6 CHAPTER

Beams

Q.1 The most efficient and economical section used as a beam is
(a) I-section (b) Circular section
(c) Angle section (d) *H* section

Q.2 When a beam is subjected to lateral load, the designer choice for section should be
(a) angle
(b) *H* section
(c) I-section with channel section at top flange
(d) I-section

Q.3 Which of the following is correct?
(a) Rolled I-sections as given in IS Handbook No.-1 are plastic
(b) Rolled I-sections as given in IS Handbook No. 1 are compact
(c) Both (a) and (b)
(d) Neither (a) are (b)

Q.4 In case of buckling, the dispersion of load from bearing plate to neutral axis takes place at
(a) 30° (b) 60°
(c) 45° (d) 10°

Q.5 Shear determines the design of beams, in which
(a) depth of beam section is small and is loaded uniformly
(b) large concentrated loads are placed near beam supports
(c) both (a) and (b)
(d) none of these

Q.6 Maximum bending moment in a purlin of length '*L*' when subjected to a distributed load '*w*' is assumed to be
(a) $\frac{wL^2}{6}$ (b) $\frac{wL^2}{8}$
(c) $\frac{wL^2}{12}$ (d) $\frac{wL^2}{10}$

Q.7 An angle section can be used as purlin when slope of roof truss is
(a) between 40° and 70°
(b) less than 30°
(c) greater than 30°
(d) less than 45°

Q.8 To minimize total cost of roof truss, the ratio of cost of truss to the cost of purlin shall be
(a) 1 (b) 2
(c) 3 (d) 4

Q.9 Generally purlines are placed at the panel points so as the avoid
(a) axial force in rafter
(b) shear force in rafter
(c) deflection of rafter
(d) bending moment in rafter

Q.10 A simply supported beam of 8m effective span carries a uniformly distributed factored load of 3 kN/m over the effective span. If the steel is of grade Fe410 then the most suitable trial steel shape and size would be
(a) Solid circular section of dia = 110 mm, Area = 9500 mm^2, maximum sectional modulus = 130600 mm^3
(b) Solid rectangular section of size 60 mm × 100 mm deep Area = 6000 mm^2, maximum sectional modulus = 100000 mm^3
(c) T section of size 200 mm × 200 mm × 1 mm thickness, Area = 3900 mm^2 Maximum section modulus = 105780 mm^3
(d) I section of size 60 mm × 150 mm deep × 10 mm thickness, Area = 2900 mm^2 Maximum section modulus = 129100 mm^3

Q.11 As per IS : 800, the maximum deflection in a beam should not exceed (where *L* is span of beam)
(a) $\frac{L}{180}$ (b) $\frac{L}{250}$
(c) $\frac{L}{325}$ (d) $\frac{L}{360}$

Q.12 A steel beam supporting loads from the floor slab as well as from wall is termed as
(a) stringer beam (b) lintel beam
(c) spandrel beam (d) header beam

Q.13 The angle of dispersion of a concentrated load on the flange to the web plate of a steel beam is
(a) 90° with the horizontal
(b) 60° with the vertical
(c) 45° with the horizontal
(d) 30° with the vertical

Q.14 The rolled steel section used in a cased beam has width '*B*' mm and diameter '*D*' mm. The minimum width in mm of the finished cased beam is given by
(a) $(B + 50)$ (b) $(B + 100)$
(c) $[(B/D) + 100]$ (d) $2(B + D)$

Q.15 For a cantilever beam of length *L* built-in at the support and restrained against torsion at the free end, the effective projecting length *l* is
(a) $l = 0.7L$ (b) $l = 0.75L$
(c) $l = 0.5L$ (d) $l = 3L$

Q.16 Under a concentrated load, bearing stress f_b in a beam, is given by
(a) $f_b = \frac{W}{(b+h\sqrt{3})t_w}$
(b) $f_b = \frac{W}{(b+2h\sqrt{3})t_w}$
(c) $f_b = \frac{W}{(b+2h\sqrt{2})t_w}$
(d) $f_b = -\frac{W}{(b+h\sqrt{2})t_w}$

Q.17 The area of cover plates A_p in one flange of a built up beam, is given by
(a) $A_p = \frac{Z_{req.d} + Z_{provided}}{h}$
(b) $A_p = \frac{Z_{req.d} / Z_{beam}}{h}$
(c) $A_p = \frac{Z_{req.d} \times Z_{beam}}{h}$
(d) $A_p = \frac{Z_{req.d} - Z_{beam}}{h}$

Q.18 Match List-I (Type of connection) with List-II (Type of beam) and select the correct answer using the codes given below the lists:
List-I
A. Semirigid connection
B. Framed connection
C. Flexible connection
D. Seated connection
List-II
1. To permit large angles of rotation and to transmit negligible moment
2. To allow small end rotation and transmit appreciable moment
3. When a beam is connected to a beam or stanchion by means of an angle at the bottom of the beam which is shop-riveted to the beam
4. When a beam is connected to a beam or stanchion by means of two angles riveted to them

Codes:

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

Q.19 The maximum bending stress in a beam section subjected to unsymmetrical bending can be determined by
1. locating the neutral axis of the section
2. resolving bending moment in two components along the principal axes
3. resolving bending moment in two perpendicular axes passing through the centroid of the section

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

Q.20 A steel beam of rectangular cross-section is clamped at both ends. Plastic deformation is just observed when the UDL on the beam is 10 kN/m. At the instant of collapse, the load on the beam will be
(a) 10 kN/m (b) 15 kN/m
(c) 20 kN/m (d) 30 kN/m

Q.21 A steel beam is connected to a steel column by means of two angles placed on the two sides of the web of the beam. What is this called?
(a) Stiffened seat connection
(b) Unstiffened seat connection
(c) Framed connection
(d) Rigid connection

Q.22 In a simply supported beam of span l, each end is restrained against torsion, compression flange being unrestrained. According to IS : 800, the effective length of the compression flange will be equal to
(a) l (b) $0.85l$
(c) $0.75l$ (d) $0.70l$

Q.23 The maximum shear force at a section is 56 kN. An ISWB of height 350 mm, breadth 200 mm, thickness of web 8 mm, with a section modulus of 887 cm^3 is used as a beam at the section. The shearing stress is
(a) 10 N/mm^2 (b) 20 N/mm^2
(c) 28.4 N/mm^2 (d) 41.6 N/mm^2

Q.24 The outstand of the flange of built-up beam from the line of connection should not extend beyond
(a) $10\,T$ (b) $85\,T$
(c) $\frac{256T}{\sqrt{f_y}}$ (d) $180\,t_w$

(where T is the thickness of flange and t_w is the thickness of web)

Q.25 Which one of the following is the correct maximum shear capacity of a prismatic beam under plastic design of steel structures?
(a) $0.5A_wF_y$ (b) $0.55A_wF_y$
(c) $0.75A_wF_y$ (d) A_wF_y

Q.26 A cantilever arm is to be attached to a column. Which one among the following is the best connection?
(a) Framed connection
(b) Seated connection
(c) Stiffened seated connection
(d) End plate connection

Q.27 A cantilever steel beam of 3 m span carries a uniformly distributed load of 20 kN/m inclusive of self-weight. The beam comprises of ISLB200@198 N/m, flange = 100 mm × 7.3 mm; web thickness = 5.4 mm; I_{zz} = 1696.6 cm^4; I_{yy} = 115.4 cm^4. What is the maximum bending stress in the beam ?
(a) 132.62 N/mm^2
(b) 530.47 N/mm^2
(c) 1949.74 N/mm^2
(d) 3899.48 N/mm^2

Q.28 The design bending strength of A laterally supported beam is given by $M_d = \frac{\beta_b Z_p f_y}{\gamma_{mo}}$, where all terms have their usual meaning. β_b for plastic and compact sections are given by
(a) 1.0, 0.8 (b) 0.8, 1.0
(c) $1.0, \frac{Z_e}{Z_p}$ (d) 1.0, 1.0

Q.29 In selecting a rolled I-section for a simply supported beam a minimum value of span/depth ratio is also ensured. This is stipulated to ensure that
(a) the buckling of beam does not take place
(b) the shear stress in the beam remains within permissible limits.
(c) the deflection of beam remains within the permissible limits.
(d) the bending stress in compression is within permissible limit.

Q.30 For rolled steel sections recommended for beams, the depth to thickness ratio of web is less than
(a) 50 (b) 85
(c) 145 (d) 180

Q.31 Web crippling occurs due to
(a) column action of web
(b) failure of web under point load
(c) excessive bending moment
(d) secondary bending moment

Q.32 The lateral buckling of I-beam in steel is governed by
(a) torsional constant
(b) maximum moment of inertia
(c) boundary conditions of the flanges
(d) width of flanges

Q.33 The allowable shear stress in the web of mild steel beam decreases with
(a) decrease in h/t ratio
(b) increase in h/t ratio
(c) decrease in thickness
(d) increase in height
where 'h' is height and 't' is thickness

Q.34 The heaviest I section for same depth is
(a) ISMB (b) ISLB
(c) ISHB (d) ISWB

Q.35 Lateral buckling of beam is not prevented by
(a) shear connector
(b) embedding compression flange into the slab
(c) lateral bracing
(d) increasing the depth of web

Q.36 By how much percentage is the permissible stress in a grillage beam be increased if it is encased in concrete
(a) 15% (b) 25%
(c) 33% (d) 0%

Q.37 In web crippling, the bearing length under reactions at the support is calculated by
(a) $b+2\sqrt{3}h$ (b) $b+\sqrt{3}h$
(c) $b+2\sqrt{2}h$ (d) $b+\sqrt{2}h$
where
b = width of the bearing plate.
h = depth of root of the fillet in mm.

Q.38 If ends are assumed to be fixed, then slenderness ratio for web buckling and diagonal buckling respectively are
(a) $\frac{d\sqrt{3}}{t}, \frac{d\sqrt{3}}{t}$ (b) $\frac{d\sqrt{3}}{t}, \frac{d\sqrt{6}}{t}$
(c) $\frac{d\sqrt{6}}{t}, \frac{d\sqrt{3}}{t}$ (d) $\frac{d\sqrt{6}}{t}, \frac{d\sqrt{6}}{t}$
where
d = clear depth of web between roots of fillet
t = web thickness

Q.39 Lateral buckling of beam starts from top flange because of
(a) compression in top flange
(b) different nature of forces in top and bottom flange
(c) less value of shear force over cross-section
(d) None of the above

Q.40 The behaviour of a beam-column cross-section is expressed by which of the following relationship?
(a) moment-curvature
(b) moment-axial compression
(c) axial-compression curvature
(d) moment curvature-axial compression

Q.41 The effective length of the beam with full torsional resistant and warping restraint for both flanges at the ends will be less by
(a) 5% (b) 10%
(c) 15% (d) 30%

Q.42 The purpose of placing the heel of the rafter angle on the top for following reason.
1. The rafter angle acts as beam in carrying self weight.
2. If heel is kept down the angle will act like a gutter and may lead the rain water down to the connections.
(a) Only 1 is correct
(b) Only 2 is correct
(c) Both 1 and 2 are correct
(d) None of 1 and 2 is correct

Q.43 The properties of ISLB 200 section are
Depth of section, h = 200 mm
Width of flange, b_f = 100 mm

Thickness of flange, $t_f = 7.3$ mm
Thickness of web, $t_w = 5.4$ mm
Effective depth of web = $d = 166.4$ mm
As per IS: 800, the section is classified as which of following category?
(a) Semi-plastic (b) Plastic
(c) Compact (d) None of the above

Q.44 A beam of length, $L = 6.5$ m is subjected to factored uniformly distributed load 63 kN/m. As per IS: 800-2007, which is correct regarding serviceability criteria of beam?
(Permissible deflection = δ_p and $EI = 46253.16 \times 10^9$ N mm)
(a) $\delta_p \Rightarrow 21.66$ mm, safe in deflection
(b) $\delta_p \Rightarrow 12.33$ mm, not safe in deflection
(c) $\delta_p \Rightarrow 32.11$ mm, safe in deflection
(d) $\delta_p \Rightarrow 39.22$ mm, not safe in deflection

■■■■

Answers Beams

1. (a)	2. (c)	3. (c)	4. (c)	5. (c)	6. (d)	7. (b)	8. (b)	9. (d)	10. (d)
11. (c)	12. (c)	13. (b)	14. (b)	15. (b)	16. (b)	17. (d)	18. (c)	19. (d)	20. (c)
21. (c)	22. (a)	23. (b)	24. (c)	25. (b)	26. (d)	27. (b)	28. (d)	29. (c)	30. (b)
31. (b)	32. (c)	33. (b)	34. (c)	35. (d)	36. (c)	37. (b)	38. (b)	39. (a)	40. (d)
41. (d)	42. (c)	43. (b)	44. (a)						

Explanations Beams

1. (a)
I-section has maximum section modulus.

2. (c)
Such sections have good lateral buckling strength.

3. (c)
Rolled I-section and channel sections as given is IS Handbook No.-1 are either plastic or compact.

10. (d)
Design bending moment for simply supported beam,

$$M_d = \frac{1.2 Z_e f_y}{\gamma_{m_0}}$$

Also, $M = \frac{wL^2}{8} = \frac{3 \times 8^2}{8} = 24$ kN-m

Thus, $24 = \frac{1.2 Z_e f_y}{\gamma_{m_0}}$

So, $Z_e = \frac{24 \times 1.1 \times 10^6}{1.2 \times 250}$

$= 88000$ mm^3

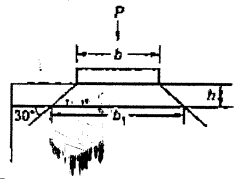
The section with maximum section modulus and minimum area will be most suitable for beam.

11. (c)
The maximum deflection of a beam should not exceed 1/325 of span in general. This limit may be exceeded in cases where greater deflection does not affect strength or crack the floor finishing.

14. (b)
In multistoreyed building consisting of steel stanchions and beam framing, it is advisable to encase the steel frame in concrete to make it fire resistant and more pleasing to eye. It is a composite beam. The minimum width of solid casing is $(B + 100)$. The radius of gyration about y - y axis is $0.2(B + 100)$.

16. (b)
We know,

$$\sigma_b = \frac{P}{\text{Bearing area}}$$



where
P = concentrated load
t = thickness of web
h = depth of roof of fillet
Assuming angle of dispersion of load to be 30°.
∴ Bearing length

$= b_1 = b + 2h\sqrt{3}$

$$\therefore \quad \sigma_b = \frac{P}{(b + 2h\sqrt{3})t}$$

18. (c)
The framed connection is made by two angles placed on two sides of the web of the beam. The framed connection and seated connection are classified as flexible connections. Seated connection consists of a horizontal angle with its horizontal leg at its top to receive the beam on it.

20. (c)
When the load is such that the maximum moment is equal to yield moment (M_y) at clamped ends, the beam starts deforming significantly. The load for M is given as

$w_1 = 10$ kN/m

Now hinges at clamps will be formed at a load equal to w_2
where, w_2 = shape factor × w_1
$= 1.5 \times 10 = 15$ kN/m

Collapse load = $\frac{16}{12} \times w_2$

∴ Collapse load

$$w_p = \frac{4}{3} \times 15 = 20 \text{ kN/m}$$

23. (b)
Shearing stress at neutral axis

$$= \frac{VQ}{It}$$

Given, $t = 8$ mm

$$I = 887 \times 10^3 \times \frac{350}{2} \text{mm}^4$$

$Q = A\bar{y}$

However the flanges of beam take very small shear and most of it being shared by the web. Thus for I-section, the shear stress

$$f_s = \frac{V}{t_w D} = \frac{56 \times 10^3}{8 \times 350} = 20 \text{ N/mm}^2$$

24. (c)
As per Cl. 6.7.4.4 of IS 800 : 1984 unless the outer edge of each stiffener is continuously stiffened, the outstand of all stiffeners from the web shall not exceed $\frac{256t}{\sqrt{f_y}}$ for section and 12 t for flats where 't' is the thickness of the section or flat.

26. (d)
The beam column connections expected to resist and transfer end reactions only are termed as shear connections or flexible connections. These permit free rotation of the beam end and do not have any moment restraint. Bracket connections, seat connections (unstiffened and stiffened) and framed connections are of flexible type.
The other type of connections which do not permit any relative rotation between the beam and column and are expected to resist moment in addition to end reactions are termed as moment connections or rigid connections. For cantilever arm, both moment and end reaction are to be transferred without rotation and therefore rigid connections would be the best choice. Clip angle connection, split beam connection and bracket connection (end plate connection) are rigid connections.

27. (b)

The maximum bending stress is given by

$$f_{max} = \frac{M_{max}}{Z}$$

But $$M_{max} = \frac{wl^2}{2} = \frac{20 \times 3^2}{2} = 90 \text{ kN-m}$$

$$Z = \frac{I_{yc}}{200/2} = \frac{1696.6 \times 10^4}{100}$$

$$= 169660 \text{ mm}^3$$

$$\therefore \quad f_{max} = \frac{90 \times 10^6}{169660} = 530.47 \text{ N/mm}^2$$

33. (b)

According to IS 800 : 1984 the maximum permissible shear stress should not exceed the value of τ_{vm} given by $\tau_{vm} = 0.45\ f_y$. The permissible average shear stress τ_{va} on a web whose depth does not exceed 85 times its thickness, is equal to $0.40\ f_y$.

The allowable shear stress in the web of a mild steel beam decreases with increase in *h/t* ratio. And for same *h/t* ratio, allowable shear stress decreases with increase in spacing of stiffeners.

40. (d)

The behaviour of beam column cross-section is expressed by moment curvature-axial compression relationship.

41. (d)

The effective length of the beam with full torsional restraint and warping restraint for both flanges at the ends will be reduced by 30% as per IS: 800-2007.

42. (c)

The heel of the rafter angle is placed on the top because it acts as beam in carrying self weight and kept down the angle like a gutter and may lead the rain water down to connections.

43. (b)

As per IS: 800,

$$\epsilon = \sqrt{\frac{250}{f_y}} = \sqrt{\frac{250}{250}} = 1$$

Outstand of flange,

$$b = \frac{b_f}{2} = \frac{100}{2} = 50 \text{ mm}$$

$$\Rightarrow \quad \frac{b}{t_f} = \frac{50}{7.3} = 6.849 < 9.4$$

$$\Rightarrow \quad \frac{d}{t_w} = \frac{166.40}{5.4} = 30.81 < 84$$

Hence, the section is plastic.

44. (a)

Service load

$$= \frac{63}{\gamma_f} = \frac{63}{1.5} = 42 \text{ kN/m}$$

As per IS: 800 permissible deflection

$$\delta = \frac{L}{300} = \frac{6.5 \times 10^3}{300} = 21.66 \text{ mm}$$

$$\delta_{max} = \frac{5}{384} \times \frac{Wl^4}{EI}$$

$$= \frac{5}{384} \times \frac{42 \times (6500)^4}{2 \times 10^5 \times 3.16 \times 10^9}$$

$$= 21.10 < 21.66 \text{ mm}$$

Which is all right.