Design of Reinforced Concrete (RC) Structures
EG 3103 CE

Year: III
Semester: I

Total: 8 Hrs. /week
Lecture: 4 Hrs./week
Tutorial: 2 Hrs./week
Practical: 2 Hrs./week
Lab: Hrs./week

Course Description:
This course provides the general ideas and design of RC members using relevant codes of practice. After completion of this course, students must be able to supervise RC constructions and he should be able to design simple RC members and prepare detail drawings of reinforcements in foundation, columns, beams, slabs, sills, lintels and also able to prepare ductile detailing of beam-column joints, column bases and bar bending schedule. Hence, it mainly focuses on the design of RC members and check as per code for strength and serviceability requirements.

Course Objectives:
After the completion of this course, the students will be able to:

1. Identify and select proper materials, calculate the design values for the materials.
2. Able to design structural elements of steel beams and columns- compression and tension members, timber beams, steel and timber joints.
3. Able to design structural elements of RCC: Slabs, beams, columns, stairs by LSM.
4. Understand concept of design and codal provisions
5. Able to prepare the proper detailing of structural members (steel, timber and reinforcement) and their connections using NBC: 101, 102, 103, 104, 105, 110; IS: 875, IS: 456-2000 & 2016, SP-34 & IS: 13920 and related codes of practice.

Course Contents:

Unit1: Design Concept of Reinforced Concrete by Working Stress Method (WSM) [10 Hrs.]

1.1 Concept of reinforced cement concrete (RCC) as composite material, role of reinforcement, requirements of materials, loads on structure as per NBC: 102, 103, 104, 106 & IS: 875.
1.2 Different grades of cement and steel. Properties of concrete and steel reinforcement (mild &HYSD bars), concept of characteristics strength, grades of concrete reinforcing bars.
1.3 Working Stress Method (WSM) of Design: Assumptions, merits and demerits/limitations.
1.4 Modular ratio, permissible-, ultimate stresses and factor of safety.
1.5 Stress strain diagram, actual and critical neutral axis (NA), position of NA, Lever Arm, Moment of Resistance (MR).
1.6 Under reinforced, over reinforced and balanced sections.
1.7 Behavior of RCC sections in bending
1.8 Analysis and design of singly reinforced rectangular sections.
1.9 Analysis and design of doubly reinforced rectangular sections.
1.10 Concept of shear reinforcement.

Unit 2: Design Concept of Reinforced Concrete by Limit State Method (LSM) [4 Hrs.]

2.1 Concept of different limit states and assumptions made in limit state of collapse.

2.2 Limit state of strength and serviceability. Safety and serviceability requirements/deflection control of structures as per codes.
2.3 Partial safety factor for loads, partial safety factor for materials, design strength of materials and design loads.
2.4 Stress-strain curves for concrete and steel, stress block, maximum strain in concrete, idealized stress-strain diagrams for steel and concrete.

Unit 3: Design of Reinforced Concrete beams by Limit State Method (LSM) [14 Hrs.]

3.1 Limiting values of NA for different grades of steel. Design bending moments and shear force. MR for singly and doubly reinforced rectangular sections.
3.2 Effective span for cantilever, simply supported and continuous beams, limits on area and spacing of reinforcement, side-face reinforcement as per NBC: 110 and IS 456:2000 & 2016.
3.3 Design of singly reinforced cantilever and simply supported rectangular beams. Numerical problems to evaluate moment of resistance and design related problems.
3.4 Design of doubly reinforced rectangular sections.
3.5 Behavior of T- and L-beams. Design of T- and L-beams.
3.6 Concept of continuous beams and knowledge on reinforcement placement.
3.7 Design of doglegged and open-well staircase.

Unit 4: Design Concept of Reinforced Concrete Beams on Shear by LSM [8 Hrs.]

4.1 Shear behavior and failure in shear with examples. Critical section for shear. Forms of shear reinforcement.
4.2 Design shear strength of concrete, maximum shear stress, design shear strengths of vertical/inclined stirrups/bent-up bars. Nominal shear stress.
4.3 Design of shear reinforcement in the form of vertical stirrups, inclined stirrups and bent-up bars. Minimum shear reinforcement. Simple design examples.
4.4 Bond between concrete and steel reinforcement, types of bond, bond stress, and check for bond stress.
4.5 Development length in tension and compression anchorage value of hooks, 90° bend and 45° bend, standard lapping of bars, check for development length.
4.6 Need for bar curtailment and detailing.

Unit 5: Design Concept on one-way and two-way slabs by LSM [8 Hrs.]

5.1 Introduction and classification of slabs. One-way and two-way slabs. Effective span of slab, live (imposed) loads on slabs (NBC: 103, IS: 875).
5.2 One-way slab design: Determination of slab thickness for simply supported slab to satisfy strength and stiffness requirements. Code requirement on the minimum/maximum area of reinforcement (main & secondary) and spacing of bars. Check for deflection and shear.
5.3 Introduction of cantilever and continuous slabs, design and reinforcement detailing.
5.4 Design of two-way slab: Effective span, classification of slabs as per code, bending moments (BM) coefficients for different edge conditions, design bending moments. Determine slab thickness and reinforcement bars for simply supported, restrained and continuous support condition to satisfy strength and stiffness requirements.
5.5 Edge and middle strips for different support conditions. Code requirements on the minimum/maximum area of reinforcement (main & secondary) and spacing

of bars, torsion reinforcement and curtailment of reinforcement. Check for deflection and shear.

Unit 6: Design of Columns by LSM [10 Hrs.]

6.1 Limit state of collapse in compression- assumptions.
6.2 Slenderness ratios, classification of columns, effective lengths. Minimum eccentricity for column loads.
6.3 Minimum/maximum reinforcement, number of bars in rectangular, square and circular sections, diameter and spacing of lateral ties as per NBC and IS codes.
6.4 Design of axially loaded short columns with lateral ties/helical reinforcement.
6.5 Reinforcement detailing and code requirements.
6.6 Introduction to long columns.
6.7 Column footing: Code requirements for square and rectangular footings as thickness, critical sections, minimum and maximum requirement on main and distribution reinforcement, minimum edge thickness, cover, anchorage and development lengths.
6.8 Design of isolated square and rectangular footings.

Unit 7: Introduction to Pre-Stressed Concrete: [6 Hrs.]

7.1 Concept of pre-stressing
7.2 Materials used in pre-stressed concrete and their requirements.
7.3 Methods of pre-stressing: pre-tensioning and post-tensioning
7.4 Systems of pre-stressing and post-tensioning.
7.5 Losses in pre-stress.
7.6 Merits and demerits of pre-stressing and post-tensioning.
7.7 Sagging profile of cable for post-tensioning.

Tutorial: [30 Hrs.]

1. Problems related to under reinforced, over reinforced and balanced sections in WSM.
2. Numerical problems on determining design constants, moment of resistance and area of steel for singly and doubly reinforced beams by WSM.
3. Moment of resistance and design of singly reinforced cantilever and simply supported rectangular beams by LSM.
4. Evaluation of moment of resistance and design of doubly reinforced rectangular sections by LSM.
5. Problems on design of shear reinforcement in the form of vertical stirrups, inclined stirrups and bent-up bars. Check for minimum shear reinforcement.
6. Determination of development length and check.
7. Design of one-way slabs. Check for deflection and reinforcement requirement.
8. Design of two-way slabs for different edge conditions.
9. Problems related to design of doglegged staircase.
10. Design of axially loaded short columns with lateral ties/helical reinforcement.
11. Design of square and rectangular footings.

Practical: **[30 Hrs.]**

Design and draw followings:

1. Singly reinforced rectangular beams with reinforcements detailing
2. Doubly reinforced rectangular beams
3. Singly reinforced T– beams and L-beams
4. One-way slabs (simply supported, cantilever and overhang)
5. Two-way slab with different edge conditions
6. Doglegged and open-well staircases
7. Short and long columns (axially loaded)
8. Simple pad footings for columns
9. Prepare a column-beam joint showing bars as per ductile detailing code requirement.
10. Preparation of bar bending schedule for all RC drawings
11. Introduction to structural analysis software (SAP, ETABS, STAAD Pro. etc.)

**** Note: IS: 456 is allowed in the examination***.

Text Books:

1. A. k. Jain, "Design of RC Structures",……(LSM)
2. C. M. Kale, "RCC Structures",…….. (WSM)

References:

1. S Pillai and D Menon, “Reinforced Concrete Design”, Tata McGraw Hill Publishing Co., New Delhi.
2. P. Dayaratnam, “Design of Reinforced Concrete Structures”, Oxford & IBH Publishing Company.
3. R Suwal, “Design of Reinforced Concrete Structures”, A.K. Book Publication, Kathmandu
4. NBC 101, 102, 103, 104, 105, 110, Nepal standards and related codes of practice.
5. IS: 456-2000 & 2016, SP-34 & IS 13920 and related codes of practice.
6. BS, EURO codes, FEMA and relevant codes.

Evaluation System

Unit	Title	Hrs.	Marks
1	Design Concept of Reinforced Concrete by Working Stress Method (WSM)	10	12
2	Design Concept of Reinforced Concrete by Limit State Method (LSM)	4	4
3	Design of Reinforced Concrete beams by Limit State Method (LSM)	14	24
4	Design Concept of Reinforced Concrete Beams on Shear by LSM	8	12
5	Design Concept on one-way and two-way slabs by LSM	8	12
6	Design of Columns by LSM	10	12
7	Introduction to Pre-Stressed Concrete:	6	4
Total		**60**	**80**