6}bt^2 f_{bs} = M$$

$$\Rightarrow t = \sqrt{\frac{6M}{bf_{bs}}}$$

where f_{bs} = design bending stress

55. (d)

As per IS: 800-2007, the design compressive stress of axially loaded compression member is given by,

$$f_{cd} = \chi\frac{f_y}{\gamma_{mc}}$$

where χ is stress reduction factor and depends on all factors mentioned above.

56. (a)

As per IS: 800-2007, compression members are not designed using Merchant-Rankine formula.

57. (b)

Buckling stress,

$$f_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2 EI}{L^2 A} = \frac{\pi^2 E(A r^2)}{L^2 A} = \frac{\pi^2 E}{\lambda^2}$$

where $\lambda = \frac{L}{r}$ = slenderness ratio

Elastic critical load P_{cr} provides a measure of the slenderness of a compression member.

$$f_{cr} \propto \frac{1}{\lambda^2}$$

58. (c)

Buckling of individual rolled section constituting column is not the design criteria for column.

■■■■