# GUJARAT TECHNOLOGICAL UNIVERSITY

**Program Name: Bachelor of Engineering**
**Level: UG**
**Branch: Civil Engineering**
**Subject Code: BE05006011**
**Subject Name: Design of Reinforced Concrete Structures**

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| w.e.f. Academic Year: | 2024-25 |
| Semester: | 5 |
| Category of the Course: | Professional Core Course |

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| **Prerequisite:** | Structural Analysis |
| **Rationale:** | Reinforced Cement Concrete (RCC) is one of the most widely used construction materials in civil engineering infrastructure. Therefore, understanding the analysis, design, and detailing of RCC structures is essential for civil engineers to ensure safety, serviceability, durability, and sustainability throughout the life cycle of structures. This course introduces the principles of reinforced concrete behavior, limit state design philosophy, codal provisions, and structural detailing practices as per relevant Indian Standards. The course aims to develop the ability to design RCC structural elements and low-rise structural systems considering strength, stability, durability, economy, and sustainability requirements. |

**Course Outcomes:**

| Sr. No. | CO statement | % weightage |
|---|---|---|
| CO-1 | Apply the fundamentals of reinforced concrete behavior, loading standards, and limit state design principles to interpret codal provisions as per relevant Indian Standards *(RBT level : U, A)* | 20 |
| CO-2 | Design RCC elements such as beams, slabs, columns, and footings using limit state method in accordance with relevant Indian Standards. *(RBT level : A, N)* | 20 |
| CO-3 | Analyze, design and detail low rise RCC framed structure under gravity loads using manual methods and software tools. *(RBT level : N, E)* | 20 |
| CO-4 | Design and detail RCC structures including retaining walls and water tanks ensuring strength, stability, serviceability, and durability requirements. *(RBT level : A, N)* | 20 |
| CO-5 | Develop complete structural design reports, reinforcement detailing and engineering drawings incorporating codal provisions *(RBT level : C)* | 20 |

**Teaching and Examination Scheme:**

| Teaching / Learning Scheme (in Hours per semester) | | | | | Total Credits | Assessment Pattern and Marks | | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Theory | | Tutorial / Practical | | | |
| L | T | P | PBL | Total no of hours per semester | | ESE (E) | PA / CA (M) | PA/ CA (I) | PBL (I) | ESE (V) | |
| 45 | 30 | 0 | 45 | 120 | 4 | 70 | 30 | 20 | 30 | 50 | 200 |

**** Problem-Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

**Content:**

| Sr.No. | Content | Total Hrs |
|---|---|---|
| 1 | **Unit-1: Introduction & Limit state design philosophy for RC structures**<br>**Introduction:**<br>• Objectives, Properties of Reinforced Concrete, Loads & load combinations, Methods of Analysis, Codes & specifications, Design Philosophies - Working stress Method, Ultimate Load Method, Limit State Method, Plastic Method<br>• Introduction of High Strength Materials<br>**Limit State Design:**<br>Limit state for stability, strength & serviceability, partial safety factors for material & loading.<br>Limit State of Flexure**:** Stress-strain characteristics of concrete & reinforcing steel, Type of section-under reinforced, over reinforced & balance section, Neutral Axis depth, Moment of Resistance for singly reinforced, doubly reinforced and flanged sections.<br>Limit state of Axial, Shear and Torsion, combined flexure & torsion, Bond & Anchorage, Development length, splicing | 10 |
| 2 | **Unit-2: Limit state design of RC structural Element**<br>Design of Beams: Simply supported, cantilever and continuous beams<br>Design of Slab: One way, two way simply supported and continuous slabs<br>Design of Column: Classifications, Assumptions, Design of Short Columns under axial load, Uniaxial and Biaxial Bending<br>Design of Foundations: Design of isolated footing under axial load. | 12 |
| 3 | **Unit-3: Building Layout and Design**<br>Loads as per I.S., distribution & flow of Gravity loads, load combinations, guide lines for preparation of structural layout for building. Analysis, design & detailing of G+3 RC framed building for residential /commercial purpose for Gravity loads. | 08 |
| 4 | **Unit-4: Design of Retaining walls**<br>Types, behavior and application of retaining wall, stability criteria, design & detailing of cantilever & counter-fort type retaining wall for various ground conditions. | 06 |

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| **5** | **Unit-5: Design of Water Tank**<br>Classification of water tank and method of analysis, permissible stresses, IS code provisions, Design of circular and rectangular under-ground water tanks using relevant IS code method | 09 |
| | **TOTAL** | **45** |

**Suggested Specification table with Marks (Theory):**

| **Distribution of Theory Marks** | | | | | |
|---|---|---|---|---|---|
| R Level | U Level | A Level | N Level | E Level | C Level |
| **10** | **20** | **30** | **20** | **10** | **10** |

**R:Remembrance; U:Understanding; A:Application, N:Analyze and E:Evaluate C:Create and above Levels (Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

The syllabus of **Design of Reinforced Concrete Structures** directly contributes to

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| **SDG 9** | **Industry, Innovation and Infrastructure :** Develops knowledge of safe, durable, and efficient RCC infrastructure through scientific structural design practices and use of modern engineering tools. |
| **SDG 11** | **Sustainable Cities and Communities :** Promotes sustainable urban infrastructure through planning and design of RCC framed buildings, retaining walls, and water tanks considering safety, durability, and serviceability requirements. |
| **SDG 12** | **Responsible Consumption and Production :** Encourages efficient structural design and proper utilization of construction materials in RCC structures. |
| **SDG 13** | **Climate Action :** Supports development of durable RCC structures capable of providing long-term structural safety and serviceability. |

**Codes:**

1. IS 456:2000 - Code of practice for plain and reinforced concrete
2. IS 875 (Part I to V) - Code of practice for structural safety of Buildings Loading standards
3. IS 1893: 2016- Criteria for Earthquake Resistant Design of Structures - Part 1: General Provisions and Buildings)
4. IS 13920: 2016 -Code of Practice for ductile detailing of RC structure subjected to seismic force

5. IS 3370 (Part I to IV): 2021- concrete structures retaining aqueous liquids
6. SP 16 - Design Aids for Reinforced Concrete
7. SP 34 - Handbook on Concrete Reinforcement and Detailing

**Note: Latest revisions/amendments of all relevant IS codes shall be applicable.**

**Reference Books:**

1. P. C. Vargheese, Limit State Design of Concrete structure,
2. Shah & Karve; Limit State Theory & Design of Reinforced Concrete; Structure Pub., Pune
3. Dr. H.J. Shah; Reinforced concrete Vol-I; Charotar Pub. Anand
4. A. K. Jain; Design of Concrete Structures, Nemchand Publication
5. Punmia B.C "Advanced RCC Design" Laxmi Publications Pvt. Ltd". 2006.
6. Varghese P. C.., Advanced Reinforced Concrete, Varghese, Prentice Hall of India.
7. Sinha S. N., Reinforced Concrete Design, Tata Mc-Graw Hill, Delhi.
8. N. Krishna Raju, Advanced Reinforced Concrete Design, CBS Publishers.
9. S. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, Tata McGraw Hill.

**List of Experiments:**

The students will have to solve at least five examples and related theory from each topic as an assignment/tutorial. Students will have to perform following experiments in laboratory and prepare the laboratory manual.

1. The students will have to solve at least five examples and related theory from each topic as an assignment/tutorial.
2. Prepare sketches of structural detailing of RC components in sketch book/A3 size sheet.
3. Experiments may be designed and carried out related to the topics of the course such as; Design, casting and testing of under reinforced, over reinforced and limiting section.
4. Solve at least full design of (1) design of low rise G+3 building (design manually & check with software) (2) Retaining wall/water tank with detailing in A2 size drawing sheet covering all required details in structural drawing.
5. Practical examinations shall consist of oral based on term-work and above course.

**Major Equipment/Software:**

1. Any professional software of Structural analysis such as STAAD-pro, SAP, ETABS
2. Universal testing machine/Compression Testing Machine/ loading frame & loading jack, Concrete Mixture

**List of Open Source Software/learning website:**

1. http://nptel.ac.in/

**List of suggested activities for Problem based learning (PBL):**

| Sl. No. | PBL Category | Name of the activity | No. of hours | Evaluation Criteria |
|---|---|---|---|---|
| 1. | Seminar | Advances in the area of subject or Real-world case studies such as<br>• Failure analysis of RCC structures<br>• Earthquake-resistant housing in India<br>• Sustainable RCC building design<br>• Affordable or Low cost Housing design | Duration 10-15 hrs. | 10 Marks<br>Based on in-depth study, technical depth, data collected, fact finding, Report preparation & Presentation. |
| 2 | Mini Project | Mini project in the area of subject or Real-world case studies such as<br>• Design of load bearing vs framed structure<br>• Design of water tank with different types of containers and/or supporting structures<br>• Comparative study: manual vs software design using STAAD/ETABS | Duration 15 hrs.<br><br>Problem Statement, Data Collection / Assumptions, Analysis, Design, Drawings, Summary and/or Conclusion. | 10 Marks<br>Based on in-depth study, technical depth, data collected, fact finding, Report preparation, Presentation etc. |
| 3. | Industry/Field visit | Field Visit/survey<br>Visit sustainable construction sites / green buildings | Visit = 5h,<br>Report preparation = 5h<br>Total = 10h | 05 Marks<br>Based on report submitted. Report should contain observations and calculations based on industry/ lab data. |
| 4. | Video based learing | Technical Video based learning related to the subject | Duration of video = 5h<br>Report preparation = 5h<br>Total = 10h | 05 Marks<br>Report /presentation based on the video learning outcomes. |
| 5. | Assignment | Assignment writing. Numerical based | 5 assignments of 2h each. Total = 10h | 05 Marks<br>Based on the assignment |

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| | | assignment is preferable. | | submitted. |
| 6. | Problem solving/Coding | Problem solving/Coding using Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software such as<br>• Material quantity optimization using Excel/Python | 5 small coding-based assignment of 2h each. Total = 10h | 05 Marks<br>Based on the coding solution submitted. |
| 7. | Online courses | On-line courses related to the subjects | Minimum duration of the course should be 10h. | 05 Marks<br>Examination based assessment at the end of course. Based on the certificate produced. |
| 8. | Poster/chart/ Power point presentation | Poster/chart/power point preparation on technical topics | Duration = 6 h | 03 Marks<br>Based on poster/chart preparation and presentation skills |
| 9. | Model preparation | Working/non-working model on technical topics | Working = 12 h<br>Non- working = 8 h | 05 Marks<br>Based on inter department/external evaluation |
| 10. | Group discussion | Group Discussion on emerging/trending technical topics based on subject | Duration = 1 h each | 01 Mark/1 hr.GD<br>Based on performance in group discussion, technical depth, knowledge etc. |

**Note**:

1. All the suggested activity should be related to the subject.
2. Any two activities from Sr. No.- 1,2 & 3 are compulsory and rest of the activities can be planned to satisfy the PBL hours mentioned in the syllabus.
3. The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
4. Minimum 03 activities shall be covered per subject.
5. Rubrics for the evaluation can be prepared by the faculty.

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