6 CHAPTER

Design for Shear

Q.1 If the nominal shear stress (τ_v) at a section does not exceed the permissible shear stress (τ_c).
(a) minimum shear reinforcement is still provided.
(b) shear reinforcement is provided to resist the nominal shear stress.
(c) no shear reinforcement is provided.
(d) shear reinforcement is provided for the difference of the two.

Q.2 Shear span is defined as the zone where
(a) bending moment is zero.
(b) shear force is zero.
(c) shear force is constant.
(d) bending moment is constant.

Q.3 Which one of the following statement is correct?
(a) Web shear cracks start due to high diagonal tension in case of beams with their webs and high prestressing force
(b) Shear design for a prestressed concrete beam is based on elastic theory.
(c) In the zone where bending moment is dominant and shear is insignificant, cracks occur at 20° to 30°.
(d) After diagonal cracking, the mechanism of shear transfer in a prestressed concrete member is very much different from that in reinforced concrete members.

Q.4 Assertion (A) : Shear capacity of a concrete beam increases with the increase in tension reinforcement.
Reason (R) : Increase in tension reinforcement increases aggregate interlocking force.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.5 The maximum permissible shear stress $\tau_{c\,max}$ given in IS : 456 : 2000 is based on
(a) diagonal tension failure
(b) diagonal compression failure
(c) flexural tension failure
(d) flexural compression failure

Q.6 In case of deep beam or in thin webbed RCC members, the first crack formed is
(a) flexural crack.
(b) diagonal crack due to compression.
(c) diagonal crack due to tension.
(d) shear crack.

Q.7 The chances of diagonal tension crack in RCC member reduces when
(a) axial compression and shear force act simultaneously.
(b) axial tension and shear force act simultaneously.
(c) only shear force act.
(d) flexural and shear force act.

Q.8 The codal provisions recommend minimum shear reinforcement in the form of stirrups in the beams
I. to cater for any torsion in the beam section.
II. to improve ductility of the cross-section.
III. to improve dowel action of longitudinal tension bars.
Select the correct answer using the codes given below:
(a) I, II and III (b) II and III
(c) Only I (d) Only II

Q.9 A reinforced concrete beam of 10 m effective span and 1 m effective depth is supported on 500 mm x 500 mm columns. If the total uniformly distributed load on the beam is 10 MN/m, the design shear force for the beam is

(a) 50 MN (b) 47.5 MN
(c) 37.5 MN (d) 43 MN

Q.10 Assertion (A) : Minimum shear reinforcement as stirrups must be provided in beams, even if the shear stress τ_v is less than the shear strength of concrete τ_c.
Reason (R) : The bending of beams creates a tendency in the particles to slide upon each other with the beam. This tendency is called shear.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.11 Minimum shear reinforcement in beams is provided in the form of stirrups
(a) to resist extra shear force due to live load.
(b) to resist the effect of shrinkage of concrete.
(c) to resist principal tension.
(d) to resist shear cracks at the bottom of beam.

Q.12 Diagonal tension reinforcement is provided in a beam as
(a) longitudinal bars.
(b) bent up bars.
(c) helical reinforcement.
(d) 90° bend at the bends of main bars.

Q.13 Minimum shear reinforcement is provided to
(a) resist shear force at the support.
(b) resist shear on account of accidental torsion.
(c) arrest the longitudinal cracks on side faces due to shrinkage and temperature variation.
(d) resist shear in concrete developing on account of non-homogeneity of concrete.

Q.14 Assertion (A) : Minimum shear reinforcement in all shallow beam is provided when shear stress exceeds 0.5 τ_c (where τ_c is design shear stress).
Reason (R) : Minimum shar reinforcement prevents formation of inclined cracks and avoids abrupt failures and introduces ductility in shear.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.15 Shear strength of concrete in a reinforced concrete beam is a function of which of the following?
I. Compressive strength of concrete.
II. Percentage of shear reinforcement.
III. Percentage of longitudinal reinforcement in tension in the section.
IV. Percentage total longitudinal reinforcement in the section.
Select correct answer using the codes given below:
(a) I, II and IV
(b) I, II and III
(c) Only I and III
(d) Only I and IV

Q.16 What is the adoptable maximum spacing between vertical stirrups in an RCC beam of rectangular cross section having an effective depth of 300 mm?
(a) 300 mm (b) 275 mm
(c) 250 mm (d) 225 mm

Q.17 Consider the following statements dealing with flexural reinforcement to be terminated in the tension zone:
I. The shear at the cut-off point not to exceed two-third of the otherwise permitted value.
II. Shear reinforcement is provided along each terminated bar overlapping three fourth of the appropriate distance from the cut-off point.
III. For 36 mm and smaller bars, the continuing bars shall provide double the area required for flexure at the cutoff and shear does not exceed three-fourth of the permitted value.
Which of these statement/s is/are correct?
(a) I, II and III (b) I and II only
(c) II and III only (d) III only

Common Data for Q.18 and Q.19
A reinforced concrete beam of rectangular cross section of breadth 230 mm and effective depth 400 mm is subjected to a maximum factored shear force of 120 kN. The grades of concrete, main steel and stirrup steel are M20, Fe 415 and Fe 250 respectively. For the area of main steel provided, the design shear strength τ_c as per IS:456-2000 is 0.48 N/mm^2. The beam is designed for collapse limit state.

Q.18 The spacing (mm) of 2-legged 8 mm stirrups to be provided is
(a) 40 (b) 115
(c) 250 (d) 400

Q.19 In addition, the beam is subjected to a torque whose factored value is 10.9 kNm. The stirrups have to be provided to carry a shear force (kN) equal to
(a) 50.42 (b) 130.56
(c) 151.67 (d) 200.23

Q.20 The state of two dimensional stress acting in a concrete lamina consists of direct tensile stress σ_x = 1.5 N/mm^2 and shear stress τ = 1.2 N/mm^2 which causes cracking of concrete. Then the tensile strength of the concrete (in N/mm^2) is
(a) 1.50 (b) 2.08
(c) 2.17 (d) 2.29

Q.21 The shape of the shear stress diagram in a rectangular RCC beam is
(a) rectangular.
(b) parabolic.
(c) parabolic above neutral axis and rectangular below neutral axis.
(d) none of the above.

Q.22 The maximum value of permissible shear stress in concrete for M20 grade of concrete with 0.6% tension steel as per IS 456-2000, is
(a) 0.44 N/mm^2 (b) 0.51 N/mm^2
(c) 0.57 N/mm^2 (d) 0.22 N/mm^2

Q.23 For M20 grade of concrete, the maximum shear stress shall not exceed
(a) 1.6 N/mm^2 (b) 1.9 N/mm^2
(c) 2.8 N/mm^2 (d) 2.2 N/mm^2

Q.24 Minimum shear reinforcement is provided when
(a) nominal shear stress is less than permissible shear stress.
(b) nominal shear stress is more than permissible shear stress.
(c) nominal shear stress exceeds half the value of permissible shear stress.
(d) none of the above.

Q.25 The contribution of bent up bars towards shear resistance shall not be more than
(a) 50% of total shear reinforcement.
(b) 40% of total shear reinforcement.
(c) 55% of total shear reinforcement.
(d) 30% of total shear reinforcement.

Q.26 The maximum spacing of shear reinforcement measured along the axis of the member shall not exceed
(a) 0.75d for vertical stirrups.
(b) 0.75d for inclined stirrups.
(c) 200 mm for vertical stirrups.
(d) 250 mm for inclined stirrups.

Q.27 Study the following statements:
1. In no case, the spacing of stirrups in a beam shall exceed 300 mm.
2. Shear reinforcement in the form of stirrups shall not be less than $\frac{0.4bS_v}{0.87f_y}$ where S_v is stirrup spacing, b is breadth of the beam and f_y is the characteristic strength of stirrups.
3. The characteristic strength of stirrups shall not exceed 415 N/mm^2.
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.28 When shear reinforcement is not provided in flat slab, the calculated shear stress at the critical section shall not exceed $K_s\tau_c$, where K_s is
(a) $(1 + \beta_c)$ (b) $(0.6 + \beta_c)$
(c) $(0.5 + \beta_c)$ (d) $(1.5 + \beta_c)$
and β_c is the ratio of short side to long side of the column/capital.

Q.29 The ratio of the permissible shear stress in limit state method of design and working stress method of design is

(a) 25 : 16 (b) 5 : 4
(c) 16 : 25 (d) 4 : 5

Q.30 In a ring beam subjected to uniformly distributed load
1. shear force at mid span is zero.
2. shear force at mid span is maximum.
3. torsion at mid span is zero.
4. torsion at mid span is maximum.

Which of these statements are correct?
(a) 1 and 3 (b) 1 and 4
(c) 2 and 3 (d) 2 and 4

Q.31 **Assertion (A) :** Tensile reinforcement bars of a rectangular beam are bent at suitable places.
Reason (R) : Bent tensile reinforcement bars in a rectangular beam resist bending moment and provided local bond stress.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.32 Flexural shear failure in a reinforced concrete beam
1. occurs under large bending moment and less shear force.
2. results in cracks which are normally at 90° with the horizontal.
3. occurs when shear span to effective depth ratio is less than 1.

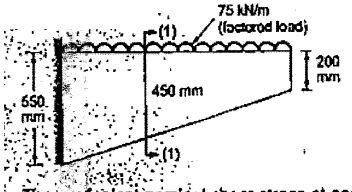
Which of these statements are correct?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.33 In a reinforced concrete retaining wall, a shear key is provided, if the
(a) shear stress in the vertical stem is excessive.
(b) shear force in the toe slab is more than that in the heel slab.
(c) retaining wall is not safe against sliding.
(d) retaining wall is not safe against overturning.

Q.34 The diagonal tension which results in ultimate failure due to development of diagonal tension cracks, depends on
(a) shear span (b) effective depth
(c) both (a) and (b) (d) none of the above

Q.35. The minimum shear reinforcement of simply supported beam of effective span 8 m and effective depth 450 mm and width 250 mm with shear stirrup spacing of 145 mm is given as:
(a) 40.16 mm² (b) 60.16 mm²
(c) 30.26 mm² (d) 40.26 mm²

Q.36 Consider the tapered cantilever beam of width b = 300 mm and cover 50 mm



The equivalent nominal shear stress at section (1) – (1) is:
(a) 0.876 N/mm² (b) 1.276 N/mm²
(c) 1.074 N/mm² (d) 1.867 N/mm²

Q.37 If a 2-legged HYSD bar of 8 mm diameter is used as a shear reinforcement for a beam of width 250 mm and depth 340 mm with nominal cover of 40 mm, the spacing to satisfy the minimum shear reinforcement requirement as per IS : 456.
(a) 240 mm (b) 395 mm
(c) 980 mm (d) 360 mm

Q.38 Consider a member having cross-sectional area 400 mm² is subjected to axial compression, P = 150 N. Assuming M30 grade concrete having shear strength, τ_c. The designed shear strength is represented to $k\tau_c$ where k is
(a) 1.056 (b) 1.082
(c) 1.506 (d) 1.802

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Answers Design for Shear

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

Explanations Design for Shear

1. (a)
If $\tau_v < \tau_c$ the minimum shear reinforcement in the form of stirrups shall be provided such that

$$\frac{A_{sv}}{BS_v} \geq \frac{0.4}{0.87 f_y}$$

5. (b)
We know, $\tau_{c,max} = 0.6375\sqrt{f_{ck}}$. If area of shear reinforcement is large failure may occur due to shear compression failure of concrete prior to yielding of steel.

11. (c)
The shear at which the inclined crack in beam without shear reinforcement is formed first, is taken as the shear strength of concrete as the difference between the loads corresponding to the first crack and the ultimate failure is very less. Formation of such crack occur when the principal tensile stress reaches the tensile strength of concrete. At the mid-span of a simply supported beam subjected to uniformly distributed load, where shear is small and bending stress is large, the direction of principal tensile stress is flat and is nearly equal to the flexural tensile stress. This will cause flexural cracks nearly vertical to the axis of the beam. These are initiated even when $0.5\tau_c < \tau_v < \tau_c$. Thus minimum reinforce-ment is needed to prevent flexural crack due to principal tension

16. (d)
For vertical stirrups:
Maximum spacing = 0.75 d
= 0.75 × 300 = 225 mm

20. (c)

$$\sigma_t = \frac{\sigma_x}{2} + \sqrt{\left(\frac{\sigma_x}{2}\right)^2 + \tau^2}$$

$$\Rightarrow \quad \sigma_t = \frac{1.5}{2} + \sqrt{\left(\frac{1.5}{2}\right)^2 + 1.2^2} = 2.17 \text{ N/mm}^2$$

23. (c)

$$\tau_{cmax} = 0.62\sqrt{f_{ck}} = 0.62\sqrt{20}$$
$$= 2.77 \text{ N/mm}^2 \simeq 2.8 \text{ N/mm}^2$$

24. (a)
The code requires that shear reinforcement need not be provided in the following cases:
1. Where shear force V_u is less than 0.5 times the shear capacity of the section and
2. In members of minor structural importance such as lintels etc.

25. (a)
Total shear strength = Shear resistance of effective concrete area as a function of longitudinal bars + shear resistance of vertical shear stirrups + shear resistance of inclined shear stirrups.
Tests have shown that inclined bars alone do not provide a satisfactory solution and their contribution is limited to 50% of net shear strength after deducting the contribution of concrete. The remaining shear resistance is provided by vertical stirrups.

26. (c)

$$k_s = 0.5 + \beta_c \leq 1$$

$$\beta_c = \frac{\text{shorter side}}{\text{longer side}}$$

29. (a)

Permissible shear stress:

In limit state method of design $\tau_c = 0.25\sqrt{f_{ck}}$

In working stress method of design $\tau_c = 0.16\sqrt{f_{ck}}$

$$\text{Ratio} = \frac{25}{16}$$

35. (a)

As per IS : 456;

$$\frac{A_{SV(\text{minimum})}}{bS_v} \geq \frac{0.4}{0.87f_y}$$

$$\Rightarrow \quad A_{SV(\text{minimum})} = \frac{0.4bS_v}{0.87f_y} = \frac{0.4 \times 250 \times 145}{0.87 \times 415}$$

$$= 40.16 \text{ mm}^2$$

36. (c)

Bending moment M_u at section 2-2

$$= 75 \times 2.5 \times \frac{2.5}{2} = 234.375 \text{ kN}$$

Shear force, V_u at section 2-2

$$= 75 \times 2.5 = 187.5 \text{ kNm}$$

Effective depth at section 2-2

$$= 450 - 50 = 400 \text{ mm}$$

Width, $b = 300$ mm

$$\tan\beta = \frac{550 - 200}{3500} = 0.10$$

$$\tau_v = \frac{V_u - \frac{M_u}{d}\tan\beta}{bd}$$

$$= \frac{10^3\{187.5 - (234.375 \times 0.1)/0.4\}}{(300 \times 400)}$$

$$= 1.074 \text{ N/mm}^2$$

37. (d)

As per IS 456 : 200, for minimum shear reinforcement requirement;

$$\frac{A_{SV}}{bS_v} \geq \frac{0.4}{0.87f_y}$$

$$\Rightarrow \quad \frac{2 \times \frac{\pi}{4} \times (8)^2}{250 \times S_v} \geq \frac{0.4}{0.87 \times 415}$$

$$\Rightarrow \quad S_v \leq 363 \text{ mm}$$

38. (a)

As per IS : 456 (Cl 40.2.2); the shear strength is increased by axial compression factor k.

$$k = \begin{cases} 1 + \dfrac{3P_u}{A_g f_{ck}} \\ 1.5 \end{cases} \text{ whichever is less}$$

$$k = \begin{cases} 1 + \left(\dfrac{3 \times 150 \times 1.5}{400 \times 30}\right) = \begin{cases} 1.056 \\ 1.5 \end{cases} \\ 1.5 \end{cases}$$

$$k = 1.056$$

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