SEMESTER-V

16BECE502 DESIGN OF RC STRUCTURES I 3 0 0 3 100

OBJECTIVE

- To study the stress strain behavior of steel and concrete
- To understand the concept of working stress and limit state methods
- To gain the knowledge of limit state design for flexure, shear, torsion, bond and anchorage
- To understand the behavior of columns subjected to eccentric load and use of interaction diagrams

UNIT I

INTRODUCTION 9

Materials for concrete- Stress-Strain curve for concrete in compression-Concrete mix proportioning-Design mix and nominal mix-Types of reinforcement-Plain and deformed bars-Stress-strain curve for reinforcing steel.

Concept of WSD (No problems) and LSD-Difference between WSD and LSD-Characteristic loads and strengths-Partial safety factor-Various limit states.

DESIGN FOR FLEXURE:

Design of singly and doubly reinforced rectangular and flanged sections as per IS code

UNIT II

DESIGN BASICS FOR SHEAR, BOND AND TORSION 9

Design for shear-concept of bond and anchorage-Design for torsion-IS code provision for the design of beams-Design of lintels-Design of continuous beams using B.M. and S.F. co-efficient as per IS code-detailing.

UNIT III

DESIGN OF SLABS 9

Types of slabs-IS code regulations-Stiffness requirements-Design of one-way simply supported and continuous slab using BM and SF co-efficient as per IS code-Principles of Rankine-Grashof's method(no problems)-design of two way, simply supported and continuous slab as per IS code.

UNIT IV

DESIGN OF COLUMNS 9

IS-code regulations-Design of short rectangular and circular columns subjected to axial compressive load-Design of short columns subjected to combined axial compressive load and uni-axial and biaxial bending moments using design aids(SP 16)- Introduction to long column design

UNIT V

DESIGN OF FOOTINGS **9**

Design of wall footings- Design of isolated, square and rectangular footings.-combined rectangular and trapezoidal footings.

TOTAL HRS: 45

TEXT BOOKS:

Sl.No	Title of Book	Author of Book	Publisher	Year of Publishing
1.	Reinforced Concrete Design	UnnikrishnaPillai&DevadosMenon	Tata McGraw Hill Publishing Co, New Delhi	2012
2.	IS 456-2000 Indian Standard Code of practice for Reinforced Concrete.			
3	SP-16 Design Aids for IS 456-1978. IS 875-1987-Code of Practice for Design Loads			

REFERENCE:

Sl.No	Title of Book	Author of Book	Publisher	Year of Publishing
1.	Reinforced Concrete	Mallick, S.K., and Gupta, A.P	Oxford & IBH Publishing Co., New Delhi	2008
2.	Reinforced Concrete Design	Sibha,S.N.	Tata McGraw-Hill Publishing Co, Ltd., New Delhi	2001
3.	Reinforced Concrete Mechanics and Design	MacGregor J.G	Prentice Hall, New Jersey	2008
4.	Reinforced Concrete limit state design	Ashok K Jain	Nem Chand Bros, Roorkee	2012
5.	Limit State Design of R.C.Structures	Varghese, P.C	PHI Learning Pvt. Ltd.. New Delhi	2008

WEBSITES:

- http://www.icivilengineer.com
- http://www.engineeringcivil.com/
- http://www.aboutcivil.com/
- http://www.engineersdaily.com
- http://www.asce.org/
- http://www.cif.org/

COURSE OUTCOMES

On completion of the course, the students will be able to:

- Apply the fundamental concepts of working stress method and limit state method.
- Use IS code of practice for the design of concrete elements.
- Design the beams, slab, stairs, column and footing.
- Draw detailing of various RCC structural elements.

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Established Under Section 3 of UGC Act, 1956)

COIMBATORE-641 021

FACULTY OF ENGINEERING
DEPARMENT OF CIVIL ENGINEERING

16BECE502 / DESIGN OF RC STRUCTURES I
LECTURE PLAN

Number of credits : 4
Contact hours : 5 hours per week
Lecturer : V.Johnpaul
Semester : VI
Course Type : Core

S.No	Period/ Hours	Topics	Units	T(Book)	Page No
		UNIT-1 INTRODUCTION			
1	1	Introduction –concrete and concrete materials	**1**	T1	1-19
2	1	Stress-Strain curve for concrete in compression		T1	57
3	1	Nominal concrete mix design concept and design principles		T1	24-26
4	1	Concrete mix proportioning-Design concrete mix concept and design principles		T1	37-38
5	1	Stress-strain curve for Plan and deformed bars		T1	46,47
6	1	Concept of WSD and LSD, Partial safety factor, Various limit states.		T1	49,51, 55-56
7	1	Design of singly reinforced rectangular beam sections- load and S.F calculation		T1	79
8	1	Moment Calculation and Reinforcement detailing		T1	80
9	1	Design of doubly reinforced rectangular beam sections- N.A check, load calculation and S.F calculation		T1	97-98
10	1	Moment Calculation and Reinforcement detailing		T1	98-99
11	1	**Tutorial-1**			
12	1	Design of singly and doubly reinforced L-flanged sections		T1	142
13	1	Design of singly and doubly reinforced T-flanged sections		T1	142-143
14	1	**Tutorial-2**			
Total	14hours (12+2)				
		UNIT-II(DESIGN FOR SHEAR, BOND AND TORSION)			

15	1	Concept of bond and anchorage in concrete	**2**	T1	180-186
16	1	Design concept of shear & torsion		T1	154-159, 194-195
17	1	Design of beams subjected to shear- Preliminary dimension and load calculation		T1	176-177
18	1	S.F calculation and torsional Reinforcement detailing		T1	177-179
19	1	Design of lintels subjected to shear- Preliminary dimension and load calculation		T1	241-242
20	1	S.F calculation and reinforcement detailing		T1	242-244
21	1	**Tutorial -3**			
22	1	Design of continuous beams using B.M. and S.F. co-efficient as per IS code-detailing.- load & B.M Calculation		T1	282-284
23	1	S.F Calculation & Reinforcement detailing		T1	284-287
24	1	**Tutorial-4**			
Total	10hours (8+2)				
UNIT III (DESIGN OF SLABS & DESIGN OF STAIRCASE SLAB)					
25	2	Types of slabs, IS code regulations, Stiffness requirements of slabs	**3**	T1	250
26	2	Design of one-way simply supported slab – Dimensions of slab, load calculation & S.F calculation		T1	252-253
27	1	B.M. Calculation & Reinforcement detailing		T1	253-255
28	1	Design of one-way continuous slab- Dimensions of slab, load calculation & S.F calculation		T1	264-266
29	1	B.M. Calculation & Reinforcement detailing		T1	266-268
30	1	Principles of Rankine-Grashof's method		T1	310
31	1	**Tutorial-5**			
32	1	Design of two way simply supported slab - Dimensions of slab, load calculation & S.F calculation		T1	333-335
33	1	B.M. Calculation & Reinforcement detailing		T1	335-337
34	1	Design of two way continuous slab- Dimensions of slab, load calculation & S.F calculation		T1	323-326
35	1	B.M. Calculation & Reinforcement detailing		T1	326-329
36	1	**Tutorial-6**			
	14hours (12+2)				

UNIT IV (DESIGN OF COLUMNS)					
37	1	IS-code regulations for design of columns	**4**	T1	400
38	1	Design of short rectangular column subjected to axial compressive load- Load calculation, Axial force calculation		T1	410-411
39	1	Area of steel calculation and Reinforcement detailing		T1	411-412
40	1	Design of short circular column subjected to axial compressive load- Load calculation, Axial force calculation		T1	408-409
41	1	Area of steel calculation and Reinforcement detailing		T1	409-410
42	1	**Tutorial -7**			
43	1	Design of short columns subjected to combined axial compressive load and uni-axial bending moments- Preliminary dimensions, load calculation, Main Reinforcement calculation		T1	444
44	1	Ties calculation and Reinforcement detailing		T1	445
45	1	Design of short columns subjected to combined axial compressive load and biaxial bending moments- Preliminary dimensions, load calculation, Main Reinforcement calculation		T1	492-493
46	1	Ties calculation and Reinforcement detailing		T1	493-495
47	1	**Tutorial-8**			
	11 hours (9+2)				
UNIT V- DESIGN OF FOOTINGS					
48	1	Design of wall footings	**5**	T1	583-585
49	1	Design of isolated square footings- load , area of footing and B.M calculation		T1	587-588
50	1	S.F and Reinforcement calculation, One way & two way shear check		T1	588-589
51	1	Design of isolated rectangular footings- load , area of footing and B.M calculation		T1	589-591
52	1	S.F and Reinforcement calculation, One way & two way shear check		T1	591-592
53	1	**Tutorial -9**			
54	1	Combined rectangular footing design- load , area of footing and B.M calculation		T1	609-611
55	1	S.F and Reinforcement calculation, One way & two way shear check		T1	611-615
56	1	Combined trapezoidal footing design- load , area of footing and B.M calculation		T1	616-619
57	1	S.F and Reinforcement calculation, One way & two way shear check		T1	619-6-23
58	1	**Tutorial -10**			
Total	11 hours (9+2)				

SUPPORT MATERIALS

TEXT BOOKS				
Sl.No	**Title of Book**	**Author of Book**	**Publisher**	**Year of Publishing**
1	Limit state design of reinforced Concrete	Dr.B.C.Punmia	Laxmi publications (p) ltd	2007

REFERENCE BOOKS

Sl.No	**Title of Book**	**Author of Book**	**Publisher**	**Year of Publishing**
2	Design of Reinforced Concrete Structures	Krishna Raju.N	CBS publishers & Distributors Pvt. Ltd, New Delhi	2011
3	Fundamentals of Reinforced Concrete	Sinha, N.C., and Roy, S.K	S.Chand and Company, New Delhi	2001
4	Reinforced Concrete Design	Sibha,S.N.	Tata Mc Graw-Hill Publishing Co, Ltd., New Delhi	2001

WEBSITES:

- http://www.icivilengineer.com
- http://www.engineeringcivil.com/
- http://www.aboutcivil.com/
- http://www.engineersdaily.com
- http://www.asce.org/
- http://www.cif.org/
- http://icevirtuallibrary.com/
- http://www.ice.org.uk/

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DESIGN OF RCC STRUCTURES

UNIT – 1

1. Define reinforced concrete.

Reinforced cement concrete is a composite material is made of concrete and steel reinforcement. The concrete may be assumed to work purely in compression whereas the reinforcement is predominately subjected to tension. For a large range of applications it is sufficient to consider the uni-axial response of either material.

2. What is the purpose of using reinforced cement concrete?

- Plain cement concrete has very low tensile strength. The tensile strength of concrete is about one-tenth of its compressive strength. As a result, a plain concrete beam fails suddenly as soon as the tension cracks start to develop.
- To improve the tensile strength of concrete, some sort of reinforcement is needed which can take up the tensile stress developed in the structure.
- It's not only increases the strength but also in preventing the temperature and shrinkage.
- Therefore, reinforcing steel is added in the tension zone to carry all the developed tensile stresses.

3. What are the advantages of RCC when compared with other building materials?

- Concrete is workable when fresh and strong when hardens.

- It can be molded into any required shape and size.
- The raw materials required are easily available.
- Skill is not required for casting concrete elements.
- Concrete is durable, fire resisting and rigid.
- Concrete requires less maintenance.

4. What are the disadvantages of RCC when compared with other building materials?

- The self-weight of the structural elements will be more while concrete is used.
- Concrete has a very low tensile strength. Hence cracks will form in the tension zone if reinforcement is not provided properly.
- Cracks develop in concrete, also due to shrinkage, creep, temperature, etc. which permit seepage of water into the concrete. This causes corrosion of steel reinforcement and thereby peeling of concrete.
- Concrete has poor insulating property.
- Dismantling and reusing of concrete elements are mostly not possible.
- Concrete is brittle in nature and hence has low impact resisting capacity.

5. What are the uses of reinforced concrete?

It is used for the construction of,

- Buildings
- Bunkers and silos
- Chimneys and towers
- Flyovers
- Retaining walls

- Roads and railway bridges
- Water tanks

6. **What are the types of load on R.C.C structures?**
   - Dead load
   - Live load or Imposed load
   - Wind load
   - Snow load
   - Earthquake load
   - Seismic load

7. **What are the elements of structures?**
   - Beam
   - Column
   - Floor
   - Foundation
   - Slab
   - Staircase

8. **What are the methods of design?**
   - Modular Ratio Method (or) Working Stress Method(WSM) (or) Elastic Method of Design
   - Load Factor Method (or) Ultimate Load Method(ULM) (or) Ultimate Strength Method
   - Limit State Method(LSM)

9. Define elastic method of design.

The elastic method of design of reinforced concrete member is also known as Working Stress Method (or) Modular Ratio Method. Elastic behaviors of materials are used in Elastic Method of Design. The method of elastic design of a structure is defined as a method which limits the structural usefulness of the material of the structure upto a certain load at which the maximum stress in extreme fibre reaches the characteristic strength of material in bending.

10. Define ultimate load design method.

This method is otherwise known as Load Factor Method or Ultimate Strength Method. This method is based on the ultimate strength, when the design member would fail. In this method factors are taken into account only on loads are load factors. The method of ultimate design of a structure is defined as a method which limits the structural usefulness of the material of the structure upto ultimate load.

11. Define limit state method.

The Limit State Method is defined as a method which limits the structural usefulness of the material of the structure upto a certain load at which acceptable limit of safety and serviceability are applied so that the failure of structure does not occur. It is the combination of Working Stress Method and Ultimate Load Method. In this method partial factor of safety is considered on both loads and stresses. This method is advance over other methods. Since, safety and serviceability are considered.

12. Define characteristic load.

A characteristic load is defined as that value of load which has a 95% probability of not being exceeded during the life of the structure.

$$F_k = F_m + K\, S_d$$

Where,

F_k = characteristic load

F_m = mean load

K = constant = 2.645 ≏ 2.65

S_d = standard deviation for the load

13. Define permissible stress.

It is defined as the ratio of yield stress to the factor of safety.

$$Permissible\ stress = \frac{Ultimate\ or\ Yield\ strength\ of\ materials}{Factor\ Of\ Safety}$$

14. Define factor of safety.

Factor of safety is a number used to determine the working stress. It is fixed based on the experimental works on the material. It accounts all uncertainties such as, material defects, unforeseen loads, manufacturing defects, unskilled workmanship, temperature effects etc. Factor of safety is a dimensionless number. It is defined as the ratio of ultimate stress to working stress for brittle materials or yield stress to working stress for ductile material.

$$FOS = \frac{Ultimate\ stress}{Working\ stress}\ (for\ brittle\ material)$$

15.Define modular ratio.

It is defined as the ratio of elastic modulus of steel to that of concrete. It is used to transform the composite section into an equivalent concrete section.

$$m = \frac{280}{3\,\sigma_{cbc}}$$

16.What is the expression recommended by the IS 456-2000 for modulus of elasticity?

$$Modulus\ of\ elasticity = E_c = 5000\sqrt{f_{ck}}$$

17.State the assumption made for design of RC members in working stress method.

(Refer IS 456:2000 Page no: 80)

18.What are the advantages in limit state method?

- Ultimate load method only deals with on safety such as strength, overturning, and sliding, buckling, fatigue.
- Working stress method only deals with serviceability such as crack, vibration, deflection etc.
- But, Limit state method advances than other two methods. Hence by considering safety at ultimate load and serviceability at working load.
- The process of stress redistribution and moment redistribution are considered in the analysis and more realistic factor of safety values are used in the design. Hence, the design by limit state method is found to be more economical.

- The overall sizes of flexural members arrived by limit state method are less and hence they provide better appearance to the structure.

19.What are the advantages of working stress method?

- The design usually results in relatively large sections of structural members, compared to ultimate load. Due to this structures designed by working stress method gives better serviceability performance under working loads.
- This method is only the method available when one has to investigate the reinforced concrete section for service stresses and for the serviceability state of deflection and cracking.

20.What are the disadvantages of working stress method?

- The WSM does not show the real strength nor gives the true factor of safety of the structure under failure.
- The modular ratio design results in larger percentage of compression steel than that given by the limit state design, thus leading to un-economic design.
- Because of creep and non-linear stress-strain relationship, concrete does not have definite modulus of elasticity.
- The WSM fails to discriminate between different types of loads that act simultaneously but have different uncertainties.

21.What are the advantages of ultimate load method?

- While the WSM uses only the nearly linear part of stress-strain curve, the ULM uses fully the actual stress-strain curve.
- The load factor gives the exact margin of safety against collapse.

- The method allows using different load factors for different types of loads and the combination thereof.
- The failure load computed by ULM matches with the experimental results.
- The method is based on the ultimate strain as the failure criteria.
- The method utilizes the reserve of strength in the plastic region.

22.What are the disadvantages of ultimate load method?

- The method does not take into consideration the serviceability criteria of deflection and cracking.
- The use of high strength reinforcing steel and concrete results in increase of deflection and crack width.
- The method does not take into consideration the effects of creep and shrinkage.
- In the ULM, the distribution of stress resultants at ultimate load is taken as the distribution at service loads magnified by the load factor. This is erroneous since significant redistribution of stress resultants takes place as the loading is increased from service loads to ultimate loads.

23.What are the factors considered in limit state of collapse?

- Flexure
- Compression
- Shear
- Torsion

24. What are the factors considered in limit state of serviceability?

- Cracking
- Deflection
- Durability
- Fire resistance
- Vibration

25. What are the factors of safety in limit state?

- Partial factor of safety for concrete $\gamma_c = 1.5$
- Partial factor of safety for steel $\gamma_s = 1.15$
- Partial factor of safety for load γ_f

26. Write down the value of partial safety factor for concrete and steel.

- Partial factor of safety for concrete $\gamma_c = 1.5$
- Partial factor of safety for steel $\gamma_s = 1.15$

27. What is under reinforced section?

Steel reaches maximum permissible stress earlier than concrete due to external loads is called under reinforced section.

28. What is over reinforced section?

Concrete reaches maximum permissible stress earlier than steel due to external load is called over reinforced section.

29. What is balanced section?

Concrete and steel reaches maximum permissible stress simultaneously due to external load is called balanced section.

30.Define singly reinforced section.

Steel reinforcements are provided only on tension zone of RC flexural member is known as singly reinforced section.

31.Define doubly reinforced section.

Steel reinforcements are provided on both tension and compression zone of RC flexural member is known as doubly reinforced section.

In some situations it becomes essential for a beam to carry BM more that it can resist as a balanced section. In this case additional reinforcement is provided in compression zone such beams reinforced in both compression and tension zones are known as doubly reinforced section.

32.Under what circumstances doubly reinforced beams resorted to?

When,

$M_u > M_u\ limit$. Then, doubly reinforcement is used.

33.Write down the basic values of span to effective depth ratio for the different types of beam.

Basic values of span to effective depth ratios for spans up to 10m

Cantilever	7
Simply supported	20
Continuous	26

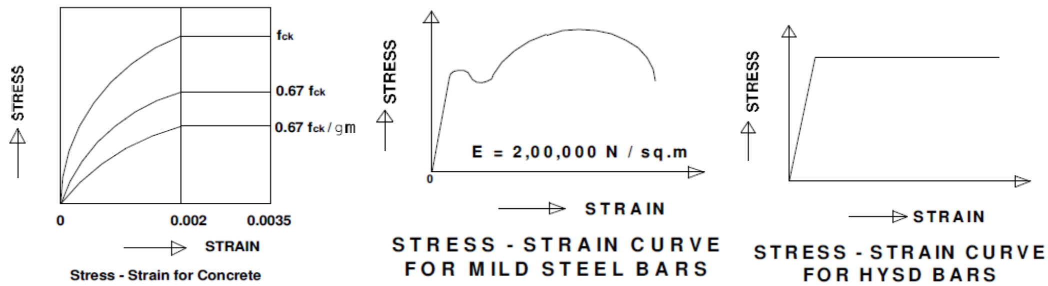
34.Define collapse state.

The limit state of collapse of the structure or part of the structure could be assessed from replace of one or more critical sections and from bulking due to elastic or plastic instability or overturning.

35.Define the terms Gross section, Transformed section, cracked section.

(Refer IS 456:2000 Page no: 35)

36.Draw the stress-strain curve for concrete, mild steel bars and HYSD bars.



37.Define brittle and ductile failure.

Materials that fracture without any plastic deformation are called brittle materials. Example: Glass and other ceramic materials.

Materials undergo plastic deformation before fracture is called ductile material. Example: aluminum, copper, steel and many metals, as well as polyethylene, nylon and many other polymers.

38.Define clear cover.

The distance between the bottom of the bars and bottom most edge of the beam is called clear cover.

39.Define effective cover.

The distance between the centre of the reinforcement bar and the bottom edge of the beam is called effective cover.

$$Effective\ cover\ =\ clear\ cover\ +\ \frac{diameter\ of\ bar}{2}$$

UNIT – 2

1. **What do you understand by development length of bar?**

   The reinforced bar must extend in the anchorage zone of concrete sufficiently, to develop the required stress. The extended length of bar inside the face of the support is known as development length. It is denoted by the symbol, L_d.

2. **Define anchorage length.**

   Anchorage length is defined as embedded portion of the bar in concrete, but not subjected to any flexural bond.

3. **Define anchorage bond.**

   All the types of reinforcement must be anchored within the concrete section, in order that the anchorage bond should be sufficient to develop the stress in the bar. The anchorage depends on the bond between the bar and concrete and the area of contact.

4. **Define curtailment of bars.**

   In flexural members, design of reinforcement is done based on bending moment along the span. As the magnitude of bending moment on a beam decreases along its length, that case the area of bending reinforcement may be reduced by curtailing bars as they are no longer required.

5. **What do you mean by equilibrium torsion?**

   Torsion induced by eccentric loading and equilibrium condition alone sufficient to determine twisting moments is known as equilibrium torsion.

6. **Define torsion.**

    Equal and opposite moments applied at both ends of structural element or its part about its longitudinal axis is called torsion. It is also called as torsional moment or twist or torque.

7. **What is compatibility torsion?**

    Torsion induced by application of an angle of twist and the resulting moment depends on the torsional stiffness of the member is known as compatibility torsion.

8. **How can torsional resistance of RC members be enhanced?**

    Increasing strength of concrete and the amount of longitudinal as well as transverse reinforcements over and above those required for bending and shear can enhance the torsional resistance of a member.

9. **Name the locations in beam where the development lengths of torsion bars should be checked.**

    At beams, development lengths should be checked at the sections where,

    - Maximum bending moment occurs
    - Point of curtailment
    - Point of inflation

10. **Write down the effect of torsion in RC beams.**

    RC members may be subjected to torsion in combination with bending and shear. Longitudinal and transverse reinforcement shall be provided for RC beams to resist torsion.

Torsional reinforcement is not calculated separately from that required for bending and shear. Instead, the total longitudinal reinforcement is determined for a fictitious bending moment which is a function of actual bending moment and torsion.

11. Write about local bond and anchorage length.

All types of reinforcement must be anchored within the concrete section, in order that the anchorage bond should be sufficient to develop the stress in the bar. Anchorage length is defined as embedded portion of the bar in concrete, but not subjected to any flexural bond.

12. Distinguish between flexural bond and development bond.

FLEXURAL BOND	DEVELOPMENT BOND
It arises in flexural members on account of shear or variations in bending moment, which in turn causes a variation in axial tension along the length of a reinforcing.	It arises over the length of anchorage provide for a bar or near the end of a reinforcing bar.

13. Why is bond stress more in compression bars than in tension bars?

- Deformed bars subjected to tension, τ_{bd} values shall be increased by 60%.
- Deformed bars subjected to compression, τ_{bd} values shall be increased by 25%.

14. What are the types of reinforcement used to resist shear and write down the expressions for to shear resistance offered by the type?

Shear reinforcement is necessary if the nominal shear stress (τ_v) exceeds the design shear stress(τ_c). In general, shear reinforcement is provided in any one of the following three forms. (Refer IS 456:2000 Page no: 72)

15. Write down the value of design bond stress for M30 grade of concrete.

Design bond stress in limit state methods for plain bars (mild steel) in tension is $\tau_{bd} = 1.5 \frac{N}{mm^2}$

16. What is RC slab?

Reinforced concrete slabs are used in roofs of buildings. Slab is a flexural member transmits imposed and dead load to the supports. Support may be a wall, beam or column.

17. Reinforced concrete slabs are generally safe and do not require shear reinforcement. Why?

Normally the thickness of slab is so chosen that the shear can be resisted by concrete itself and the slab does not need extra shear reinforcements.

18. What are the types of slab?

- One way slab
- Two way slab

19.How can be classified the slab?

- $\frac{L_y}{L_x} > 2$ (One way slab)
- $\frac{L_y}{L_x} < 2$ (Two way slab)

20.Define one way slab.

When the slab is supported only on two opposite sides, the slab bends in one direction only. Hence, it is called one way slab.

21.Define two way slabs.

When the slab is supported on all four sides, the slab bends in both directions. Hence, it is called two way slabs.

22.Name the two types of two-way slabs. Explain their difference in the design of slabs.

- Slabs simply supported on the four edges, with corners not held down and carrying UDL
- Slabs simply supported on the four edges, with corners held down and carrying UDL
- Slabs with edges fixed or continuous and carrying UDL

23.What are the codal provisions for a minimum reinforcement to be provided as main and secondary reinforcement in slab and their maximum spacing?

Minimum reinforcement:

$A_{st} = \frac{0.15}{100} \times b \times D$ (For mild steel)

$(A_{st})_{min} = \frac{0.15}{100} \times b \times D$ (For HYSD bars)

- Spacing = 3d or 300mm (horizontal distance between parallel main reinforcement bars). Use whichever is smaller.
- Spacing = 5d or 450mm (horizontal distance between parallel reinforcement bar provided against shrinkage and temperature). Use whichever is smaller.

24. Why is secondary reinforcement provided in one way RC slab?

Secondary reinforcement is provided running perpendicular to the main reinforcement, in order to take the temperature and shrinkage stresses. It is otherwise called as distribution or temperature reinforcement.

25. Explain the purposes of lintel beams in buildings.

Lintels are provided over the openings of doors, windows, etc. Generally, they support the load of the wall over it, and sometimes also the live loads are transferred by the sub-roof of the room. Lintel takes the masonry load over the openings and distributes to the masonry located sides of opening.

26. What type of slab usually used in practice, under reinforced or over reinforced section?

The depth of slab chosen from deflection requirements will be usually greater than the depth required for balanced design. Hence the area of steel required will be less than the balanced amount. So, the slab is designed as under reinforced section.

27. What do you understand by flanged beam?

The concrete in the slabs, which is on the compression side of the beam, can be made to resist the compression forces, and the steel in the tension side of the beam can carry the tension. These combined beam and slab units are called flanged beam.

28. Define shear strength.

The resistance to sliding offered by the material of beam is called shear strength.

29. What are the important factors affecting the shear resistance of a reinforced concrete member without shear reinforcement?

- Characteristic strength of concrete
- Percentage of longitudinal steel
- Shear span to depth ratio
- Axial compressive/tensile force
- Effect of cross section
- Effect of two way action

UNIT – 3

1. Define column.

A column, in general, may be defined as a member carrying direct axial load which causes compressive stresses of such magnitude that these stresses largely control its design.

- It transmits load coming from beam or slab and distributes to the foundation usually columns are square, rectangle, circular and 'I' shaped in cross section.
- It is reinforced with longitudinal and lateral ties.
- Load carrying capacity of column is depending upon longitudinal steel and cross sectional size of the column.
- Lateral ties are giving lateral support to the longitudinal steel. The columns are analyzed for axial force and moments.

2. Differentiate between long and short column.

Based on slenderness ratio (λ) columns can be classified into long and short.

Slenderness ratio (λ) = $\frac{Effective\ length}{Least\ lateral\ dimension}$

Short column $\lambda < 12$

Long column $\lambda > 12$

3. Differentiate between uni-axial and bi-axial bending.

Axial load and bending moment along one direction are applied simultaneously on the column is called uni-axial bending.

Axial load and bending moment along two direction are applied simultaneously on the column is called bi-axial bending.

4. According to IS code all columns should be designed for minimum eccentricity. Justify the statement.

Lateral loads such as wind and seismic loads are not considered in design.

- Misalignment in construction
- Slenderness effects not considered in design
- Accidental lateral or eccentric loads

5. Write down the formula for calculating minimum eccentricity.

$e_{min} = \frac{l}{500} + \frac{D}{30}$, subject to a minimum of 20mm

Where,

l = unsupported length of the column

D = lateral dimension of the column

6. What is spiral column?

For a circular column, longitudinal tied with closely spaced helix are called as spiral column.

7. What is the minimum and maximum percentage of reinforcement can be provided for a column?

The cross sectional area of longitudinal reinforcement shall be not less than 0.8% not more than 6% of the gross cross sectional area of the column.

8. What are the specifications for pitch of lateral ties in columns?

The pitch of the transverse reinforcement shall be not more than the least of the following distances:

- Least lateral dimension of the compression member
- Sixteen times the smallest diameter of the longitudinal reinforcement bar to be tied.
- 300mm

9. Distinguish braced and un-braced column.

BRACED COLUMN	UNBRACED COLUMN
In most of the cases, columns are subjected to horizontal loads like wind, earthquake, etc. If lateral supports are provided at the ends of the column, the lateral loads are borne entirely by the lateral supports. Such columns are known as braced columns.	Other columns, where the lateral loads have to be resisted by them, in addition to axial loads and end moments, are considered as un-braced columns.
It is not subject to side sway.	It is subject to side sway.

10. What is pedestal?

Pedestal is a compression member, the effective length of which does not exceed three times the least lateral dimension.

11. What is slender column?

If the slenderness ratio of the column about either axis is greater than 12, is classified as long column. Long column should be designed as slender column.

12. Mention the functions of the traverse reinforcement in a RC column.

- To prevent longitudinal buckling of longitudinal reinforcement.
- To resist diagonal tension caused due to transverse shear due to moment / transverse load.

- To hold the longitudinal reinforcement in position at the time of concreting.
- To confine the concrete, thereby preventing its longitudinal splitting.
- To impart ductility to the column.
- To prevent sudden brittle failure of the column.

13.Classify the column according to the material.

- Pre-stressed concrete
- Reinforced cement concrete
- Stone
- Timber

14.Classify the column according to transverse reinforcement.

- Spiral or helical
- Tied

UNIT – 4

1. What are the types of foundations?

- Deep foundation
- Shallow foundation

2. What are the types of shallow foundations?

- Combined footing
- Isolated footing
- Mat or raft footing
- Spread or strip footing

- Strap or cantilever footing

3. **What are the types of deep foundations?**
   - Pier foundation
   - Pile foundation
   - Well foundation

4. **What are the factors governing to decide the depth of footing?**

   The footing is generally to resist the bending moments and shear forces developed due to soil reactions. The main purpose of the footing is to effectively support the super structures.

5. **Define safe bearing capacity of soil.**

   It is the maximum intensity of load or pressure developed under the foundation without causing failure of soil. Unit for safe bearing capacity of soil is $\frac{kN}{m^2}$. Safe bearing capacity of soil is determined by the plate load test at the site.

6. **What is punching or two way shear in RCC footing?**

   Punching shear is a type of shear failure occurs in reinforced concrete footings due to axial load from the column and upward soil thrust from the ground.

7. **What are the advantages of providing pedestals to columns?**
   - Where pedestals are providing, and full force is transferred to the footing without additional reinforcement.

- Pedestal provides a plane surface for the convenience of column construction.

8. **What is the situation in which trapezoidal shape is preferred to a rectangular shape for a two column combined footing?**

   If the one column is carrying load is much larger than the other one, trapezoidal combined footing is preferred.

9. **When combined footings are adopted?**
   - When two or more columns/walls are located close to each other and/or if they are relatively heavily loaded and/or rest on soil with low safe bearing capacity.
   - An exterior column located along the periphery of the building is so close to the property line that an isolated footing cannot be symmetrically placed without extending beyond the property line.

10. **Under what circumstances rectangular shape preferred for a two-column combined footing.**

    When loads are equal and no restriction on sides, the footing will be rectangular with equal overhang on both sides.

11. **Under what circumstances combined footing is preferred.**
    - When isolated footings for individual columns are touching or overlapping each other.
    - When the columns are located near the boundary lines or expansion joints.

12. What is meant by eccentric loading on a footing and under what situation does this occur?

The load P acting on a footing may act eccentrically with respect to the centroid of the footing base. This eccentricity may result from one or more of the following effects.

- The column transmitting a moment M in addition to the vertical load.
- The column carrying a vertical load offset with respect to the centroid of the footing.
- The column or pedestal transmitting a lateral force located above the foundation level, in addition to the vertical load.

13. Write down the formula for calculating maximum and minimum soil pressures for a rectangular footing carries eccentric point load.

The structural design of the footing, which includes the design of the depth and reinforcement, is done for factored loads using the relevant safety factors applications for the limit state of collapse.

14. Define stair case.

Staircase flights are generally designed as slabs spanning between wall supports or landing beams or as cantilever from a longitudinal inclined beam. The staircase fulfills the function of access between the various floors in the building. Generally the flight steps consist of one or more landings between the floor levels.

15. What are the components of stairs?

The components of stairs are,

- Baluster

- Flight
- Going
- Landing
- Rise
- Riser
- Soffit
- Step
- Tread
- Winders

16. What are the normal range of tread and rise values of steps of a staircase in residential building?

As per IS 456:2000 the normal range of tread and rise values of steps of a staircase in residential building are,

- Rise: 150mm to 180mm
- Tread: 200mm to 250mm

17. List the various types of stair cases.

- Bifurcated stairs
- Dog-legged stairs
- Geometrical stairs such as circular, spiral stair, etc
- Multi-flight stairs
- Open newel stair with quarter space landing
- Quarter-turn stairs
- Straight stairs
- Three quarter-turn stairs

18.Define flat slab.

A flat slab is a reinforced concrete slab supported directly over columns without beams generally used when headroom is limited such as in cellars and warehouses.

19.Define Box Culvert.

These are provided for conveying water to serve the following requirements:

- To serve as means for a cross drainage
- To provide a supporting slab for road way under which the cross drainage flows

20.What are cases available in Box Culvert?

- Case (I) when the top slab carries the dead and live load and culvert is empty
- Case (II) when the top slab carries the dead and live load and culvert is full of water
- Case (III) when the sides of culvert do not carry live load and culvert is full of water.

21.How the effectively span of a stair is decided when the landing slab spans in the same direction as the stair.

When the landing slab spans in the same direction as the stairs, they should be considered as acting together to form a single slab and the span determined at the distance centre to centre of the supporting beams or walls, the going being measured horizontally.

22. Give the guidelines of the size of rise and tread as per IS code norms.

The following guidelines may be followed while deciding the size of rise and tread of a stair.

- 400mm < (rise + tread) < 450mm
- 580mm < (rise + tread) < 630mm

23. How the load is distributed in the case of an open well stairs?

In the case of stairs with open wells, where spans partly crossings at right angles occur, the load on areas common to any two such spans may be taken as one-half in each direction.

24. How the load is distributed when flights or landings are embedded into walls?

Where flights or landings are embedded into walls for a length not less than 110 mm and designed to span in the direction of the flight, a 150 mm strip may be deducted from the loaded area and effective breadth of the section increased to 75 mm for the purpose of design.

25. Define depth of section.

The depth of section shall be taken as the minimum thickness perpendicular to the soffit of the staircase.

26. What are the loads acting on staircases? Explain.

DEAD LOADS:

Self-weight of stair slab which includes the waist slab, tread-rise, etc. Self-weight of finishes (0.5 to 1 kN/m^2)

LIVE LOADS:

IS 875 parts II specifies the load to be considered as UDL of intensity 5kN/m^2 for public buildings and 3kN/m^2 for residential building where the specified floor do not exceed 2kN/m^2 and the staircases are should not liable for overcrowding.

27.Explain structural behaviors of stair cases.

Staircases can be grouped depending upon the support conditions and the direction of major bending of the slab component under the following categories.

- Staircase slab spanning horizontally (along the slope line)
- Staircase slab spanning transversely (slab width wise with central or side supports)

UNIT – 5

1. What is masonry?

Masonry is a structure built of in individual blocks of materials such as stone, brick, concrete, hollow blocks, etc bonded together with some form of mortar such as lime mortar, cement mortar.

2. What is the size of bricks?

Without mortar joints:

- Size of standard brick = 190mm * 90mm * 90mm
- Size of modular type brick = 190mm * 90mm * 40mm

With mortar joints:

- Size of brick = 200mm * 100mm * 100mm
- Size of modular type brick = 200mm * 100mm * 50mm

3. **List the Types of bricks.**

- **Common clay bricks**
  - Class I bricks
  - Class II bricks
  - Class III bricks

- **Heavy duty bricks**
  - Class I bricks (or) A class bricks
  - Class II bricks (or) B class bricks

4. **Define Mortar.**

Mortar is a combined material formed with intimately mixing a binding material like lime or cement, with a fine aggregate like sand in certain proportion and with adequate quantity of water.

5. **What is the classification of Walls?**

- **Load bearing walls**
  - Cavity wall
  - Faced wall
  - Solid wall
  - Solid wall with piers (pilaster)
  - Veneered wall

- **Non-load bearing walls**
  - Curtain wall
  - Free-standing wall
  - Panel wall
  - Partition wall

6. **What are the classifications of loads on walls?**
   - Axial (or) Vertical
   - Lateral (or) transverse

7. **Define criteria.**

   Design criterion is that the actual stress produced due to loads in the structure should be within permissible limits.

8. **What are the factors of permissible stress (or) allowable compressive stress?**
   - Cross sectional area of the masonry
   - Eccentricity of loading
   - Shape and size of bricks
   - Slenderness ratio
   - Strength of mortar
   - Type and strength of bricks

9. **What is the purpose of providing a lateral support into a masonry structure?**

   Masonry structures gain stability from support offered by cross walls, floors and roofs. Lateral supports for load bearing walls or columns limit the slenderness of the structure. Further the lateral support reduces the possibility of buckling of member due to vertical loads and to resist horizontal forces.

10. What is a pilaster in bricks masonry wall?

Solid walls are thickened at intervals by increasing the cross section. The thickened portions are called as piers or pilasters. They are used for one of the following purposes.

- To carry concentrated loads from roof or floor beams
- To provide lateral support
- To reduce the slenderness ratio by stiffening the walls.

11. What is meant by slenderness ratio of a masonry wall?

$$Slenderness\ ratio = \frac{effective\ height}{effective\ thickness}$$

12. What is an equivalent eccentricity?

In an eccentricity loaded wall, there is an axial load and a bending moment these two may be combined into single resultant load acting at a distance. This is known as equivalent eccentricity.

13. List the factors which contribute for eccentricity on bricks walls.

- Geometry of the support
- Long floor edges
- Magnitude of loads
- Relative stiffness of slab or beam and the wall
- Unequal spans

14. How do you determine the average effective thickness of wall with opening?

$Area\ (A) = (L - a) \times t$

$Effective\ thickness\ (t) = (L - a)$

Where,

L = length between outer wall faces

a = width of spacing

t = thickness of wall

15. Define Retaining walls.

Retaining walls are structures used to provide stability of earth masses other loose materials. That is when field conditions do not allow the earth pressure to assume its natural shape or when abrupt changes in the ground surface elevation are needed retaining walls are used.

16. Where are used the retaining walls?

- Basement wall
- Box culvert
- Depressed roads
- Elevated protection
- Erosion protection
- Flood wall
- For underground water tanks
- Landscaping
- Retaining a rail-road or highway in hilly area
- Used at the ends of bridges in the form of abutments

17.Types of retaining walls.

- **<u>Buttressed wall</u>**:

  A buttressed wall is a modification of the counter fort retaining wall in which the counterforts, called the buttresses, are provided to the other side of the backfill. However the buttresses reduce the clearance in front of the wall, and therefore these walls are not commonly used.

- **<u>Cantilever retaining wall</u>**:

  A taller wall with extended toe and heel to offset the large lateral pressure tends to overturn the wall. A cantilever wall has part of the base extending underneath the backfill, and the weight of the soil above this part of the base helps prevent overturning.

  - T-shaped
  - L-shaped

- **<u>Counter fort retaining wall</u>**:

  The vertical stem and the heel slab are strengthened by providing counterforts at some suitable intervals. Because of provision of counterforts, the vertical stem as well as the heel slab acts as continuous slab, in contrast to the cantilevers of cantilever retaining wall. The toe slab however acts as cantilever bending upwards. This type of retaining wall is used when backfill of greater height is to be retained.

- **<u>Gravity retaining wall</u>**:

  A gravity retaining wall is the one which resists the lateral earth pressure by its weight in contrast to the cantilever and counter fort retaining walls in which the pressure is resisted by bending action. A gravity retaining wall is therefore, thicker in section. They are constructed of mass concrete, brick or stone masonry.

  - Massive Gravity Wall
  - Counter fort Wall
  - Cantilever Gravity Wall

18. What are the assumptions for coulomb's earth pressure theory?

The earth pressure theory proposed by coulomb is based on the following assumptions:

- The soil or the retained material is isotropic, homogeneous and possesses both internal friction and cohesion.
- The rupture surface is a plane surface.
- The friction forces are uniformly distributed along the plane rupture surface.
- The failure used is a rigidly body.
- There is a wall friction.
- Failure is a Plane strain problem.

19. What is the structural action of the stem, heel and toe?

<u>STEM</u>:

The vertical arm or stem is subjected to lateral pressure and acts as a cantilever. The lateral pressure causes maximum bending moment and shear forces at junction of the stem.

HEEL:

The heel is subjected to soil pressure from the bottom acting towards and the downward loads due to self-weight and the earth above the heel. The downward load is more hence the heel acts like a cantilever is more hence the heel acts like a cantilever bending downwards. Maximum bending moment and shear force occur at the junction of the heel with stem.

TOE:

The toe is subjected to upward pressure from the soil and the downward pressure is due to self-weight. Hence the toe is designed as cantilever. Maximum bending moment and shear force occur at the face of the stem.

20. How the development of tension in a base slab is checked?

In order to avoid development of tension in the base slab, the resultant of various forces acting on the wall should cut the base in the middle-third of the width of the base. Further the maximum pressure on the base slab should not exceed the allowable soil pressure.

21. Why counter forts are provided in a counter fort retaining wall?

In a cantilever retaining wall with more height, the bending moment development in the stem, heel slab and toe slab become very large and require thickness. The bending very large and require moments and so the thickness. The bending moments and so the thickness of stem and slab can be considerably reduced by introducing transverse supports called counter forts. They are spaced at regular intervals of about 0.3 to 0.6hl where ‘h’ is the height of the retaining wall. The counter forts are concealed within the backfill.

22. What are the factors governing the spacing of counter forts?

Spacing of counter forts depends on various factors such as height of retaining wall, cost of steel and concrete, allowable soil pressure and cost of form work. Keeping the spacing of counter forts closer reduces the thickness of vertical slab and the heel slab and cost of formwork increases. Thus the spacing is the one which makes the design economical. Spacing generally varies from n0.3 to 0.6h where 'h' is the height of the wall.

23. Define the stability of retaining wall structure.

Retaining wall as a wholes stability the following external stability requirements:

- Safety against bearing capacity failure
- Safety against overturning
- Safety against sliding

24. Define factor of safety against overturning.

Factor of safety against sliding along the base is defined as the ratio of resisting moment to disturbing moment about the toe. Factor of safety against sliding should not be less than 2.0

25. What do you mean by the backfill of retaining wall?

Loose material like soil, coal or ore piles retained on the back of a retaining wall is called a backfill. Backfill materials for retaining structure should be designed to minimize the lateral pressure. A good backfill material should satisfy two important requirements via, high long – term strength and free drainage. Granular materials make the best types of backfill.

26.List out the various forces subjected to a cantilever retaining wall.

The forces are,

- W_c = weight of the cantilever wall
- W_a = weight of soil above the back fill
- P_a = lateral pressure from backfill
- P_p = lateral pressure at the front of the wall
- P_{max} & P_{min} = soil pressures beneath the retaining wall

27.What is the function of a shear key?

A retaining wall should be safe against overturning, sliding and bearing capacity failure. The horizontal forces causing sliding forces are the steering resistance offered at the base and the passive resistance before the wall. A main FOS of 1.5 is generally provided. If adequate forces not achieved, a shear key is incorporated in the base.

28.Define Active and Passive Earth Pressure.

Active Earth Pressure:

It is the pressure that at all times are tending to move or overturn the retaining wall.

Passive Earth Pressure:

It is reactionary pressures that will react in the form of a resistance to movement of the wall.

29. What are the Effects of Active and Passive Earth Pressure?

Active Earth Pressure:

It is composed of the earth wedge being retained together with any hydrostatic pressure caused by the presence of groundwater. This pressure can be reduced by:

- The use of subsoil drainage behind the wall.
- Inserting drainage openings called weep holes through the thickness of the stem to enable the water to drain away.

Passive Earth Pressure:

It builds up in front of the toe to resist the movement of the wall if it tries to move forward. This pressure can be increased by enlarging the depth of the toe or by forming a rib on the underside of the base.

30. What are the factors to be considered while designing the Retaining Walls?

- Overturning doesn't occur
- Sliding doesn't occur
- The soil on which the wall rests mustn't be overloaded
- The materials used in construction are not overstressed.

31. What are the forces or pressure that has to be calculated while designing the retaining walls?

- Height of water table
- Nature and type of soil
- Subsoil water movements
- Type of wall

- Material used in the construction of wall

32. What are the various loads considered in heel slab of Retaining Walls?

- Weight of the backing
- Dead load on heel slab
- Vertical component of lateral
- Upward soil reaction

33. What do you mean by surcharge angle?

The position of the backfill lying above the horizontal plane at the elevation of the top of a wall is called the surcharge, and its inclination to the horizontal is called the surcharge angle β.

34. What is angle of internal friction (Φ)?

The angle of internal friction which is equal to the ratio of the maximum resistance to sliding on any internal plane to the normal pressure acting on the plane

35. What are the points to be noted in the design of Cantilever Retaining Wall?

- The thickness of the stem may be kept the same throughout the height to provide adequate
- Dead load
- The base slab may be made about 100mm thicker than stem
- The width of the base slab may be kept about 0.7 to 0.8 times the total height of the wall

- It may most probably require a key to be provided to have a safe factor of safety against sliding

36. What are the loads acting on the heel slab of the Counter fort Retaining Wall?

- Dead load of the strip
- Weight of the earth above the strip
- Vertical components of the lateral pressure in the case of the earth surcharged at an angle.

37. What are the structural components of Retaining Walls?

Base, heel, toe, stem and backfill are the structural components of a retaining wall.

38. What are the components of counter fort retaining wall?

Upright slab:

Its design as a continuous slab spanning horizontally on the Counter fort subjected to lateral earth pressure

Base slab:

The width of the base slab may be taken as 0.6H to0.7H

Where,

H= overall height of the retaining wall.

Heel slab:

The Heel slab should be designed as a continuous horizontal slab with counter fort as the supports.

39.State the advantages of pre-stressed concrete over reinforced concrete.

- Since the technique of pre-stressing eliminates cracking of concrete under all stage of loading, the entire section of the structures takes part in resisting the external load. In contrast to this, in the reinforced concrete, only portion of concrete above the neutral axis is effective.
- Since concrete does not cracks, the possibility of steel to rust and concrete to deteriorate is minimized.
- Absence of cracks results in higher capacity of the structure to bear reversal of stresses, impact, vibration and shock.
- In pre-stressed concrete beams, dead loads are practically neutralized. The reactions required are therefore, much smaller than required in reinforced concrete. The reduced dead weight of structure results in saving in the cost of foundations. The neutralization of dead weight is of importance in large bridges.
- The use of curved tendons and the pre-composition of concrete help to resist shear.
- The quantity of steel required for pre-stressing about 1/3 of that required for reinforced concrete, though the steel for the former should have high tensile strength.
- Pre-stressed concrete beams have usually low deflection.
- In pre-stressed concrete, precast blocks and elements can be assumed and used as one unit. This saves in the cost of shuttering and centring for large structures.