8
CHAPTER

Design for Torsion

Q.1 Torsion resisting capacity of given *RC* section
(a) decreases with decrease in stirrup spacing
(b) decreases with increase in longitudinal bars
(c) does not depend upon stirrup and longitudinal steel.
(d) increases with the increase in stirrup and longitudinal steel.

Q.2 A beam of rectangular cross-section ($b \times d$) is subjected to a torque *T*. What is the maximum torsional stress induced in the beam ($b < d$ and α is a constant)?
(a) $\frac{T}{\alpha b^2 d}$ (b) $\frac{T}{\alpha b d^2}$
(c) $\frac{T}{\alpha b d}$ (d) $\frac{T}{bd}$

Q.3 An *RC* structural member rectangular in cross-section of width *b* and depth *D* is subjected to a combined action of bending moment *M* and torsional moment *T*. The longitudinal reinforcement shall be designed for a moment M_e given by
(a) $M_e = M + \frac{T(1+D/b)}{1.7}$
(b) $M_e = \frac{T(1-D/b)}{1.7}$
(c) $M_e = \frac{T(1+D/b)}{1.7}$
(d) $M_e = \frac{T(1-b/D)}{1.7}$

Common data for Questions (Q.4 and Q.5)
At the limit state of collapse, a RC beam is subjected to a flexural moment of 200 kN-m, shear force of 20 kN and torque of 9 kN-m. The beam is 300 mm wide and has a gross depth of 425 mm, with an effective cover of 25 mm. The equivalent nominal shear stress (τ_{ve}) as calculated by using the design code turns out to be lesser than the design shear strength (τ_c) of the concrete.

Q.4 The equivalent shear force (V_e) is
(a) 20 kN (b) 54 kN
(c) 56 kN (d) 68 kN

Q.5 The equivalent flexural moment (M_{eq}) for designing the longitudinal tension steel is
(a) 187 kN-m (b) 200 kN-m
(c) 209 kN-m (d) 213 kN-m

Q.6 Primary torsion occurs in the case of
(a) a simply supported, but laterally restrained beam subjected to eccentric loading along the span.
(b) the edge beam of a building frame.
(c) shells elastically restrained by edge beams.
(d) a cantilever beam subjected to uniformly distributed load along the span.

Q.7 Match List-I (Reinforcement Type) with List-II (Anchorage Requirement) and select the correct answer using the codes given below the lists:
List-I
A. Footing slab tensile reinforcement
B. Cantilever beam, tensile reinforcement
3. L_d into the support reinforcement
D. Beam, shear stirrup
List-II
1. $L_d/3$ into the support
2. 6ϕ for 135° bend
C. Simply supported beam, tensile
4. L_d from the column face
Codes:

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

Q.8 Side face reinforcement is provided in a beam when the depth of web exceeds
(a) 300 mm (b) 450 mm
(c) 500 mm (d) 750 mm

Q.9 The torsional longitudinal reinforcement in RCC beams should be placed at:
(a) Each corner of the beam
(b) Middle of each face
(c) Middle of the beam
(d) Core of the beam

Q.10 The spacing of transverse reinforcement of column is decided by the following considerations:
(a) The least lateral dimension of the column
(b) Sixteen times the diameter of the smallest longitudinal bar in the column
(c) Forty eight times the diameter of the transverse reinforcement
(d) All of the above

Q.11 A rectangular beam section, 350 mm wide and 750 mm deep subjected to ultimate twisting moment of 140 kNm combined with an ultimate (hogging) bending moment of 200 kNm and ultimate shear force of 110 kN. Assume M25 concrete, Fe415. The flexural tension (moment) (equivalent *bm* for design) at top and bottom of the section are: (respectively)
(a) 409, 59 kNm
(b) 459 kNm and 59 kNm
(c) 459 and 65 kNm
(d) 409 kNm and 65 kNm

Q.12 A ring beam is subjected to factored bending moment, M_u = 200 kNm torsional bending moment, T_u = 100 kN having width equal to 400 mm and Eq. depth, d = 650 mm. The value of equivalent shear stress is:
(a) 0.923 N/mm² (b) 1.923 N/mm²
(c) 1.239 N/mm² (d) 0.239 N/mm²

■■■■

Answers Design for Torsion

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

Explanations Design for Torsion

2. (a)
Torsional constant of a rectangular section of width *b* and depth *d* ($b < d$) may be expressed as

$$J = b^3 d$$

For *T*, *L* and *I* sections, torsion constant

$$J = \sum \frac{1}{3} b_i^3 d_i$$

where b_i and d_i are the dimensions of each of the component rectangles into which the section may be divided.

Torsional shear stress for rectangular section

$$\tau = \frac{T}{\alpha b^2 d}$$

For *T*, *L* and *I* sections, torsional shear stress may be calculated for each component rectangle by considering them subjected to torsional moment

$$T_i' = T\left[\frac{b_i^3 d_i}{\sum b_i^3 d_i}\right]$$

4. (d)

$$V_e = V_u + 1.6\frac{T_u}{b}$$

$$= 20 + 1.6 \times \frac{9000}{300} = 68 \text{ kN}$$

5. (d)

$$M_{eq} = 200 + \frac{9 \times \left(1 + \frac{425}{300}\right)}{1.7}$$

$$= 213 \text{ kN}$$

6. (b)

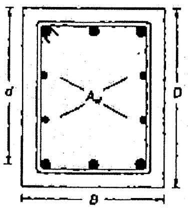
See annex-D of IS 456 : 2000

8. (d)

Requirement of side face reinforcement:

(i) When depth of beam is greater than 750 mm and beam is not subjected to torsion.

(ii) When beam is subjected to torsion and depth of beam is greater than 450 mm.



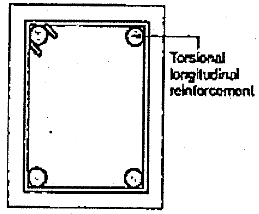
Side face reinforcement shall be provided @0.1% of web area and distributed on both faces.

$$A_{st} = \frac{0.1}{100} \times BD$$

Hence option (d) is correct.

9. (a)

Torsional longitudinal reinforcement shall be placed as close as is practicable to the corners of the cross-section and in all cases, these shall be at least one longitudinal bar in each corner of the ties. When the cross-sectional diamension of the member exceeds 450 mm, additional longitudinal bars shall be provided to satisfy the requirements of minimum reinforcement and spacing.



Hence option (a) is correct.

10. (d)

Spacing of transverse reinforcement:

(i) Least lateral dimension (B or D).

(ii) 16 × smallest dia used in longitudinal reinforcement.

(iii) 48 × diameter of transverse reinforcement.

(iv) 300 mm.

Hence option (d) is correct.

11. (b)

Effective bending moment due to torsion are:

$$M_t = \frac{T_u}{1.7}\left(1 + \frac{D}{b}\right)$$

$$= \frac{140}{1.7}\left(1 + \frac{750}{350}\right)$$

$$= 259 \text{ kNm}$$

Equivalent bending moments for design:

$$M_e = M_t \pm M_u$$

$$= 259 \pm 200$$

$$= \begin{cases} 459 \text{ kNm (flexural tension at top)} \\ 59 \text{ kNm (flexural tension at bottom)} \end{cases}$$

12. (b)

As per IS456:2000,

Equivalent shear,

$$V_e = V_u + \frac{1.6T_u}{b}$$

$$= 100 + 1.6 \times \frac{100}{0.4} = (100 + 400) = 500 \text{ kN}$$

$\therefore$ Equivalent shear stress, $\tau_{Ve} = \frac{V_e}{bd}$

$$= \frac{500}{0.4 \times 0.65} = 1.923 \text{ N/mm}^2$$

■■■■