Limit State Design Method

Answer Keys and Explanations

1. **[Ans. C]**

2. **[Ans. C]**

3. **[Ans. B]**

4. **[Ans. *] Range: 0.0042 to 0.0042**

5. **[Ans. C]**

6. **[Ans. *] Range: 2666.67 to 2666.67**

$$b_{eff} = \frac{l_0}{6} + b_w + 6D_f$$
$$= \frac{7000}{6} + 300 + 6 \times 200$$
$$= 2666.67 \text{ mm}$$

7. **[Ans. *] Range: 27386.13 to 27386.13**

$$E = 5000 \times \sqrt{30} = 27386.13 \text{ N/mm}^2$$

8. **[Ans. *] Range: 4.41 to 4.14**

$$f_{cr} = 0.7 \times \sqrt{35} = 4.14 \text{ N/mm}^2$$

9. **[Ans. A]**

10. **[Ans. *] Range: 1.3 to 1.3**

FOS for concrete $= 1.5$

FOS for steel $= 1.15$

$$\text{Ratio} = \frac{1.5}{1.15} = 1.3$$

11. **[Ans. D]**

$$f_{avg} = \frac{32 + 33.5 + 31}{3} = 32.167$$

$$\% \text{ variation} = \frac{f_c - f_{avg}}{f_{avg}} \times 100$$
$$= \frac{32 - 32.167}{32.167} = -0.52\%$$
$$= \frac{33.5 - 32.167}{32.167} = 4.41\%$$

$$= \frac{31 - 32.167}{32.167} = -3.63\%$$

For all the cubes, variation is less than 15%

12. **[Ans. C]**

If footing is directly laid on the ground (Raft), minimum clear cover = 75 mm.
But if it is resting on lean concrete, then minimum clear cover is 50 mm.

13. **[Ans. *] Range: 27.75 to 27.75**

A structure fails, when

- Probability of exceeding of load = 15%
- Probability of strength to be less then characteristic strength = 15%
- If first two reasons occur together = 15% × 15%

Total probability of any structure = $0.15 \times 0.85 + 0.15 \times 0.85 + 0.15 \times 0.15 = 27.75\%$

14. **[Ans. *] Range: 7812.5 to 7812.5**

$$E_{cr} = \frac{5000\sqrt{25}}{1 + 2.2} = 7812.5$$

15. **[Ans. *] Range: 427.5 to 427.5**

$1.5\ M_{DL} + 1.5M_{IL} = 217.5$ kN-m

$1.2(M_{DL} + M_{IL} \pm M_{WL/EQ}) = 414$ kN-m

$1.5\ M_{DL} \pm 1.5\ M_{WL/EQ} = 427.5$ kN-m

$0.9M_{DL} \pm 1.5\ M_{WL/EQ} = 376.5$ kN-m

Maximum value is the design value of bending moment.

16. **[Ans. C]**

$f_m = f_{ck} + 1.65\ \sigma$
$= 35 + 1.65 \times 5$
$= 43.25\ N/mm^2$

17. **[Ans. A]**

$$\frac{A_{st_{min}}}{bd} \geq \frac{0.85}{f_y}$$

$$A_{st_{min}} = \frac{0.85}{500} \times 250 \times 350$$

$A_{st_{min}} = 148.75\ mm^2$

$A_{st_{max}} = 0.04BD$
$= 0.04 \times 250 \times 400$
$= 4000\ mm^2$

Difference
$= A_{st_{max}} - A_{st_{min}}$
$= 4000 - 148.75$
$= 3851.25\ mm^2$

18. **[Ans. C]**

19. **[Ans. D]**

20. **[Ans. *] Range: 3.64 to 3.64**

For cantilever beam

$$l_{eff} = l_c + \frac{d}{2}$$

$$= 3.5 + \frac{0.27}{2}$$

$$= 3.5 + 0.135$$

$$= 3.635 \text{ m}$$

$$= 3.64 \text{ m}$$