CHAPTER 7

Design for Bond in RC

Q.1 In a limit state design, permissible bond stress in the case of deformed bars is more than that in plain bars by
(a) 60% (b) 50%
(c) 40% (d) 25%

Q.2 Consider the following statements:
I. At the point of inflection, the embedment length need not exceed the development length L_d.
II. The condition that $L_d \le \left(\frac{M_1}{V} + L_0\right)$ need not be checked for negative reinforcement.
III. At least one-third of the total negative reinforcement provided must extended beyond the point of inflection for a distance not less than 'd' or 12ϕ or clear-span whichever is larger.
Which of these statements are correct?
(a) I, II and III (b) I and II
(c) I and III (d) II and III

Q.3 Consider the following statements:
Bars that extend into a simple support must be able to develop their full strength at a designated point L so that their moment capacity is more than the bending moment at that point. The clauses of the code require that ($\sigma_s = 0.85\,\sigma_{sy}$)
I. $L_d \le \dfrac{1.3M_1}{V} + L_0$
II. $\dfrac{\phi\sigma_s}{4\tau_{bd}} \le \dfrac{1.3\,M_1}{V} + L_0$
III. $\phi \le \dfrac{4\tau_{bd}}{\sigma_s}\left(\dfrac{1.3\,M_1}{V} + L_0\right)$
which of these statements are correct?
(a) I and II (b) II and III
(c) I and III (d) I, II and III

Q.4 Consider the following statements:
I. Reinforcement that is no longer required for flexure beyond a certain section, shall however be extended by 'd' or 12ϕ, whichever is greater, before it is being curtailed.
II. At least half the bars should be bent up at the cut-off point.
III. The shear capacity at cut-off point should be at least 1.5 times the shear force at that section.
which of these statements are correct?
(a) I and II (b) I and III
(c) II and III (d) I, II and III

Q.5 In a reinforced concrete member, the best way to ensure adequate bond is
(a) to provide minimum number of large diameter bars.
(b) to provide large number of smaller diameter bars.
(c) to increase the cover for reinforcement.
(d) to provide additional stirrups.

Q.6 A beam is designed for uniformly distributed loads causing compression in the supporting columns. Where is the critical section for shear? (d is effective depth of beam and L_d is development length)
(a) A distance $L_d/3$ from the face of the support
(b) A distance d from the face of the support
(c) At the centre of the support
(d) At the mid span of the beam

Q.7 Which one of the following is the correct expression to estimate the development length of deformed reinforcing bar as per IS code in limit state design?
(a) $\dfrac{\phi\sigma_s}{4.5\tau_{bd}}$ (b) $\dfrac{\phi\sigma_s}{5\tau_{bd}}$
(c) $\dfrac{\phi\sigma_s}{6.4\tau_{bd}}$ (d) $\dfrac{\phi\sigma_s}{8\tau_{bd}}$

Q.8 When HYSD bars are used in place of mild steel bars in a beam, the bond strength
(a) does not change (b) increases
(c) decreases (d) becomes zero

Q.9 Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I	List-II
A. $\frac{V_u}{bd}$	1. Modulus of rupture
B. $0.7\sqrt{f_{ck}}$	2. Development length
C. $5000\sqrt{f_{ck}}$	3. Nominal shear stress
D. $\frac{\phi f_s}{4\tau_{bd}}\sqrt{f_{ck}}$	4. Hook anchorage value
	5. Modulus of elasticity of concrete

Codes:

	A	B	C	D
(a)	3	1	5	2
(b)	2	1	4	3
(c)	3	5	1	4
(d)	2	4	1	3

Q.10 What is the anchorage value of a standard hook of a reinforcement bar of diameter D?
(a) $4D$ (b) $8D$
(c) $12D$ (d) $16D$

Q.11 The average permissible bond stress in deformed bars is more than that in plain bars by
(a) 15% (b) 25%
(c) 40% (d) 60%

Q.12 Development length of bars is given by
(a) $\frac{\phi\sigma_s}{4\tau_{bd}}$ (b) $\frac{\phi\sigma_s}{\tau_{bd}}$
(c) $\frac{2\phi\sigma_s}{3\tau_{bd}}$ (d) $\frac{3}{4}\frac{\phi\sigma_s}{\tau_{bd}}$

Q.13 Consider the following statements:
1. Development length includes anchorage value of hooks in tension reinforcement.
2. The development length of each bar of bundled bars shall be that for the individual bar, increased by 33% for three bars in contact.
3. Deformed bars may be used without end anchorage provided development length requirement is satisfied.

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

Q.14 Match List-I (Stress) with List-II (Nature) and select the correct answer using the codes given below the lists:

List-I
A. Bond stress
B. Thermal stress
C. Hoop stress
D. Torsional stress shear

List-II
1. Zero at centre of cross-section
2. Circumferential stress
3. Linear stress
4. Longitudinal stress
5. Zero on the surface

Codes:

	A	B	C	D
(a)	5	2	4	1
(b)	4	3	2	1
(c)	4	5	2	3
(d)	1	3	4	5

Directions: The following items consists of two statements; one labelled as 'Assertion (A)' and the other as 'Reason (R)'. You are to examine these two statements carefully and select the answers to these items using the codes given below:

Codes:
(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 Assertion (A): The development length for Fe415 bars is less than that for mild steel plain bars.
Reason (R): The permissible bond stress for HYSD bars is more than that for mild steel plain bars.

Q.16 Assertion (A): Detailing of bars as per the requirements of maximum spacing of reinforcement in beams and slabs is sufficient to control flexural cracking.
Reason (R): A large number of smaller diameter bars, well distributed in the tension zone, reduce the crack width more effectively than a few larger diameter bars of the same area.

Q.17 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
C. L_d into the support reinforcement
D. Beam, shear stirrup

List-II
1. $L_d/3$ into the support
2. 6ϕ for 135° bend
3. 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.18 The development length in compression for a 20 mm diameter deformed bar of grade Fe-415 embedded in concrete of grade M-25, whose design bond stress is 1.40 N/mm² is
(a) $\frac{20\times0.87\times415}{4\times1.40}$
(b) $\frac{20\times0.87\times415}{4\times1.25\times1.40}$
(c) $\frac{20\times0.87\times415}{4\times1.6\times1.40}$
(d) $\frac{20\times0.87\times415}{4\times1.25\times1.6\times1.40}$

Q.19 The bond strength between steel reinforcement and concrete is affected by
1. steel properties.
2. concrete properties.
3. shrinkage of concrete.

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

Q.20 Bond strength can be enhanced when
(i) high grade concrete is used
(ii) mechanical anchorages are employed
(iii) smaller diameter bars are used
(iv) deformed bars are used
Which of these statements are correct?
(a) (i), (ii) and (iii)
(b) (i), (ii) and (iv)
(c) (i), (iii) and (iv)
(d) (i), (ii), (iii) and (iv)

Q.21 If a R.C. beam is getting failed in bond, its bond strength can be increased by:
(a) increasing the depth of beam
(b) using thinner bars but more in numbers
(c) using thicker bars but less in numbers
(d) providing vertical stirrups

Q.22 The equivalent development length of a 90° bend in a reinforcement bar of diameter ℓ is
(a) 4ϕ (b) 8ϕ
(c) 12ϕ (d) 16ϕ

Q.23 Lap length including anchorage value of hooks for bars in flexural tension shall be
(a) L_d or 20ϕ, whichever is greater
(b) $2L_d$ or 20ϕ, whichever is greater
(c) L_d or 30ϕ, whichever is greater
(d) $3L_d$ or 30ϕ, whichever is greater

Q.24 The development length for longitudinal tension bars (2 - 25ϕ) in the cantilever beam subjected to uniformly distributed load of 100 kN including self weight is: (Assume M20 concrete and Fe 415 steel, deformed bars)
(a) 1076 mm (b) 1376 mm
(c) 1175 mm (d) 1276 mm
(τ_{bd} for M20, = 1.2 MPa)

Q.25 As per IS : 456, which of the following matches correctly:
1. Lap length in flexural tension
2. Lap length in direct tension
3. Lap length in compression

A. $2L_d$ or 30ϕ
B. 24ϕ or L_d
C. L_d or 30ϕ
D. $2L_d$ or 24ϕ

(a) 1 – C, 2 – A and 3 – B
(b) 1 – C, 2 – A and 3 – D
(c) 1 – A, 2 – C and 3 – D
(d) 1 – D, 2 – B and 3 – C

■■■■

Answers Design for Bond in RC

1. (a)	2. (d)	3. (d)	4. (a)	5. (b)
6. (b)	7. (c)	8. (b)	9. (a)	10. (d)
11. (d)	12. (a)	13. (b)	14. (b)	15. (d)
16. (d)	17. (c)	18. (d)	19. (d)	20. (d)
21. (b)	22. (b)	23. (c)	24. (c)	25. (a)

Explanations Design for Bond in RC

4. (a)
The shar at cut-off point doesn't exceed two-thirds that permitted including the shear strength of web reinforcement provided.

11. (d)
For bars in compression, permissible bond stress can be increased by 25% and for deformed bars, it is increased by 60%.

12. (a)
Bond resistance of concrete = Strength of bar

$$\Rightarrow \quad \tau_{bd}\pi\phi L_d = \frac{\pi}{4}\phi^2\sigma_s$$

$$\Rightarrow \quad L_d = \frac{\phi\sigma_s}{4\tau_{bd}}$$

13. (b)
In case of bundled bars in contact, the development length is increased for individual bar by
1. 10 % for two bars in contact.
2. 20% for three bars in contact.
3. 33% for four bars in contact.

15. (d)
The development length, L_d, is given by

$$L_d = \frac{\phi\sigma_s}{4\tau_{bd}}$$

For HYSD Fe 415 bars, the values of τ_{bd} shall be increased by 60 percent.

18. (d)
For bars in compression the value of bond stress is increased by 25%.
For deformed bars value of bond stress is increased by 60%.

22. (b)
1. Anchoring bars in tension: Deformed bars may be used without end anchorages provided, if development length requirement is satisfied.
Normally hooks should be provided for plain bars in tension. The anchorage value of bend shall be taken as 4 times the diameter of the bar for each 45° bend subjected to maximum of 16 times the diameter of the bar
(a) For 45° bend = 4ϕ
(b) For 90° bend = 8ϕ
(c) For 135° bend = 12ϕ

2. Anchoring bar in compression: The anchorage length of straight bar in compression shall be equal to the development length of bar in compression. The projected length of hooks, bends and straight length beyond bends if provided for a bar in compression, shall be considered for development length.

Hence option (b) is correct.

23. (c)
Requirement of Lap length (Including anchorage value of hook)
(i) Lap length in compression shall not be less than 24ϕ
(ii) Lap length in flexural tension shall be greater of L_d or 30ϕ
(iii) Lap length in direct tension shall be greater of $2L_d$ or 30ϕ
Where L_d is the development length
Hence option (c) is correct.

24. (c)
For tension bars,

$$L_d = \left(\frac{0.87f_y}{4\tau_{bd}}\right)\phi = \frac{0.87\times 415\phi}{4\times\tau_{bd}} = 47\phi$$

where $\tau_{bd} = 1.2 \times 1.6$
(for deformed bars, τ_{bd} is increased by 60%)
$\therefore \quad L_d = 47 \times 25 = 1175$ mm

25. (a)
As per IS : 456 – 2000, the correct option is A (clause 26.25.1)

■■■■