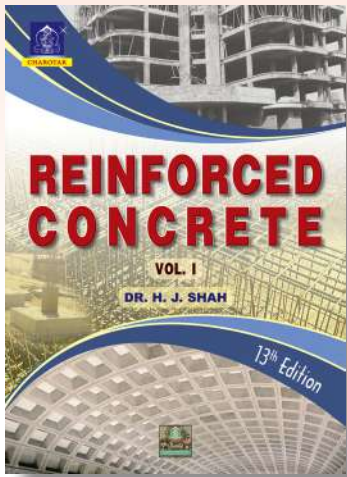


# REINFORCED CONCRETE VOL. I



By  
Dr. H. J. Shah

REVISED  
& ENLARGED

**Edition** : 13<sup>th</sup> Edition : 2025  
**ISBN** : 9789385039812  
**Binding** : Paperback  
**Pages** : 1086 + 22 = 1108  
**Size (mm)** : 279 × 45 × 203  
**Weight** : 2020 g

₹ 1800.00 **BUY**

Best  
Seller



## ABOUT THE BOOK

This edition is a combined edition of earlier edition published "Reinforced Concrete Vol. I" in two parts i.e., "Reinforced Concrete Vol. I – Part I" and "Reinforced Concrete Vol. I – Part II". This book presents the basic principles involved in Analysis and Design of Reinforced Concrete Structures. Mix design as per latest IS:10262 with excel programs is added. A number of excel programs have been added to clarify the subject matter and design the elements of structure. As per prevailing market conditions the default combination of materials is revised to M20 grade concrete and Fe 500 grade steel, however, the other combinations of materials have not been completely ignored.

The outline of the book is as mentioned below:

Chapter 1 to 3 discuss mainly Concrete Technology. Chapter 1 introduces the subject, while Chapter 2 deals with properties of ingredients of concrete. Chapter 3 deals with properties of wet and set concrete. It explains design mix concrete and presents excel programs to design a concrete mix for standard concretes based on IS:10262-2019. Chapter 4 to 6 discuss fundamentals of flexure design, also discuss working stress method as well as limit state method for flexure design. It designs singly and doubly reinforced rectangular and flanged beams for flexure. Chapter 7 and 8 presents design for Shear and checking for Development Length, Deflection and Cracking. Chapter 9 and 10 deal with the design of Simply Supported and Cantilever Beams and Slabs. Chapter 11 Continuous beams and slabs capable of free rotation at supports are discussed, including redistribution of moments. Chapter 12 and 13 Simple cases of torsion and stairs are discussed. Chapter 14 and 15 Introduce the Load Calculations and Simple designs. Considering the fundamentals developed in earlier chapters, the load calculations on simple structures like Slabs and Beams, capable of free rotation at supports are considered. A few cases are designed in chapter 15. Chapter 16 Designs of Framed Beams are introduced with examples considering it appropriate to discuss with the elements that are not free to rotate at their supports. Chapter 17 contains design of columns used in framed structures. The design interaction diagrams are derived and excel program is prepared for rectangular columns. Chapter 18 emphasis on Design of Foundations: Fundamentals. Moreover this chapter is extensively revised and soil design is sufficiently elaborated. Chapter 19 on Isolated Footings for walls and columns subjected to various types of loads. Discusses topics on axially loaded pad and sloped footing; eccentrically loaded footings; isolated slab and beam type footing; footing for multi-storeyed building columns and also gives an excel program on design of an isolated footing. Chapter 20 discusses Combined Footings for two axially loaded columns and also explains strap, strip and raft foundations. Also includes the guidelines to design a combined footing for general loading system. Chapter 21 elucidates topics on Pile Foundations such as loads on pile groups; soil design of a pile; structural design of a pile; design of a pile cap. Chapter 22 Circular raft foundations with annular and solid rafts used under circular peripheral columns or RCC shafts are discussed. Chapter 23 on Retaining walls includes design of cantilever and counterfort retaining walls. Chapter 24, 25 and 26 deals with variety of roof coverings, viz., Circular, Ribbed and Waffle slabs; Flat slabs and domes are discussed in these chapters. Chapter 27 discusses the empirical designs of both, the deep beams and corbels Chapter 28 Grid or Coffered Floors are designed by using classical analysis. Chapter 29 Formworks: Basic formworks used on general sites for slabs, beams and columns are discussed in this chapter. Chapter 30 Detailing of Reinforcement: This chapter explains basic style of practical RCC structural drawings.

Now this book "Reinforced Concrete Vol. I", in its 30 Chapters and Appendix contains:

611	Neatly drawn sketches	329	Questions at the end of the chapters
100	Useful tables	021	Excel programs
253	Design problems	422	Short questions with answers.

## CONTENT

01 : INTRODUCTION
02 : PROPERTIES OF INGREDIENTS OF CONCRETE
03 : STRUCTURAL CONCRETE
04 : DESIGN FOR FLEXURE: FUNDAMENTALS
05 : DESIGN FOR FLEXURE:
06 : LIMIT STATE METHOD
07 : SHEAR AND DEVELOPMENT LENGTH
08 : DEFLECTION AND CRACKING
09 : SIMPLY SUPPORTED AND CANTILEVER BEAMS
10 : SIMPLY SUPPORTED AND CANTILEVER BEAMS
11 : CONTINUOUS BEAMS AND SLABS
12 : TORSION
13 : STAIRS
14 : LOAD CALCULATIONS FOR
15 : SIMPLE DESIGNS
16 : FRAMED BEAMS
17 : COLUMNS
18 : DESIGN OF FOUNDATIONS: FUNDAMENTALS
19 : ISOLATED FOOTINGS
20 : COMBINED FOOTINGS
21 : PILE FOUNDATIONS
22 : CIRCULAR RAFT FOUNDATIONS
23 : RETAINING WALLS
24 : CIRCULAR, RIBBED AND WAFFLE SLABS
25 : FLAT SLABS
26 : DOMES
27 : DEEP BEAMS AND CORBELS
28 : GRID OR COFFERED FLOORS
29 : FORMWORK
30 : DETAILING OF REINFORCEMENT
APPENDIX A : SHORT QUESTIONS WITH ANSWERS
APPENDIX B : USEFUL TABLE
INDEX

The book in the present form will prove to be extremely useful to the students preparing for the Degree examinations in Civil Engineering and Architecture of all the Indian Universities, Diploma examinations conducted by various Boards of Technical Education, Certificate Courses as well as for the A.M.I.E., U.P.S.C., G.A.T.E., I.E.S., and other similar competitive and professional examinations. It should also be an immense use to practicing Civil Engineers.

Catalogue Checklist

**REINFORCED CONCRETE – VOL. I**  
**DETAILED CONTENTS**

**CHAPTER 1 INTRODUCTION**

- 1-1. Structural design—Role of a structural engineer
  - 1-2. Concrete and Reinforced Concrete
  - 1-3. Mechanics of Reinforced Concrete
  - 1-4. Advantages and Limitations of using concrete
  - 1-5. Structural elements
    - (1) Slabs           (4) Walls
    - (2) Beams       (5) Foundations
    - (3) Columns
  - 1-6. Loads on structure
    - (1) Dead loads       (4) Wind loads
    - (2) Live loads       (5) Earthquake loads
    - (3) Impact loads   (6) Longitudinal loads
  - 1-7. Load combinations
  - 1-8. Ductility versus brittleness
  - 1-9. Strength and serviceability
  - 1-10. Response of a structure to wind and earthquake loads
  - 1-11. Ordinary and ductile structures
  - 1-12. Methods of design
    - (1) Working stress method
    - (2) Limit state method
  - 1-13. Codes of practice
  - 1-14. Adaptation of SI units
  - 1-15. Presentation of design calculation of a project
- Questions 1

**CHAPTER 2 PROPERTIES OF INGREDIENTS OF CONCRETE**

**2-1. Introductory**

**CEMENT**

- 2-2. General
- 2-3. Manufacture of Portland cement
- 2-4. Basic chemistry of cement
  - (1) Lime           (5) Magnesia
  - (2) Silica       (6) Calcium sulphate
  - (3) Alumina     (7) Alkalis
  - (4) Iron oxide   (8) Sulphur trioxide
- 2-5. Chemical properties of cement
  - (1) Lime saturation factor
  - (2) Ratio of alumina to iron oxide
  - (3) Insoluble residue
  - (4) Magnesia
  - (5) Total sulphate content as sulphuric anhydride
  - (6) Total loss on ignition
- 2-6. Hydration of cement
  - (1) General
  - (2) Chemistry of hydration
  - (3) Heat of hydration and strength
  - (4) Rate of hydration
- 2-7. Types of cement
  - (1) Ordinary portland cement
  - (2) Rapid hardening cement
  - (3) Blast furnace slag portland cement
  - (4) Portland pozzolana cement
  - (5) Hydrophobic cement
  - (6) Low heat portland cement
  - (7) Sulphate resisting cement
  - (8) High alumina cement
  - (9) Super-sulphated cement
  - (10) Oil-well cement
  - (11) Ultra-rapid hardening portland cement
  - (12) White cement
  - (13) Coloured cements
  - (14) Water-proof portland cement
  - (15) Masonry cement
  - (16) Expanding cement
  - (17) Quick setting cement
  - (18) Air-entraining cement

- 2-8. Selection of cement for production of concrete
- 2-9. Tests for cement
- 2-10. Fineness test
  - (1) By dry sieving
  - (2) Blaine's air permeability method
- 2-11. Consistency of standard cement paste
- 2-12. Test for setting times
- 2-13. Soundness test
- 2-14. Autoclave expansion
- 2-15. Density test
- 2-16. Test for compressive strength
- 2-17. Heat of hydration test
- 2-18. Storing of cement

**MINERAL ADMIXTURES**

- 2-19. Mineral admixtures
  - (1) Pozzolana
  - (2) Ground granulated blast furnace slag

**AGGREGATES**

- 2-20. Introductory
- 2-21. Aggregate size
  - (1) Single size aggregate
  - (2) Graded aggregates
- 2-22. Fine and coarse aggregate
- 2-23. Properties of aggregate
  - 2-23-1. Particle shape
  - 2-23-2. Surface texture
  - 2-23-3. Strength of aggregate
    - (1) Compressive strength of prepared samples of parent rocks
    - (2) Aggregate crushing value
    - (3) Ten percent fines value
    - (4) Aggregate impact value
  - 2-23-4. Specific gravity
    - (1) Apparent specific gravity
    - (2) Specific gravity based on saturated surface dry basis
  - 2-23-5. Bulk density
  - 2-23-6. Water absorption and surface moisture
    - (1) Water absorption
    - (2) Surface moisture
  - 2-23-7. Bulking of sand
  - 2-23-8. Deleterious substances in aggregates
    - (1) Organic impurities
    - (2) Surface coatings
    - (3) Salt contamination
    - (4) Weak or Unsound particles
  - 2-23-9. Soundness of aggregate
  - 2-23-10. Alkali-aggregate reaction
- 2-24. Sieve analysis
- 2-25. Standard grading
  - (1) Coarse aggregate
  - (2) Fine aggregate
  - (3) All-in-aggregate
- 2-26. Use of grading curves
  - (1) Coarse aggregates
  - (2) Fine aggregates

**WATER**

- 2-27. Water for mixing concrete
- 2-28. Water-Cement Ratio and Water-Cementitious materials ratio

**CHEMICAL ADMIXTURES**

- 2-29. Admixtures
  - (1) Accelerators       (3) Water reducing admixtures
  - (2) Retarders       (4) Air-entraining agents

**REINFORCEMENT**

- 2-30. Steel as reinforcement
- 2-31. Types of Reinforcement
  - (1) Plain bars
  - (2) High strength deformed (HSD) bars

**REINFORCED CONCRETE – VOL. I**  
**DETAILED CONTENTS**

- 2-31-1. Plain bars  
(1) Mild steel bars  
(2) Medium tensile steel bars  
(3) Hard drawn wire or welded wire fabric
- 2-31-2. High strength deformed (HSD) bars  
(1) Cold Twisted Deformed (CTD) bars  
(2) Thermo-Mechanically Treated (TMT) bars
- 2-32. Corrosion-resistant steel
- 2-33. Grades of normal and enhanced quality HSD rebars for reinforced Concrete
- 2-34. Bending and fixing of bars
- 2-35. Welding of reinforcement
- 2-36. General notes for site engineers
- Questions 2  
Examples 2
- CHAPTER 3 STRUCTURAL CONCRETE**
- General
- 3-1. Proportioning of ingredients  
(1) Design mix concrete  
(2) Nominal mix concrete
- 3-2. Estimation of materials for nominal mix
- 3-3. Measurement of materials  
(1) Mass-batching  
(2) Volume-batching
- 3-4. Mixing and placing of concrete  
(1) Batch mixers  
(2) Ready mix concrete (RMC)  
(3) Continuous mixers
- 3-5. Compaction of concrete
- 3-6. Curing  
(1) Moist curing  
(2) Membrane curing  
(3) Steam curing
- 3-7. Formwork for R.C.C. members
- 3-8. Workability  
(1) Slump test  
(2) Compacting factor test  
(3) Vee-Bee test
- 3-9. Factors influencing workability
- 3-10. Strength of concrete and w/c ratio  
(1) Compaction  
(2) Curing  
(3) Fineness of aggregate  
(4) Fatigue and impact  
(5) Age  
(6) Compressive strength of cement and concrete
- 3-11. Compressive strength of concrete  
(1) Object (4) Capping  
(2) Equipments (5) Testing  
(3) Preparation (6) Results
- 3-12. Tensile strength of concrete  
(1) Split cylinder test  
(2) Standard beam test — modulus of rupture test
- 3-13. Non-destructive tests  
(1) Rebound hardness test  
(2) Ultrasonic pulse velocity test
- 3-14. Stress-strain behaviour of concrete under short term loads  
(1) Compressive loads  
(2) Tensile loads
- 3-15. Short term static modulus of elasticity
- 3-16. Shrinkage  
(1) Plastic shrinkage (3) Carbonation shrinkage  
(2) Drying shrinkage (4) Autogenous shrinkage
- 3-17. Creep
- 3-18. Durability of concrete  
(1) Use of inferior quality materials  
(2) Improper compaction and curing
- (3) Limits on cement content  
(4) Requirements of concrete cover to steel reinforcement  
(5) Improper design and detailing
- 3-19. Temperature change
- 3-20. Concrete quality control
- 3-21. Sampling and strength tests of concrete  
(1) Sampling and frequency of sampling  
(2) Strength tests  
(3) Preparing sampling and testing records  
(4) Checking the record  
(5) Analyse the results
- 3-22. Statistical analysis of test results  
(1) Density function  
(2) Normal distribution  
(3) Mean  
(4) Standard deviation
- 3-23. Standard deviation  
(1) Standard deviation based on test strength of sample  
(2) Assumed standard deviation
- 3-24. Acceptance criteria
- DESIGN MIX CONCRETE**
- 3-25. Introductory
- 3-26. Use of plasticizers and super-plasticizers
- MIX DESIGN FOR ORDINARY AND STANDARD GRADES OF CONCRETE**
- 3-27. Basic assumptions
- 3-28. Data for mix design
- 3-29. Target strength for mix design
- 3-30. Assumed standard deviation
- 3-31. Selection of water-cement/water-cementitious materials ratio
- 3-32. Estimation of air content
- 3-33. Selection of water content and admixture content
- 3-34. Calculation of cement/cementitious materials content
- 3-35. Estimation of coarse and fine aggregate proportion in all-in aggregates
- 3-36. Estimation of masses of various ingredients
- 3-37. Trial mixes
- Questions 3  
Examples 3
- CHAPTER 4 DESIGN FOR FLEXURE: FUNDAMENTALS**
- 4-1. Introductory
- 4-2. Review of theory of simple bending
- 4-3. Practical requirements of an R.C.C. beam
- 4-4. Size of the beam
- 4-5. Cover to the reinforcement
- 4-6. Spacing of bars
- 4-7. Design requirements of a beam
- 4-8. Classification of beams  
(1) Singly reinforced and doubly reinforced beams  
(2) Rectangular and flanged beams
- 4-9. Effective width of a flanged beam
- 4-10. Cracking moment
- 4-11. Balanced, Under-reinforced and Over-reinforced design  
(1) Balanced design  
(2) Under-reinforced design  
(3) Over-reinforced design
- 4-12. Bending of an R.C.C. beam  
(1) Uncracked concrete stage  
(2) Concrete cracked-elastic stresses stage  
(3) Ultimate strength stage
- 4-13. Design methods
- CHAPTER 5 DESIGN FOR FLEXURE: WORKING STRESS METHOD**
- 5-1. Permissible stresses
- 5-2. Modular ratio
- 5-3. Design for flexure—assumptions

**REINFORCED CONCRETE – VOL. I**  
**DETAILED CONTENTS**

**SINGLY REINFORCED BEAMS**

- 5-4. Derivation of formulae for balanced design
- 5-5. Transformed area method
- 5-6. Types of problems in singly reinforced concrete
- 5-7. Analysis of the section
- 5-8. Design of the section
  - (1) Dimensions not given
  - (2) Dimensions are given
- 5-9. Use of design aids

**DOUBLY REINFORCED BEAMS**

- 5-10. Introductory
- 5-11. Derivation of formulae for balanced design
- 5-12. Transformed area method
- 5-13. Types of problems for doubly reinforced concrete
- 5-14. Use of design aids

**FLANGED BEAMS**

- 5-15. Moment of resistance of a singly reinforced flanged beam
  - (1) Neutral axis lies in flange
  - (2) Neutral axis lies in web
- 5-16. Types of problems for flanged beams
- 5-17. Doubly reinforced flanged beams
- 5-18. Slabs

Examples 5

**CHAPTER 6 LIMIT STATE METHOD**

- 6-1. Inelastic behaviour of materials
- 6-2. Ultimate load theory
- 6-3. Limit state method
- 6-4. Limit state of collapse
- 6-5. Limit state of serviceability
- 6-6. Characteristic and design values and partial safety factors
  - (1) Characteristic strength of materials
  - (2) Characteristic loads
  - (3) Partial safety factors
  - (4) Design values
- 6-7. Limit state of collapse: Flexure

**SINGLY REINFORCED RECTANGULAR BEAMS**

- 6-8. Derivation of formulae
  - (1) With respect to compression
  - (2) With respect to tension
- 6-9. General values
  - (1) Limiting moment of resistance index
  - (2) Limiting reinforcement index
- 6-10. Types of problems
- 6-11. Failure of R.C.C. beam in flexure
- 6-12. Code provisions to prevent the brittle failure
- 6-13. Computer programmes

**DOUBLY REINFORCED BEAMS**

- 6-14. Derivation of formulae
  - 6-15. Types of problems
  - 6-16. Use of design aids
  - 6-17. Computer programmes for doubly reinforced rectangular sections
- FLANGED BEAMS**
- 6-18. Introductory
  - 6-19. Position of neutral axis
  - 6-20. Derivation of formulae
  - 6-21. Use of design aids
  - 6-22. Doubly reinforced flanged beams
  - 6-23. Sections subjected to reversal of moments
    - (1) Hogging moment
    - (2) Sagging moment
  - 6-24. Computer programmes for flanged sections

Examples 6

**CHAPTER 7 SHEAR AND DEVELOPMENT LENGTH**

- 7-1. Shear in structural members
  - (1) Flexural shear
  - (2) Punching shear
  - (3) Torsion shear

- 7-2. Flexure and shear in homogeneous beam
- 7-3. Shear in reinforced concrete beams – Elastic theory
- 7-4. Diagonal tension and diagonal compression
- 7-5. Limit state theory
- 7-6. Design shear strength of concrete for various member without shear reinforcement
  - (1) Beams
  - (2) Solid slabs
  - (3) Members under axial compression
- 7-7. Design for shear
- 7-8. Shear reinforcement in beams
  - (1) Vertical stirrups
  - (2) Inclined stirrups
  - (3) Bent bars
  - (4) Shear resistance capacity of a section
- 7-9. Practical considerations
  - (1) Distance of first bent bar from support
  - (2) Maximum spacing
  - (3) Minimum shear reinforcement
  - (4) Maximum shear stress
- 7-10. Critical sections for shear
  - (1) Tension in end region of a member
  - (2) Compression in end region of a member
- 7-11. Design of a complete beam for shear
- 7-12. Use of design aids
  - (1) Minimum shear reinforcement
  - (2) Vertical stirrups
  - (3) Bent bars
- 7-13. Shear design of beams with variable depth

**DEVELOPMENT LENGTH**

- 7-14. Bond and Bond stress
  - (1) Features of reinforced concrete attributed to bond
  - (2) Grip or bond attributed to various mechanisms
- 7-15. Flexural (Local) bond and Development (Anchorage) Bond
  - (1) Flexural or local bond
  - (2) Secondary effects
  - (3) Development or Anchorage bond
- 7-16. Anchorage length and Development length
  - (1) Anchorage length
  - (2) Development length
- 7-17. Development length: Pull out test
  - (1) Pull out failure
  - (2) Splitting failure
- 7-18. Code provision
- 7-19. Use of bundled bars
- 7-20. Anchoring reinforcements
  - (1) Anchoring bars in tension
  - (2) Anchoring bars in compression
  - (3) Anchoring bars in shear
- 7-21. Bearing stresses at bends
- 7-22. Reinforcement splicing
  - (1) Lap splices
  - (2) End bearing splices
  - (3) Welded splices
  - (4) Mechanical splices
- 7-23. Ensuring ductile failure

Examples 7

Long Questions of chapter 7

**CHAPTER 8 DEFLECTION AND CRACKING**

**DEFLECTION**

- 8-1. Limit state of serviceability
- 8-2. Deflections in a structure or structural members
  - (1) Structural damage
  - (2) Non-structural damage
  - (3) Discomfort to the occupants
- 8-3. Span/effective depth ratio

**REINFORCED CONCRETE – VOL. I**  
**DETAILED CONTENTS**

- 8-4. Control of deflection on site  
(1) Cambering  
(2) Controlling concrete work  
(3) Removal of forms  
(4) Controlling temporary loads
- 8-5. Deflection calculations
- 8-6. Short term deflections  
(1) Modulus of elasticity of concrete  
(2) Moment of inertia of the section
- 8-7. Long term deflections  
(1) Deflection due to shrinkage  
(2) Deflection due of creep
- CRACKING**
- 8-8. Introductory  
(1) Bar spacing controls  
(2) Crack width calculations
- 8-9. Bar spacing controls  
(1) Beams  
(2) Slabs
- 8-10. Calculation of crack width  
(1) Assumptions  
(2) Approximate method
- 8-11. Computer programs  
Examples 8
- CHAPTER 9 SIMPLY SUPPORTED AND CANTILEVER BEAMS**
- 9-1. Design procedure  
(1) Estimation of loads  
(2) Analysis  
(3) Design
- 9-2. Anchorage of bars check for development length
- 9-3. Reinforcement requirements  
(1) Tension reinforcement  
(2) Compression reinforcement  
(3) Cover to the reinforcement
- 9-4. Slenderness limits for beams to ensure lateral stability
- SIMPLY SUPPORTED BEAMS**
- 9-5. Introductory
- 9-6. Design S.F. diagram
- 9-7. Curtailment of bars
- 9-8. Design of a template
- 9-9. Design of a lintel  
(1) Loads  
(2) Size  
(3) Cover
- CANTILEVER BEAMS**
- 9-10. Design considerations
- 9-11. Computer programs  
Examples 9
- CHAPTER 10 SIMPLY SUPPORTED AND CANTILEVER SLABS**
- 10-1. Introductory  
(1) One-way spanning slabs  
(2) Two-way spanning slabs  
(3) Flat slabs  
(4) Grid slabs  
(5) Circular slabs  
(6) Ribbed and waffle slabs
- 10-2. Analysis  
(1) Elastic analysis  
(2) Using coefficients  
(3) Yield line method
- 10-3. One-way spanning slabs  
(1) Effective span  
(2) General  
(3) Reinforcement requirements
- (4) Shear stress  
(5) Deflection  
(6) Cracking  
(7) Cover  
(8) Development length
- 10-4. Simply supported one-way slab
- 10-5. Detailing of slabs
- 10-6. Inclined slabs  
(1) Slabs spanning perpendicular to the slope  
(2) Slabs spanning parallel to the slope
- 10-7. Straight slabs having a small length inclined along the span
- 10-8. Cantilever slab
- 10-9. Concentrated load on slabs
- 10-10. Two-way slabs
- 10-11. Simply supported two-way slabs
- 10-12. Computer program  
Examples 10
- CHAPTER 11 CONTINUOUS BEAMS AND SLABS**
- CONTINUOUS BEAMS**
- 11-1. Introductory
- 11-2. Analysis parameters  
(1) Effective span  
(2) Stiffness
- 11-3. Live load arrangements
- 11-4. Redistribution of moment  
(1) Plastic hinge  
(2) Fixed beam  
(3) Code requirements
- 11-5. Reinforcement requirements
- 11-6. Flexure design considerations
- 11-7. Simplified analysis for uniform loads
- 11-8. Moment and shear coefficients for continuous beams
- 11-9. Typical continuous beam details
- CONTINUOUS SLABS**
- 11-10. Continuous one-way slab
- 11-11. Restrained two-way slabs
- 11-12. Two-way slabs subjected to large shear force
- 11-13. Computer program  
Examples 11  
Questions 11
- CHAPTER 12 TORSION**
- 12-1. General  
(1) Equilibrium torsion  
(2) Compatibility torsion
- 12-2. Effect of torsion: Provision of reinforcement
- 12-3. Code provisions  
(1) General  
(2) Design rules
- 12-4. General cases of torsion  
(1) Cantilever slab inducing torsion in supporting beam  
(2) Cantilever beam inducing torsion in supporting beam  
(3) Beams curved in plan
- 12-5. Beams curved in plan
- 12-6. Circular beam  
(1) Support moments  $M_o$   
(2) Shear, moment and torsion at  $P$
- 12-7. Circular arc fixed at ends
- 12-8. Design of beams curved in plan  
Examples 12  
Questions 12
- CHAPTER 13 STAIRS**
- 13-1. Stair slabs
- 13-2. Classification of stairs  
(1) Straight stair  
(2) Dog-legged stair  
(3) Open well stair

**REINFORCED CONCRETE – VOL. I**  
**DETAILED CONTENTS**

- 13-3. Design requirements for stair  
(1) Live loads on stair  
(2) Effective span of stair  
(3) Distribution of loading on stairs  
(4) Depth of section
- 13-4. Reducing the span
- 13-5. Tread-riser staircase
- 13-6. Closure

Examples 13

**CHAPTER 14 LOAD CALCULATIONS FOR SLABS AND BEAMS**

- 14-1. Introductory
- 14-2. Loads on slabs  
(1) Self weight of the slab (3) Live loads  
(2) Floor finish (4) Any other loads
- 14-3. Loading on beams from one-way slabs
- 14-4. Wall loads and self weight of beams
- 14-5. Loading on beams from two-way slabs
- 14-6. Unit loads

Examples 14

**CHAPTER 15 SIMPLE DESIGNS**

- 15-1. Introductory
- 15-2. Design S.F. diagram
- 15-3. Loads from two-way slabs

Examples 15

**CHAPTER 16 FRAMED BEAMS**

- 16-1. Structural joints
- 16-2. Fixed, cantilever and framed beams  
(1) Fixed beams  
(2) Cantilever beam  
(3) Framed beams
- 16-3. Analysis and design of the framed beams
- 16-4. Single span portal frame
- 16-5. Substitute frame

Examples 16

**CHAPTER 17 COLUMNS**

- 17-1. Introductory
- 17-2. Loads and displacements for building columns  
(1) Vertical gravity loads (Dead and live loads)  
(2) Horizontal loads (Wind and earthquake loads)
- 17-3. Classification of columns
- 17-3-1. Braced and unbraced columns  
(1) Braced column  
(2) Unbraced columns
- 17-3-2. No-sway and sway columns
- 17-3-3. Tied, spiral and composite columns  
(1) Tied columns  
(2) Spiral columns  
(3) Composite columns
- 17-3-4. Short and long columns  
(1) Short columns  
(2) Long (Slender) columns
- 17-4. Reinforcement requirements  
(1) Longitudinal reinforcement  
(2) Transverse reinforcements
- 17-5. Minimum eccentricity
- 17-6. Assumptions made for design

**SHORT COLUMNS**

- 17-7. Axially loaded tied columns
- 17-8. Axially loaded spiral columns
- 17-9. Short eccentrically loaded columns — Uniaxial bending  
(1) N.A. lies outside the section  
(2) N.A. lies inside the section
- 17-10. Modes of failure in combined axial load and uniaxial bending  
(1) N.A. lies outside the section  
(2) Balanced failure  
(3) Tensile failure

- 17-11. Types of problems
- 17-12. The interaction diagram
- 17-13. Stress block parameters when N.A. lies outside the section
- 17-14. Construction of interaction diagrams
- 17-14-1. Pure axial load
- 17-14-2. Axial load with uniaxial moment
- 17-15. Neutral Axis (N.A.) lies outside the section
- 17-16. Neutral Axis (N.A.) lies inside the section
- 17-17. Charts for compression with bending
- 17-18. Tension with bending
- 17-19. Use of interaction diagram
- 17-20. Unsymmetrically reinforced columns with uniaxial eccentricity  
(1) General method  
(2) Approximate method
- 17-21. Using an excel program to draw an interaction diagram of a given rectangular column
- 17-22. Short eccentrically loaded columns: Biaxial bending

**SLENDER COLUMNS**

- 17-23. Slender columns  
(1) Unsupported length  
(2) Effective length  
(3) Radius of gyration  
(4) Slenderness ratio  
(5) Short and long columns  
(6) Slenderness limits for columns
- 17-24. Effective length calculations
- 17-25. Lengths of column  
(1) Floor height  
(2) Length of column  
(3) Unsupported length of column  
(4) Effective length of column
- 17-26. Design of slender columns  
(1) Braced columns  
(2) Unbraced columns
- 17-27. Design and detailing of a practical column

Examples 17

**CHAPTER 18 DESIGN OF FOUNDATIONS: FUNDAMENTALS**

- 18-1. Introductory
- 18-2. Classification of foundations  
(1) Flexible and rigid foundations  
(2) Shallow and deep foundations
- 18-3. Types of footings  
(1) Continuous wall footing (5) Strip footing  
(2) Isolated footing (6) Raft foundation  
(3) Combined footing (7) Pile foundation  
(4) Strap footing
- 18-4. R.C.C. footings  
(1) Column/wall — footing connection  
(2) Aspects of footing design

**SOIL DESIGN**

- 18-5. Soil exploration
- 18-6. Depth of foundation
- 18-7. Cohesive and cohesionless soils  
(1) Cohesive soil  
(2) Cohesionless soil  
(3)  $c-\phi$  soil
- 18-8. Modes of soil failure  
(1) Catastrophic collapse  
(2) Excessive settlement
- 18-9. Types of Shear failures of soil  
(1) General shear failure  
(2) Local shear failure  
(3) Punching shear failure  
(4) Intermediate (mixed mode) failure
- 18-10. Vertical stress distribution
- 18-11. Contact pressure distribution under rigid footings

**REINFORCED CONCRETE – VOL. I**  
**DETAILED CONTENTS**

- 18-12. Net safe bearing capacity (net SBC) of soil
  - (1) The ultimate bearing capacity
  - (2) Net ultimate bearing capacity
- 18-13. Settlement of soil
- 18-14. Safe Bearing Pressure (SBP) on soil
- 18-15. Allowable Bearing Capacity (ABP) on soil
- 18-16. Calculation of net safe bearing capacity (net SBC) of soil
- 18-17. Simplified method of soil design for axial, inclined and eccentric loads
- 18-17-1. Transfer of loads from column to soil
- 18-17-2. Resultant loads at the base of footing
- 18-17-3. Goal of design
- 18-17-4. Selection of allowable bearing pressure
- 18-17-5. Footings subjected to axial loads
- 18-17-6. Footing subjected to axial loads and moments
  - (1) Uniaxial moment
  - (2) Biaxial moment
- 18-17-7. Footing subjected to horizontal loads
- 18-17-8. Use of passive pressure for Resisting sliding
  - (1) Cohesionless soil
  - (2) Cohesive soil
- 18-17-9. Use of slab tie and beam ties for resisting sliding

**STRUCTURAL DESIGN**

- 18-18. Selection of plan dimensions
- 18-19. Upward soil pressure
- 18-20. General soil design considerations
  - (1) Uniform settlement
  - (2) Uniform pressure
  - (3) Non-uniform pressure
- 18-21. Footing for eccentrically loaded columns
  - (1) Concentric footing
  - (2) Eccentric footing
- 18-22. General structural design considerations
- 18-23. Concrete pedestal
- 18-24. Transfer of load at the base of column
  - (1) Bearing strength
  - (2) Bond strength

Examples 18

**CHAPTER 19 ISOLATED FOOTINGS**

- 19-1. Introductory
- 19-2. Wall footings
- 19-3. Axially loaded pad footing
  - (1) Proportioning the size
  - (2) Bending moment
  - (3) Nominal reinforcement
  - (4) Development length
  - (5) Shear
  - (6) Deflection
  - (7) Cover
  - (8) Reinforcement requirements
  - (9) Transfer of load from column to footing
  - (10) Weight of the footing
- 19-4. Axially loaded sloped footing
- 19-5. Eccentrically loaded footings
  - (1) Uniaxial moment
  - (2) Biaxial moment
- 19-6. Fixing up footing dimensions
- 19-7. Isolated slab and beam type footing
- 19-8. Footing for multi-storeyed building columns
- 19-9. Excel program for design of an isolated footing

Examples 19

**CHAPTER 20 COMBINED FOOTINGS**

- 20-1. Combined footings
- 20-2. Combined footing for two axially loaded columns
- 20-3. Strap footings
- 20-4. Strip footings

- 20-5. Combined footing for generalised load system
    - (1) General
    - (2) Collinear columns
    - (3) Drawing co-ordinate axes
    - (4) Soil design
  - 20-6. Raft foundation
  - 20-7. Closure
- Examples 20

**CHAPTER 21 PILE FOUNDATIONS**

- 21-1. Introductory
  - (1) Driven piles
  - (2) Bored piles
- 21-2. Loads on pile groups
  - (1) Axial loads on a group of vertical piles
  - (2) Moment on a group of vertical piles
  - (3) Horizontal load
  - (4) Design of a pile
- 21-3. Soil Design of a pile
- 21-4. Structural design of a pile
  - (1) General
  - (2) Handling stresses
  - (3) Main reinforcement
  - (4) Ties
  - (5) Spreaders (forks)
- 21-5. Design of a pile cap

Examples 21

**CHAPTER 22 CIRCULAR RAFT FOUNDATIONS**

- 22-1. Introduction
    - (1) Annular raft
    - (2) Solid raft
- ANNULAR RAFT**
- 22-2. Soil design of an annular raft
    - (1) Raft positioning
    - (2) Upward pressures
  - 22-3. Formulae for annular raft
    - (1) Axial load
    - (2) Applied moment  $M$
  - 22-4. Design for flexure and shear
    - (1) Flexure
    - (2) Shear
    - (3) Locations for analysis and design

**SOLID RAFT**

- 22-5. Solid raft
  - (1) Axial load
  - (2) Applied moment  $M$

Examples 22

**CHAPTER 23 RETAINING WALLS**

- 23-1. Introductory
- 23-2. Types of retaining walls
  - (1) Gravity wall
  - (2) Cantilever wall
  - (3) Counterfort wall
  - (4) Buttress wall
  - (5) Bridge abutment
  - (6) Gabion walls
  - (7) Box culvert
- 23-3. Earth pressure on walls
- 23-4. Calculation of earth pressure
  - (1) Cohesionless soil
  - (2) Cohesive soil
- 23-4-1. Earth pressure of submerged soil
- 23-4-2. Earth pressure due to surcharge
- 23-5. Drainage of retaining walls
- 23-6. Stability requirements

**CANTILEVER RETAINING WALL**

- 23-7. Preliminary proportioning of cantilever retaining wall
  - (1) Height of wall
  - (2) Base width and position of stem on the base of footing
  - (3) Thickness of base slab
  - (4) Thickness of stem

**REINFORCED CONCRETE – VOL. I**  
**DETAILED CONTENTS**

- 23-8. Design of a cantilever retaining wall  
(1) Design of stem  
(2) Design of heel  
(3) Design of toe  
(4) Base key  
(5) Minimum reinforcement in walls with variable depth

**COUNTERFORT RETAINING WALL**

- 23-9. Counterfort wall  
23-10. Stability and design procedure  
(1) Stability (3) Base  
(2) Stem (4) Counterforts

Examples 23

**CHAPTER 24 CIRCULAR, RIBBED AND WAFFLE SLABS**

**CIRCULAR SLABS**

- 24-1. Introductory  
24-2. Analysis

**RIBBED SLABS**

- 24-3. Introductory  
24-4. Proportioning the dimensions  
24-5. Analysis and design procedure  
(1) Analysis  
(2) Design

**WAFFLE SLABS**

- 24-6. Two-way spanning ribbed slabs: Waffle slabs  
Examples 24

**CHAPTER 25 FLAT SLABS**

- 25-1. Introductory  
(1) Flat slab with no drop and no column head  
(2) Flat slab without drop and column with column head  
(3) Flat slab with drop and column with column head  
25-2. Column and middle strips  
(1) Column strip  
(2) Middle strip  
(3) Panel  
25-3. Proportioning of flat slab elements  
(1) Thickness of flat slab  
(2) Drops  
(3) Column head  
25-4. Design methods for flat slabs  
(1) Direct Design Method (D.D.M.)  
(2) Equivalent Frame Method (E.F.M.)

**DIRECT DESIGN METHOD (D.D.M.)**

- 25-5. Total design moment  
25-6. Distribution of moments in slabs  
(1) Moments in column strip  
(2) Moments in middle strip  
25-7. Effect of pattern loading  
(1) By increasing the flexural stiffness of columns  
(2) By increasing the positive moment  
25-8. Transfer of floor loads into columns  
(1) Transfer of vertical load  
(2) Transfer of moment  
25-9. Design for shear  
(1) Calculation of shear stress  
(2) Permissible shear stress  
25-10. Provision of reinforcement  
25-11. Moments in columns  
Examples 25

**CHAPTER 26 DOMES**

- 26-1. Introductory  
26-2. Stresses in domes  
26-3. Formulae for forces in spherical domes  
(1) Uniform loads as on dome  
(2) Concentrated loads  $W$  on crown

- 26-4. Design of a spherical dome  
26-5. Section design for pure tension  
26-6. Formulae for forces in conical domes  
Examples 26

**CHAPTER 27 DEEP BEAMS AND CORBELS**

- 27-1. Introduction

**DEEP BEAMS**

- 27-2. Definitions  
(1) Deep beams  
(2) Effective span  
(3) Lever arm  
27-3. Design and details of reinforcements of deep beams  
(1) Design of reinforcements  
(2) Details of reinforcements

**CORBELS**

- 27-4. Corbels  
27-5. Shear friction  
27-6. Corbel dimensions  
(1) Width of the corbel  
(2) Width of the base plate  
(3) Span of the corbel  
(4) Depth  $d$  at root of the corbel  
(5) Depth  $d_1$  at the outer edge of contact area  
27-7. Design of a corbel  
(1) Primary tension reinforcement  
(2) Shear reinforcements

Examples 27

**CHAPTER 28 GRID OR COFFERED FLOORS**

- 28-1. Introduction  
28-2. Analysis of grid floors  
28-3. Plate theory  
(1) The flexural rigidities  
(2) The torsional rigidity of rectangular section

Examples 28

**CHAPTER 29 FORMWORK**

- 29-1. Introductory  
29-2. Requirements for good formwork  
29-3. Materials for forms  
(1) Timber  
(2) Steel  
29-4. Choice of formwork  
29-5. Loads on formwork  
29-6. Permissible stresses for timber  
29-7. Design of formwork  
29-8. Shuttering for columns  
29-9. Shuttering for beam and slab floor  
29-10. Practical considerations  
29-11. Erection of forms  
29-12. Action prior to and during concreting  
29-13. Striking of forms  
Examples 29

**CHAPTER 30 DETAILING OF REINFORCEMENT**

- 30-1. Introduction  
30-2. General informations for drawing  
30-3. Drafting  
30-4. Columns framing plan and foundation details  
30-5. Columns details  
30-6. Slabs and beams details  
30-7. Closure

**APPENDIX A SHORT QUESTIONS WITH ANSWERS**

**APPENDIX B USEFUL TABLE: MOMENT AND SHEAR COEFFICIENTS**

**INDEX**