# 5th Semester Syllabus

| INFRASTRUCTURE ECONOMICS, PROJECT MANAGEMENT AND ENTREPRENEURSHIP | | | |
|---|---|---|---|
| Course Code: | 1BIF501 | Scheme | 2025 |
| Type of Course | HSMC | Semester | V |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90 (42:0:0:48) | SEE Marks | 50 |
| Credits | 03 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

1. CO1 (L2-Understand): Explain the basic principles, materials, and systems of prestressed concrete.
2. CO2 (L3-Apply): Analyze prestressed members for flexure, shear, and torsion using stress and load balancing.
3. CO3 (L3-Apply): Calculate losses in pre-stress and deflections in prestressed concrete members.
4. CO4 (L4-Analyze): Design prestressed concrete beams for serviceability and ultimate limit states.
5. CO5 (L5-Evaluate): Evaluate applications, anchors, and prestressed concrete sections in sustainable prestressed structures like bridges, promoting material efficiency and durability.

**Module-1**

**Infrastructure Economics:**

- Principles of engineering economics: time value of money, interest rates (simple/compound), depreciation methods (straight line, sinking fund).
- Micro/macro analysis in infrastructure: roads, bridges, role in GDP growth.
- Benefit-cost ratio (BCR), NPV, IRR for projects; breakeven analysis; sensitivity analysis.
- Case studies: highway vs. railway economics, public-private partnerships (PPP) in India.
- Statutory requirements: environmental clearances, land acquisition costs.

**Linked COs: CO1.** **Number of Hours (CI) = 8 hrs.**

**Module-2**

**Project Management Fundamentals:**

- Construction project formulation: scope management, work breakdown structure (WBS), project life cycle phases.
- Management functions: planning, organizing, staffing, directing, controlling; project organization types (matrix, functional). Bar charts, milestone charts; roles of civil engineers in teams.
- Introduction to MS Project/Primavera software. Case studies: building vs. infra projects.

**Linked COs: CO1, CO2.** **Number of Hours (CI) = 8 hrs.**

**Module-3**

**Planning & Scheduling (CPM/PERT):**

- Network diagrams: activity on arrow (AOA), activity on node (AON); critical path method (CPM) - forward/backward pass, floats (total, free).
- PERT: probabilistic times (optimistic, pessimistic, most likely), standard deviation, project variance.
- Resource leveling, crashing; updates and monitoring.
- Gantt charts to CPM conversion.
- Software applications.

**Linked COs: CO2, CO3.** **Number of Hours (CI) = 8 hrs.**

**Module-4**

**Resource, Cost & Risk Management:**

- Resource management: labor productivity factors, equipment selection (excavators, cranes - ownership/operating costs).
- Quality control: ISO 9001, TQM; safety norms (PPE, OSHA).
- Risk identification, analysis (Monte Carlo), mitigation in infra projects. Cost estimation: unit rates, quantity takeoff; value engineering.
- Labor laws, statutory wages.

**Linked COs: CO3, CO4.** **Number of Hours (CI)= 8 hrs.**

**Module-5**

**Contracts, Entrepreneurship & Finance:**

- Procurement: tenders, contracts (lump sum, item rate); FIDIC clauses, disputes (arbitration).
- Entrepreneurship: MSME definition, role in economy; schemes (KIADB, KSFC, SIDBI); project reports - techno-economic feasibility.
- Financing: banks, venture capital; SWOT for civil startups (prefab infra).
- Sustainable practices: green financing.

**Linked COs: CO4, CO5.** **Number of Hours (CI) = 10 hrs.**

**Suggested Learning Resources:**

**Text books:**

1. Chitkara, K.K., Construction Project Management: Planning, Scheduling and Control, Tata McGraw-Hill Publishing Company, New Delhi (covers CPM/PERT, planning).
2. P C Tripathi and P N Reddy, Principles of Management, Tata McGraw-Hill Education (management functions, entrepreneurship).
3. Poornima M. Charantimath, Entrepreneurship Development and Small Business Enterprise, Pearson Education (MSME, project reports).

**Reference Books:**

1. S.C. Sharma & S.V. Deodhar, Construction Engineering & Management, Khanna Publishers (project formulation, resources).
2. Chris Hendrickson, Project Management for Construction (online: https://pmbook.ce.cmu.edu), Prentice Hall (economics, scheduling).
3. Frank Harris & Ronald McCaffer, Modern Construction Management, Wiley-Blackwell (cost/risk management).
4. IS 7272 (CPM/PERT guidelines), NBC 2016 (infra codes).

**Web links and Video Lectures (e-Resources):**

1. VTU Resource: 18CV51 Construction Management & Entrepreneurship syllabus (vturesource.com).
2. NPTEL: Construction Project Management (IIT Madras) - nptel.ac.in
3. NPTEL: Project Management (covers CPM/PERT, risks).

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.
Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:** The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks.**

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**
A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.
In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**
It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**
**Students' Learning activities:** These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**
As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW) and Self Learning (SL) components in**

**Number of Hours per semester**

**Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)**

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | **Project Feasibility Portfolio:** Prepare a detailed economic feasibility study for an infrastructure project (e.g., road/bridge). Include NPV, IRR, BCR calculations, cash flow diagrams, sensitivity analysis, and risk considerations with a short report. | 24 |
| 2 | **Infrastructure Economics Case Study Portfolio:** Analyze a real infrastructure project (e.g., metro/PPP project), focusing on financing models, economic viability, sustainability aspects, and risk assessment; present findings through a seminar/report. | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | **MOOC + Project Management Track**: Complete NPTEL/MOOC modules on Construction/Project Management (CPM/PERT, risk, cost management) and solve application-based problems. | 24 |
| 2 | **Literature Review & Reflective Journal**: Review emerging tools (MS Project, Primavera, risk analysis tools), PPP models, entrepreneurship case studies, and maintain a reflective learning journal. | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

1. **Sample Rubrics - Infrastructure Project Feasibility / Case Study Mini-Project**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Conceptual Understanding | Accurate principles (e.g., NPV, IRR, PPP models), precise CO1-CO2 links, SDG 9 terms. | Mostly correct, minor misuse. | Partial gaps/misuse. | 20% |
| Coverage (CO1-CO5) | All aspects (finance, risks, PPP, sustainability, entrepreneurship) fully addressed. | Most parts covered. | Some parts only. | 20% |
| Logical Clarity | Well-organized flow with economic charts (cash flows, sensitivity), professional. | Readable with basic structure. | Confusing or unclear. | 15% |
| Analysis Depth | Insightful evaluation (risks, feasibility, CO3-CO5), checks assumptions quantitatively. | Adequate explanations. | Descriptive/superficial. | 25% |
| Visuals & Organization | Neat graphs (NPV/IRR/BCR), real refs, clear layout (CO2-CO4). | Some visuals, acceptable organization. | Poor or absent visuals. | 10% |
| Innovation/Sustainability | Creative green finance/entrepreneurship ideas, strong SDG 9/11/13 linkage. | Basic inclusion of sustainability. | No linkage/innovation. | 10% |

Continuous Internal Evaluation (CIE):

(i) The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii) Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE:

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| SOIL MECHANICS AND FOUNDATION ENGINEERING | | | |
|---|---|---|---|
| Course Code | 1BIF502 | Scheme | 2025 |
| Type of course | Integrated Professional Core Courses (IPCC) | Semester | V |
| Teaching Hours/Week (L:T:P) | 70 (3:0:2 ) | CIE Marks | 50 |
| Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL | 120 (42:0:28:50) | SEE Marks | 50 |
| Credits | 4 | Total Marks | 100 |
| Type of Examination (IPCC): | Theory- CIE +SEE, and Lab- CIE only. | Exam Hours | 03 |

**Course outcome (Course Skill Set):**

At the end of the course, the student will be able to:

- CO1 (L2 -- Understand): Explain soil classification systems, index properties, and phase relationships relevant to civil engineering applications and infrastructure development.
- CO2 (L3 -- Apply): Apply principles of permeability, seepage, and effective stress to analyze flow through soils and pressure distribution in earth structures.
- CO3 (L4 -- Analyze): Analyze compaction and consolidation behavior of soils to evaluate settlement and predict time-dependent deformation in foundations and embankments.
- CO4 (L4 -- Analyze): Analyze shear strength parameters and slope stability for safe design of embankments, cuts, and earth-retaining structures.
- CO5 (L3 -- Apply): Apply bearing capacity theories and foundation design principles to select and proportion shallow and deep foundations for various structural systems.

**Module-1**

**Soil Formation, Classification and Index Properties**

- Origin and Formation of Soils: Rock cycle, weathering processes (physical, chemical, biological), transported and residual soils, soil deposits in India.
- Phase System and Relationships: Three-phase diagram representation, definitions and relationships of water content (w), void ratio (e), porosity (n), degree of saturation (S), specific gravity (G), unit weights (bulk, dry, saturated, submerged), numerical problems.
- Grain Size Analysis: Sieve analysis for coarse-grained soils, sedimentation (hydrometer) analysis for fine-grained soils, particle size distribution curves, coefficient of uniformity (Cu), and coefficient of curvature (Cc).
- Atterberg Limits: Liquid limit (Casagrande and cone penetration methods), plastic limit, shrinkage limit, plasticity index, liquidity index, consistency index, activity of clays.
- Soil Structure and Clay Minerals: Structure of coarse-grained and fine-grained soils, single-grained, honeycomb and flocculated structures, types of clay minerals (kaolinite, illite, montmorillonite) and their influence on engineering properties.
- Soil Classification Systems: Indian Standard (IS:1498) classification system, Unified Soil Classification System (USCS) – awareness level, plasticity chart, application in infrastructure planning.

**CO linkage: CO1.** **Number of Hours (CI ): 9 hours**:

**Module-2**

**Fluid Kinematics & Dynamics:**

- Permeability and Darcy's Law: Definition, coefficient of permeability (k), Darcy's law – assumptions and validity, typical values of k for different soil types, factors affecting permeability.
- Laboratory Determination of Permeability: Constant head permeability test (for coarse-grained soils), falling head permeability test (for fine-grained soils), sample calculations.
- Seepage through Soils: One-dimensional and two-dimensional flow, Laplace equation (qualitative understanding), flow nets and their properties.
- Flow Nets: Construction of flow nets (graphical method), applications to seepage beneath sheet pile walls, dams, and weirs, determination of seepage quantity and uplift pressure.
- Effective Stress Principle: Total stress, pore water pressure, and effective stress concept (Terzaghi's principle), effective stress in different soil conditions (dry, saturated, submerged, capillary zone).

**CO linkage: CO2.** **Number of Hours (CI ): 9 hours**

**Module-3**

**Compaction and Consolidation**

- Soil Compaction: Objectives and importance, factors affecting compaction (water content, soil type, compactive effort, method of compaction).
- Laboratory Compaction Tests: Standard Proctor test and Modified Proctor test, compaction curve (dry density vs water content), optimum moisture content (OMC), maximum dry density (MDD), effect of compactive effort.
- Field Compaction Control: In-situ density tests – sand replacement method, core cutter method.
- Effect of Compaction: Influence on shear strength, permeability, compressibility, and settlement behavior.
- One-Dimensional Consolidation: Primary and secondary consolidation, Terzaghi's theory of one-dimensional consolidation (concept only – no detailed derivation), assumptions.
- Consolidation Test: Oedometer test procedure, e-log p curve, determination of pre-consolidation pressure (Casagrande's method), over-consolidated and normally consolidated clays.
- Consolidation Parameters: Compression index (Cc), recompression index (Cr), coefficient of volume compressibility (mv), coefficient of consolidation (Cv).
- Settlement Analysis: Calculation of primary consolidation settlement for foundations and embankments, time rate of consolidation, degree of consolidation (U), average degree of consolidation, time factor (Tv).
- Pre-consolidation and Settlement Mitigation: Methods to reduce settlement – preloading, surcharging, vertical drains (sand drains, PVD – concepts).

**CO linkage: CO3.** **Number of Hours (CI ): 8 hours**

**Module-4**

**Shear Strength and Slope Stability**

- Mohr's Circle and Stress Analysis: Construction of Mohr's circle, determination of principal stresses, failure envelope, determination of shear strength parameters.
- Total Stress and Effective Stress Analysis: Total stress parameters (cu, φu) and effective stress parameters (c', φ'), drained and undrained conditions.
- Laboratory Shear Strength Tests: Direct shear test – procedure and applications, unconfined compression test for cohesive soils, triaxial compression test – types (UU, CU, CD tests – concepts and applications), vane shear test. Sensitivity and thixotropy.
- Stability of Slopes: Types of slope failures (rotational, translational, flow slides), factors affecting slope stability, stability analysis methods.
- Infinite Slopes: Stability analysis of infinite slopes in cohesionless and cohesive soils (c-φ soils), with and without seepage, factor of safety calculations.
- Finite Slopes: Stability analysis by method of slices – Swedish circle method (qualitative understanding), Bishop's simplified method (use of charts), Taylor's stability charts.
- Slope Failures in Infrastructure: Causes of slope failures (rainfall, seepage, earthquakes, improper construction), case studies, preventive and remedial measures (drainage, slope flattening, retaining structures, soil reinforcement).

**CO linkage: CO4.** **Number of Hours (CI ): 8 hours**

**Module-5**

**Bearing Capacity and Foundation Design**

- Introduction to Foundations: Functions of foundations, classification of foundations (shallow vs deep), types of shallow foundations (isolated footings, combined footings, strip footings, raft/mat foundations).
- Bearing Capacity Concepts: Ultimate bearing capacity (qu), net bearing capacity (qnu), safe bearing capacity (qs), allowable bearing pressure, factor of safety.
- Terzaghi's Bearing Capacity Theory: Assumptions, bearing capacity equations for strip, square, and circular footings (general shear failure), bearing capacity factors (Nc, Nq, Nγ), numerical applications.
- Settlement of Shallow Foundations: Immediate settlement, consolidation settlement, total settlement calculations, allowable settlement criteria.
- Introduction to Deep Foundations: Pile foundations – types (driven piles, bored piles, cast-in-situ piles), classification based on load transfer (end-bearing, friction, combination), concept of pile capacity, pile

groups (concepts only).

- Ground Improvement Techniques: Need for soil improvement, mechanical stabilization (compaction, preloading, surcharging, vibro-compaction), admixture stabilization (cement, lime, fly ash stabilization), stone columns, geosynthetics in foundation engineering.
- Geosynthetics in Infrastructure: Types of geosynthetics (geotextiles, geogrids, geomembranes, geocomposites), functions and applications in reinforcement, separation, filtration, and drainage.

**CO linkage: CO5** **Number of Hours (CI ): 8 hours**

**PRACTICAL COMPONENTS OF IPCC**

**PART – A: FIXED SET OF EXPERIMENTS**

1. Determination of water content by oven-drying method and rapid moisture meter method.
2. Determination of specific gravity of soil.
3. Grain size distribution by sieve analysis.
4. Determination of Atterberg limits – Liquid limit (Casagrande apparatus and cone penetration method) and Plastic limit.
5. In-situ density determination by core cutter method and sand replacement method.
6. Determination of coefficient of permeability – Constant head test (for coarse-grained soils) and Falling head test (for fine-grained soils).
7. Standard Proctor compaction test for determination of OMC and MDD.
8. Consolidation test (one-dimensional consolidation).
9. Direct shear test for determination of shear strength parameters.
10. Unconfined compression test for cohesive soils and laboratory vane shear test

**PART – B: OPEN ENDED EXPERIMENTS**

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem Statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. **Concept 1:** Comparison of compaction characteristics of different soil types (sandy, silty, clayey) and effect on engineering properties (strength, permeability, settlement potential) – relevance to sustainable construction (SDG 9, SDG 11).
2. **Concept 2:** Investigation of effect of stabilizing agents (cement, lime, fly ash) on strength and plasticity of weak soils – desk-based feasibility analysis for soil improvement**.**
3. **Concept 3:** Analysis of bearing capacity variation with depth of foundation and water table position using data from plate load tests or SPT correlations.
4. **Concept 5:** Field visit to construction site for observation of geotechnical investigation methods (boring, sampling, SPT) and preparation of soil profile report**.**

**Suggested Learning Resources**

**Text Books**


1. Murthy, V.N.S. -- Soil Mechanics and Foundation Engineering, UBS Publishers and Distributors, New Delhi.
2. Gopal Ranjan and Rao, A.S.R. -- Basic and Applied Soil Mechanics, New Age International (P) Ltd., New Delhi.
3. Punmia, B.C., Jain, A.K., and Jain, A.K. -- Soil Mechanics and Foundations, Laxmi Publications, New Delhi.


**Reference Books / Manuals**


1. Das, Braja M. -- Principles of Geotechnical Engineering, Cengage Learning.
2. Das, Braja M. -- Principles of Foundation Engineering, Cengage Learning.
3. Arora, K.R. -- Soil Mechanics and Foundation Engineering, Standard Publishers Distributors.
4. Lambe, T.W. and Whitman, R.V. -- Soil Mechanics, John Wiley & Sons.
5. Bowles, J.E. -- Foundation Analysis and Design, McGraw-Hill.
6. IS:1498 -- Classification and Identification of Soils for General Engineering Purposes.
7. IS:2720 (Part I to Part XL) -- Methods of Test for Soils.
8. IS:6403 -- Code of Practice for Determination of Bearing Capacity of Shallow Foundations.

**Web links and Video Lectures (e-Resources):**

1. NPTEL courses on "Soil Mechanics" and "Foundation Engineering" (IITs/NITs) -- https://nptel.ac.in
2. SWAYAM platform -- Geotechnical Engineering courses
3. MIT Open Course Ware -- Advanced Soil Mechanics
4. YouTube channels: Civil Engineering Academy, The Constructor, Engineering Hub
5. Virtual labs for soil mechanics experiments -- http://civil-iitb.vlabs.ac.in

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Concept-oriented lectures with frequent physical interpretations and small in-class demonstrations.
2. Problem-solving sessions focused on civil-engineering-type examples (pipes, channels, water-supply and drainage).
3. Flipped-classroom segments for selected topics (e.g., Bernoulli applications, pipe systems, hydraulic jump) using pre-class videos and in-class collaborative problem solving.
4. Mini-projects and open-ended lab tasks that integrate SDG-6, SDG-11, SDG-13, Industry 5.0 (digital tools) and NEP 2020 emphasis on experiential, multidisciplinary learning.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks**.

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.

A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

**Students' activities for TW/SL under NCrF: Samples only:** As per National credit formwork (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/ Self learning (TW/Sl-50 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

| Term Work (TW) and Self Learning (SL) components in Number of Hours per semester | | |
|---|---|---|
| Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.) | | |
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| 1. | **Integrated Foundation Design Mini-Project (CO2, CO3, CO6):** Design a complete shallow foundation system (isolated/combined footing) for a given structure using bearing capacity analysis, settlement calculations, and soil investigation data. (SDG-6, SDG-11, SDG-13). | 25 |
| 2. | **Case Study Portfolio (CO3, CO4):** Prepare 3-4 case briefs on real geotechnical failures or successful projects (e.g., slope failures, foundation settlements, ground improvement) plus short reviews of 3-5 research papers/IS codes. | 25 |
| 3. | **Computational Analysis Workbook (CO5, CO6):** Build an Excel/MATLAB/Python workbook for soil mechanics and foundation problems (phase relationships, settlement analysis, bearing capacity calculations, slope stability). | 25 |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| 1. | **MOOC +GATE/Open- Book Track.:** Complete selected SM MOOC modules and GATE-style tests, plus at least one integrated Open-book exam on conceptual/design problems. | 25 |
| 2. | **Case Study & Literature Portfolio**: Prepare 3–4 case briefs on real Soil Mechanics and Foundation engineering systems/events plus short reviews of 3–5 Papers/standards (e.g., drainage, floods, water supply). | 25 |

| Performance Indicator | 4 – Excellent | 3 – Good | 2 – Fair | 1 – Needs Improvement |
|---|---|---|---|---|
| Problem understanding & SDG/NEP link (CO1, CO6) | Clear statement of system, objectives, constraints and explicit linkage to SDGs and NEP values. | Mostly clear; SDG/NEP link mentioned but not Deep. | Basic description; weak SDG/NEP connection. | Vague or incorrect description; no SDG/NEP link. |
| Use of fluid-mechanics concepts & calculations (CO2–CO4) | Correct methods; appropriate assumptions; consistent units and checks. | Minor errors; overall reasonable application. | Several errors; partial application of concepts. | Major conceptual errors; little use of theory. |
| Sustainability / resilience analysis (CO6) | Insightful discussion of options and their sustainability/resilience; Clear recommendations. | Some discussion with reasonable recommendations. | Limited or generic sustainability remarks. | No meaningful sustainability analysis. |
| Communication & teamwork (CO6) | Well-structured report/presentation; clear visuals; evidence of Balanced participation. | Generally clear; some imbalance/minor Issues. | Understandable but poorly structured or Dominated by few. | Disorganised; weak teamwork Evidence. |

Rubric – Mini-Project

| **Criterion** | **Exemplary (3)** | **Proficient (2)** | **Basic (1)** |
|---|---|---|---|
| Problem definition & scope | Clear objective; appropriate geotechnical problem selected (e.g., bearing capacity, settlement, slope stability); complete soil data, site conditions, and assumptions documented. | Objective mostly clear; minor gaps in soil data or assumptions. | Vague problem; key soil parameters, site details, or assumptions missing or inconsistent. |
| Fluid mechanics calculation s | correct and consistent application of soil mechanics principles (e.g., shear strength, consolidation, bearing capacity) with clear steps, formulas, and units. | Mostly correct calculations with minor non-critical errors; reasoning generally sound. | frequent conceptual or numerical errors; unclear or incorrect reasoning. |
| Design decisions & justification n | Foundation type (shallow/deep), dimensions, and soil improvement methods well-justified using analysis results and soil conditions. | Most design choices linked to results; some justification qualitative or brief | Design choices arbitrary or unsupported by analysis. |
| Documentation & reflection | Well-structured report with clear tables/figures; insightful reflection on design limitations, assumptions, and real-world implications. | Report understandable but uneven; reflection brief or descriptive. | Disorganized report; little or no reflection on learning. |

Suggested rubrics for Practical continuous assessment:

| **Performance Indicators** | **Excellent** | **Very Good** | **Good** | **Satisfactory** |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output (3) | Student will be able to run the program but not able to analyze the output (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, and Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

## Continuous Internal Evaluation (CIE):

Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus. The remaining 10 marks shall be based on the practical test conducted by two internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

| Table – ICs/IPCCs 1 Distribution of marks | | |
|---|---|---|
| **Component** | **Description** | **Marks** |
| **Allotment of marks for regular class work** | | |
| Ability in Conducting Experiments | Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions. | 5 marks |
| Laboratory Record / Journal | Regular and neat maintenance of lab record, accuracy of results, and timely submission. | 10 marks |
| | **Subtotal** | **15** |
| **Allotment of marks for CIE practical test** | | |
| Laboratory Test / Experiment Performance | Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment. | 5 marks |
| Viva-Voce | Understanding of theory, concepts, and experimental procedure; Ability to explain results and answer related questions. | 5 marks |
| **Subtotal** | | **10** |
| **Total** | | **25** |

**Continuous Internal Evaluation (CIE)**

(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

**Passing requirement in SEE**

For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| DESIGN OF REINFORCED CONCRETE STRUCTURAL ELEMENTS | | | |
|---|---|---|---|
| Course Code | 1BIF503 | Scheme | 2025 |
| Type of Course | Profession Core Course (PCC) | Semester | V |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course Outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2 - Understand):** Explain the fundamental principles of limit state design philosophy, material properties, and design basis for reinforced concrete structures as per IS 456-2000.
2. **CO2 (L3 - Apply):** Analyze and design singly reinforced, doubly reinforced, and flanged beam sections for flexure considering limit state of collapse and serviceability requirements.
3. **CO3 (L4 - Analyze):** Evaluate and design reinforced concrete beams for shear, bond, torsion, and deflection control incorporating appropriate reinforcement detailing.
4. **CO4 (L5 - Evaluate):** Design compression members including short and slender columns subjected to axial loads, uniaxial and biaxial bending with proper reinforcement arrangement.
5. **CO5 (L3 - Apply):** Apply design principles for one-way and two-way slabs, staircases, and isolated footings with appropriate reinforcement detailing as per IS code provisions.
6. **CO6 (L4 - Analyze/Evaluate):** Assess structural safety, durability requirements, and sustainable design practices in reinforced concrete construction aligned with SDG 9, SDG 11, and SDG 13.

**Module-1**

**Design philosophy, materials and flexural analysis**

- Introduction to reinforced concrete structures - advantages, limitations and applications in modern infrastructure.
- Properties of concrete - characteristic compressive strength, stress-strain relationship, modulus of elasticity, creep, shrinkage and their effects on structural behavior.
- Properties of reinforcing steel - characteristic strength, stress-strain curves for mild steel and high-strength deformed bars (Fe 415, Fe 500, Fe 550), modulus of elasticity.
- Design philosophies - working stress method (WSM) vs limit state method (LSM); limitations of WSM and advantages of probabilistic design approach.
- Limit state design concepts - limit state of collapse (flexure, compression, shear, torsion), limit state of serviceability (deflection, cracking); characteristic loads and strengths, partial safety factors for loads and materials as per IS 456-2000.
- Assumptions in limit state of collapse for flexure - plane sections remain plane, maximum strain in concrete and steel, stress block parameters, neutral axis depth limits for balanced, under-reinforced and over-reinforced sections.
- Analysis of singly reinforced rectangular sections - determination of moment of resistance, analysis for given section and reinforcement, failure modes (balanced, tension failure, compression failure).

**Linked COs: CO1, CO2, CO6** **Number of Hours Required (CI): 11 hours**

**Module-2**

**Design of flexural members - beams**

- Design of singly reinforced rectangular beam sections for limit state of collapse in flexure - design for given moment, effective depth calculation, area of steel reinforcement, checks for minimum and maximum reinforcement.
- Analysis and design of doubly reinforced rectangular sections - need for compression reinforcement, analysis for moment of resistance, design for given moment, limiting values of reinforcement.
- Flanged beams - T-beams and L-beams, effective width of flange as per IS 456-2000, isolated T-beam vs T-beam in monolithic construction.
- Analysis of T-beam and L-beam sections - determination of neutral axis position (case 1: NA in flange, case 2: NA in web), moment of resistance calculation.
- Design of T-beam and L-beam sections - design procedure for given moment, determination of reinforcement in tension and compression zones, checks for minimum and maximum steel.
- Reinforcement detailing in beams - spacing of bars, clear cover requirements, curtailment and anchorage of reinforcement, development length, standard hooks and bends.

**Linked COs: CO2, CO6** **Number of Hours Required (CI): 11 hours**

**Module-3**

**Shear, bond, torsion and serviceability**

- Limit state of collapse in shear - shear strength of concrete ($\tau c$), factors affecting shear strength, design shear strength as per IS 456-2000.
- Design of shear reinforcement - vertical stirrups, inclined stirrups, minimum shear reinforcement, maximum spacing of stirrups, design procedure for shear.
- Bond and anchorage - development length concept, bond stress, anchorage requirements for different types of bars, lap splices in tension and compression.
- Torsion in beams - torsional moments, equivalent shear force, design for combined shear and torsion, reinforcement for torsion (longitudinal and transverse).
- Limit state of serviceability - control of deflection, short-term and long-term deflection, span-to-depth ratios as per IS 456-2000, modification factors for tension reinforcement and compression reinforcement.
- Control of cracking - crack width calculation, maximum spacing of reinforcement for crack control, side face reinforcement in deep beams, distribution steel.

**Linked COs: CO3, CO6** **Number of Hours Required (CI): 11 hours**

**Module-4**

**Design of compression members - columns**

- Types of compression members - short columns and slender columns, effective length concept, slenderness ratio, classification based on slenderness ratio as per IS 456-2000.
- Short axially loaded columns - minimum and maximum reinforcement limits, minimum number of longitudinal bars, minimum column dimensions, design of axially loaded short columns (rectangular and circular sections).
- Columns with uniaxial bending - interaction diagrams, analysis and design of rectangular columns subjected to axial load and uniaxial moment, use of SP-16 design charts and interaction curves.
- Columns with biaxial bending - analysis and design using interaction curves, simplified methods for biaxial bending (Bresler's load contour method - awareness level).
- Design of lateral ties and helical reinforcement - spacing requirements, diameter of ties, pitch of helical reinforcement, requirements as per IS 456-2000.
- Slender columns - additional moments due to slenderness, moment magnification method, design considerations for slender columns (qualitative treatment).
- Reinforcement detailing in columns - arrangement of longitudinal bars, corner bars, intermediate bars, lap length, splicing of bars, confinement requirements.

**Linked COs: CO4, CO6** **Number of Hours Required (CI): 11 hours**

**Module-5**

**Design of slabs, staircases and foundations**

- One-way slabs - difference between one-way and two-way slabs, effective span, design for simply supported and continuous one-way slabs, distribution of loads, determination of bending moments and shear forces.
- Design procedure for one-way slabs - effective depth, main reinforcement and distribution reinforcement, check for deflection and cracking, detailing of reinforcement.
- Two-way slabs - load distribution in two-way slabs, supported on four edges with various edge conditions (simply supported, continuous, fixed), analysis using IS 456 moment coefficients.
- Design of two-way slabs - determination of moments in both directions, calculation of reinforcement, curtailment of bars, torsion reinforcement at corners, checks for serviceability.
- Design of staircases - types of staircases (spanning longitudinally, spanning transversely, dog-legged, open-well), loading on stairs, analysis and design of typical staircase configurations, detailing of reinforcement.
- Isolated footings - types of footings, distribution of soil pressure, design of rectangular and square footings for axial loads and moments, depth for shear (one-way and two-way action), bending reinforcement, development length and anchorage, plain concrete pedestals.
- Reinforcement detailing - IS 456 requirements for slabs (minimum reinforcement, maximum spacing, edge reinforcement), staircases (distribution steel, anchorage at supports), and footings (top and bottom reinforcement arrangement).

**Linked COs: CO5, CO6** **Number of Hours Required (CI): 11 hours**

**Suggested Learning Resources**

**Textbooks:**


1. Varghese, P.C. (2014). Limit State Design of Reinforced Concrete (3rd ed.). PHI Learning.
2. Pillai, S.U., & Menon, D. (2018). Reinforced Concrete Design (4th ed.). McGraw Hill Education.
3. Ramamrutham, S., & Narayan, R. (2017). Design of Reinforced Concrete Structures. Dhanpat Rai Publishing Company.
4. Jain, A.K., & Jain, A. (2019). Reinforced Concrete - Limit State Design (7th ed.). Nem Chand and Bros.


**Reference Books:**


1. Syal, I.C., & Goel, A.K. (2015). Reinforced Concrete Structures (4th ed.). A.H. Wheeler and Company.
2. Unnikrishna Pillai, S., & Devdas Menon. (2009). Reinforced Concrete Design (3rd ed.). Tata McGraw-Hill.
3. Reinforced Concrete Designers Handbook by C.E. Reynolds and J.C. Steedman.
4. Dayaratnam, P. (2004). Design of Reinforced Concrete Structures. Oxford and IBH Publishing.

**Indian Standard Codes:**

1. IS 456:2000 - Plain and Reinforced Concrete - Code of Practice (with all amendments).
2. IS 875 (Part 1 to 5):1987 - Code of Practice for Design Loads (other than earthquake) for Buildings and Structures.
3. IS 13920:2016 - Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.
4. SP 16:1980 - Design Aids for Reinforced Concrete to IS 456:1978 (updated for IS 456:2000).

**Web Links and Video Lectures (e-Resources):**

1. NPTEL Course: "Design of Reinforced Concrete Structures" by Prof. Devdas Menon, IIT Madras - https://nptel.ac.in
2. NPTEL Course: "Reinforced Concrete Road Bridges" by Prof. Atul Kumar, IIT Roorkee - https://nptel.ac.in
3. SWAYAM Courses on Concrete Technology and RCC Design - https://swayam.gov.in
4. IS Code Repository and Design Handbooks - Bureau of Indian Standards (BIS) - https://www.bis.gov.in
5. Concrete Design Software Tutorials - STAAD.Pro, ETABS (demonstration and practice).

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching- learning process and facilitate the achievement of course outcomes.
Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:**
The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**..

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity

**Students' Activities for TW/SL under NCrF: Samples Only**

As per National Credit Framework (NCrF), students must spend 90 hours of study for 3 credit courses, which include Course Instructions (CI - 42 hours) and Teamwork/Self Learning (TW/SL - 48 hours). Hence, students must complete two activities as part of NCrF under CCA, which carries 25 marks. The evaluations of these activities will be done using a set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours/ Semester |
|---|---|---|
| 1. | **Complete Design of Residential Building Frame**:Design and detail a typical frame from a residential building including beams, columns, slab, staircase and footing with complete design calculations, reinforcement detailing drawings and bill of quantities. | 24 |
| 2. | **Industrial Visit and Technical Report** :Visit to construction site/precast facility to observe RCC construction practices, formwork systems, reinforcement detailing, concrete placement and quality control; prepare comprehensive technical report with photographs, observations and learning outcomes. | 24 |
| 3. | **Software-based Design Project** :Complete design of a simple RCC structure (residential/commercial building) using structural analysis and design software (STAAD.Pro/ETABS/SAP2000) with modeling, analysis, design and detailing documentation. | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | **MOOC + GATE/Data- Driven Track**: Complete mapped NPTEL/MOOC modules, solve GATE-style and open-ended analysis problems involving probability and statistics in civil engineering, culminating in an integrated open-book test. | 24 |
| 2. | Literature review on emerging tools; reflective learning journal | 24 |

**A. Rubrics for Students Learning Activities - TW/SL (Samples)**

**1. Complete Design of RCC Structural Element - Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| **Problem formulation and load calculation (CO1, CO2)** | Accurately identifies all loads (dead, live, seismic/wind where applicable) with proper load combinations as per IS 875 and IS 456; assumptions clearly stated with justification. | Identifies major loads with minor omissions; load combinations mostly correct; some assumptions not clearly justified. | Incomplete load identification; incorrect load combinations; assumptions missing or unjustified. | 20% |
| **Analysis and design calculations (CO2, CO3, CO4, CO5)** | All design steps systematic and correct; proper application of IS 456 provisions; uses appropriate design aids (SP-16); checks for all limit states (collapse and serviceability); calculations neat and organized. | Design procedure mostly correct with minor computational errors; most IS 456 provisions applied correctly; some serviceability checks missing; calculations adequately organized. | Significant errors in design procedure; incorrect application of code provisions; serviceability checks largely missing; disorganized calculations. | 30% |
| **Reinforcement detailing and drawings (CO2, CO3, CO4, CO5)** | Complete reinforcement details with proper bar spacing, clear cover, development length, anchorage and splicing as per IS 456; drawings neat, to scale, with all necessary views and dimensions; follows IS drawing standards. | Reinforcement details mostly complete with minor omissions; drawings adequate with some missing dimensions or views; generally follows drawing standards. | Incomplete reinforcement details; critical detailing aspects missing; drawings poorly drawn, not to scale or missing essential information. | 25% |
| **Code compliance and safety (CO1, CO6)** | All designs strictly comply with IS 456:2000 provisions; minimum and maximum limits verified; adequate safety margins demonstrated; sustainability and durability considerations included. | Generally complies with IS 456 with minor deviations; most limits checked; adequate safety; limited consideration of sustainability. | Poor code compliance; critical limits not checked; inadequate safety margins; no consideration of sustainability or durability. | 15% |
| **Presentation and documentation (CO6)** | Professionally presented with clear problem statement, design calculations, detailing drawings, and bill of quantities; proper references to IS codes; organized and easy to follow. | Adequately presented with main components present; some organizational issues; references mostly complete. | Poorly presented; disorganized; missing key components; inadequate or no references. | 10% |

**Continuous Internal Evaluation (CIE):**

(i) The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii) Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

(i) For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

(ii) For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

(iii) If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| CONCRETE TECHNOLOGY | | | |
|---|---|---|---|
| Course Code | 1BIF504 | Scheme | 2025 |
| Type of Course | Profession Core Course (PCC) | Semester | V |
| Teaching Hours/Week(L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type(SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2 -- Understand):** Relate material characteristics and their influence on microstructure of concrete.
2. **CO2 (L4 – Analyze):** Distinguish concrete behaviour based on its fresh and hardened properties.
3. **CO3 (L4 – Analyze):** Illustrate proportioning of different types of concrete mixes for required fresh and hardened properties using professional codes
4. **CO4 (L3 – Apply, L4 – Analyze):** Apply mix design principles for designing concrete mixes suitable for various infrastructure applications using IS: 10262-2019 and international methods.
5. **CO5 (L3 – Apply, L4 – Analyze**): Select a suitable type of concrete based on specific application.

**Module-1**

**Concrete Ingredients:**

- Cement manufacturing process, chemical composition and their importance, hydration of cement, types of cement. Testing of cement, steps to reduce carbon footprint.
- Fine aggregate: Functions, requirement, Alternatives to River sand, M-sand introduction, and manufacturing.
- Coarse aggregate: Importance of size, shape and texture. Grading and blending of aggregate. Testing on aggregate, requirement. Recycled aggregates Water – qualities of water.
- Chemical admixtures – plasticizers, accelerators, retarders, and air entraining agents.
- Mineral admixtures –Pozzolanic and cementitious materials, Fly ash, GGBS, silica fumes, Metakaolin and rice husk ash.

**Linked COs: CO1, partial CO3, CO4** **Number of Hours Required (CI): 8 hrs**

**Module-2**

**Fresh Concrete:**

- Factors affecting workability. Measurement of workability–slump, Compaction factor and Vee-Bee
- Consistometer tests, flow tests. Segregation and bleeding.
- Process of manufacturing of concrete- Batching, Mixing, Transporting, Placing and Compaction. Curing – Methods of curing – Water curing, membrane curing, steam curing, accelerated curing, self- curing. Good and Bad practices of making and using fresh concrete and Effect of heat of hydration during mass concreting at project sites.

**Linked COs: CO2, partial CO3, CO4** **Number of Hours Required (CI): 8 hrs**

**Module-3**

**Hardened Concrete:**

- Factors influencing strength, W/C ratio, gel/space ratio, Maturity concept, testing of hardened concrete,
- Creep –factors affecting creep.
- Shrinkage of concrete – plastic shrinking and drying shrinkage, Factors affecting shrinkage. Definition and significance of durability. Internal and external factors influencing durability,
- Mechanisms- Sulphate attack – chloride attack, carbonation, freezing and thawing. Corrosion,
- Durability requirements as per IS-456,
- In situ testing of concrete- Penetration and pull-out test, rebound hammer test, ultrasonic pulse velocity, core extraction – Principal, applications and limitations.

**Linked COs: CO3, partial CO4,CO5** **Number of Hours Required (CI): 8 hrs**

**Module-4**

**Concrete Mix Design:**

- Principles of concrete mix design, Parameters and factors influencing mix design, Concept of Mix Design with
- and without admixtures, variables in proportioning and Exposure conditions, Selection criteria of ingredients
- Used for mix design, Procedure of mix proportioning. Numerical Examples of Mix Proportioning using IS-10262:2019

**Linked COs: CO4 CO3,** **Number of Hours Required (CI): 9 hrs**

**Module-5**

**Special Concretes:**

- RMC-manufacture and requirement as per QCI-RMCPCS, properties, advantages, and disadvantages. Self-Compacting concrete- concept, materials, tests, properties, application and typical mix
- Fiber reinforced concrete- types of fibres, properties, application of FRC. Light weight concrete-material properties and types.
- Typical light weight concrete mix proportion and applications, materials, requirements, mix proportion and properties of Geo polymer Concrete, High Strength Concrete and High-Performance Concrete.

**Linked COs: CO3, CO4, CO5** **Number of Hours Required (CI): 9 hrs**

**Suggested Learning Resources**

**Textbooks:**

1. Neville A.M. “Properties of Concrete”-4th Ed., Longman.
2. M.S. Shetty, Concrete Technology - Theory and Practice Published by S. Chand and Company, New Delhi.
3. Kumar Mehta. P and Paulo J.M. Monteiro “Concrete-Microstructure, Property and Materials”, 4th Edition, McGraw Hill Education, 2014
4. A.R. Santha Kumar, “Concrete Technology”, Oxford University Press, New Delhi (New Edition).

**Reference Books:**

1. M L Gambir, “Concrete Technology”, McGraw Hill Education, 2014.
2. N. V. Nayak, A. K. Jain Handbook on Advanced Concrete Technology, ISBN: 978-81-8487-186-9
3. Job Thomas, “Concrete Technology”, CENGAGE Learning, 2015.
4. IS 4926 (2003): Code of Practice Ready-Mixed Concrete [CED 2: Cement and Concrete] Criteria for RMC Production Control, Basic Level Certification for Production Control of Ready Mixed Concrete- BMTPC.
5. Specification and Guidelines for Self-Compacting Concrete, EFNARC, Association House.

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

Suggested Innovative Delivery Methods may include(but are not limited to):

- Flipped Classroom
- Problem-Based Learning(PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**..

**Continuous Comprehensive Assessments (CCA)+Internal Assessment Test (IA)= Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Course Project
- Case Study Presentation
- Literature Review
- Seminars/Quizz (To assist in GATE Preparations)
- Demonstrations in Lab
- Virtual Lab Experiments
- Self Study on simple topics
- Simple problems solving using Excel
- Assignment(at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farm work (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW)and Self Learning (SL)components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours/Semester |
|---|---|---|
| 1. | **Material Testing Portfolio:** Test 5 cement samples (fineness, consistency, setting time) + 3 aggregate samples (sieve analysis, specific gravity). Compare with IS 4031 specs. | 24 |
| 2. | **Case Study Analysis:** Analyze failure of Padma Bridge concrete deck (cracking issues). Propose 3 repair strategies using FRP/ geo polymer overlays. | 24 |
| 3. | **Literature Review:** Review 5 recent papers on UHPC for high-speed rail viaducts from Science Direct. Summarize mix design trends. | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours/Semester |
|---|---|---|
| 1. | **MOOC + GATE/Data- Driven Track**: Complete mapped NPTEL/MOOC modules, solve GATE-style and open-ended analysis problems involving probability and statistics in civil Engineering, culminating in an integrated open-book test. | 24 |
| 2. | Literature review on emerging tools; reflective learning journal | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

**1.Sample Rubrics-Integrated Design Mini-Project**

| Criterion | Exemplary(3) | Proficient(2) | Basic(1) | Weight |
|---|---|---|---|---|
| **Problem Identification** | Clear infrastructure problem with 3+ case studies & literature support | Defined problem with 2 case studies | Basic problem statement | 15% |
| **Methodology & Innovation** | Novel mix design/NDT method with lab validation | Standard method with minor innovation | Basic testing procedures | 35% |
| **Results & Analysis** | Statistical analysis + sustainability metrics | Basic graphs + observations | Raw data only | 35% |
| **Report & Presentation** | Professional format, error-free, 15-min demo | Good format, minor errors | Basic report | 15% |

**Continuous Internal Evaluation (CIE):**

(i) The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
(ii) Out of 50marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

(i) For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
(ii) For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
(iii) If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

# Professional Elective Course –I Syllabus

| SUSTAINABLE DESIGN CONCEPTS FOR BUILDING SERVICES AND INFRASTRUCTURE | | | |
|---|---|---|---|
| Course Code | 1BIF505A | Scheme | 2025 |
| Type of Course | Profession Elective Course (PEC) | Semester | V |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

**At the end of the course, the student will be able to:**

1. **CO1 (L2 -- Understand):** Explain the principles of sustainable development, green building concepts, and the role of building services in achieving environmental goals aligned with SDG 6, 7, 9, 11, 12 and 13.
2. **CO2 (L3 -- Apply):** Design energy-efficient HVAC systems incorporating passive design strategies, renewable energy integration, and thermal comfort principles for sustainable buildings and infrastructure.
3. **CO3 (L3 -- Apply):** Apply sustainable water management strategies including rainwater harvesting, grey water recycling, low-flow fixtures, and storm water management in building and infrastructure projects.
4. **CO4 (L3 -- Apply):** Design energy-efficient electrical systems integrating renewable energy sources, smart controls, efficient lighting, and building automation for sustainable infrastructure.
5. **CO5 (L4 -- Analyze):** Evaluate buildings and infrastructure using green rating systems (LEED, GRIHA, IGBC) and perform life cycle assessment to quantify environmental impacts and sustainability benefits.
6. **CO6 (L5 -- Evaluate/Create):** Integrate sustainable building services with infrastructure planning, assess carbon footprint, and propose holistic solutions for resilient and sustainable built environment in line with Net Zero targets.

Module-1

**Introduction to sustainable design and green buildings**

- Sustainable development -- definition, principles, three pillars (environmental, economic, social); role of construction industry in sustainability; global environmental challenges -- climate change, resource depletion, energy crisis.
- Green building movement -- evolution, benefits, global and Indian context; key concepts -- embodied energy, operational energy, carbon footprint, life cycle thinking.
- Site selection and planning -- sustainable site criteria, site preservation, heat island mitigation, storm water management; influence of climate on building design -- climatic zones of India, sun path, wind patterns.
- Building envelope design -- orientation, shading devices, thermal insulation, cool roofs; passive design strategies for energy efficiency.
- Building services -- introduction to mechanical, electrical, and plumbing (MEP) systems; role of MEP in sustainable buildings; integrated design approach.

**Linked COs: CO1,** **Number of Hours: 08**

Module-2

**Sustainable HVAC systems and thermal comfort**

- Heat transfer in buildings -- conduction, convection, radiation through building envelope; heat load calculations -- internal loads, solar heat gain, and ventilation loads (qualitative approach).
- HVAC system types -- centralized vs decentralized systems; air conditioning systems -- window AC, split AC, VRF, chilled water systems, district cooling (overview).
- Energy-efficient HVAC design -- high-efficiency equipment, variable speed drives, heat recovery systems, demand-controlled ventilation; ECBC (Energy Conservation Building Code) provisions for HVAC.
- Renewable energy for HVAC -- solar thermal systems for water and space heating; solar cooling technologies; geothermal heat pumps (awareness level).
- Building automation and controls -- BMS (Building Management System), sensors, smart thermostats; energy management strategies.

**Linked COs: CO2, CO3, CO6** **Number of Hours: 08**

Module-3

**Sustainable water supply, plumbing and drainage systems**

- Water resources and conservation -- global and Indian water scenario; water footprint of buildings; strategies for water conservation in buildings and infrastructure.
- Water-efficient fixtures and fittings -- low-flow faucets, showerheads, dual-flush toilets, sensor-based fixtures; waterless urinals; water use reduction calculations.
- Rainwater harvesting (RWH) -- principles, components (catchment, conveyance, storage, and filtration); design considerations -- rainfall data, catchment area, storage tank sizing; rooftop and surface RWH systems; recharge wells and percolation pits.
- Grey water recycling -- sources of grey water, treatment methods (physical, biological), reuse applications (toilet flushing, irrigation, cooling tower makeup); system design considerations.
- Hot water systems -- solar water heaters (flat plate, evacuated tube collectors), heat pump water heaters; efficient hot water distribution -- insulated piping, recirculation systems.
- Plumbing material selection -- eco-friendly pipes (CPVC, PEX, HDPE), lead-free fittings; water quality considerations

**Linked COs: CO1, CO2, CO4, CO6.** **Number of Hours:09**

Module-4

**Sustainable electrical systems and renewable energy integration**

- Energy-efficient lighting -- LED technology, luminous efficacy, colour temperature, CRI; daylight integration -- daylight factor, light shelves, skylights; lighting controls -- occupancy sensors, daylight sensors, dimming systems.
- Renewable energy systems for buildings -- solar photovoltaic (PV) systems: components (modules, inverters, mounting, BOS), grid-tied vs off-grid systems, net metering; small wind turbines (awareness); biomass and biogas systems (overview).
- Smart electrical systems -- smart meters, real-time energy monitoring, demand response; integration with building automation; IoT in energy management.
- Electrical safety and sustainability -- low-voltage DC distribution; energy-efficient motors and drives; reduction of electromagnetic interference
- Energy storage systems -- batteries (lithium-ion, lead-acid), charge controllers; integration with renewable systems; backup power solutions

**Linked COs: CO2, CO5, CO6.** **Number of Hours:09**

Module-5

**Green rating systems, LCA and sustainable infrastructure**

- Detailed green rating systems -- LEED: categories (sustainable sites, water efficiency, energy, materials, indoor environmental quality, and innovation); GRIHA: criteria structure (site planning, water, energy, materials, and indoor environment); IGBC rating systems for different building types.
- Documentation and certification process -- design phase vs built phase certification; role of professionals (architect, MEP consultant, commissioning agent); case studies of LEED/GRIHA certified buildings in India.
- Life Cycle Assessment (LCA) -- concept, system boundary, functional unit; LCA phases (goal and scope, inventory analysis, impact assessment, interpretation); embodied energy and embodied carbon of materials.
- Sustainable materials -- low-carbon cement, fly ash concrete, recycled materials, bamboo, compressed earth blocks; local materials and transportation impacts; green product certifications.
- Waste management in construction -- construction and demolition (C&D) waste; waste reduction, reuse, and recycling strategies; on-site waste management planning.
- Resilient infrastructure -- climate adaptation, flood resilience, heat wave mitigation; linkage to SDG 6 (clean water), SDG 7 (clean energy), SDG 9 (resilient infrastructure), SDG 11 (sustainable cities), SDG 12 (responsible consumption), SDG 13 (climate action)

**Linked COs: CO1, CO5, CO6.** **Number of Hours:08**

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Lechner, Norbert. Heating, Cooling, and Lighting: Sustainable Design Methods for Architects. John Wiley & Sons.
2. Tiwari, G.N. and Mishra, R.K. Advanced Renewable Energy Sources. RSC Publishing.
3. Emmanuel, Rohinton. An Urban Approach to Climate-Sensitive Design. Routledge.
4. GRIHA Manual Vol. 1 and Vol. 2. GRIHA Council, India

**Reference books / Manuals:**

1. Santamouris, M. Energy and Climate in the Urban Built Environment. James & James.
2. ECBC (Energy Conservation Building Code) -- Bureau of Energy Efficiency, Government of India.
3. SP 41 (S&T): 1987 -- Handbook on Functional Requirements of Buildings (other than industrial buildings). Bureau of Indian Standards.
4. IS 15902:2010 -- Splitting Tensile Strength of Concrete -- Method of Test. Bureau of Indian Standards
5. LEED Reference Guide for Building Design and Construction. U.S. Green Building Council.
6. Thomas Randall and Hootman, Tom. The EDRA Guide to Net-Zero Energy Buildings. Island Press

**Web links and Video Lectures (e-Resources):**

1. NPTEL courses on Sustainable Architecture and Energy Efficient Buildings.
2. Bureau of Energy Efficiency (BEE) -- https://beeindia.gov.in
3. GRIHA Council -- https://www.grihaindia.org
4. Indian Green Building Council (IGBC) -- https://igbc.in
5. U.S. Green Building Council (USGBC) LEED resources -- https://www.usgbc.org
6. Solar Energy Centre, MNRE -- https://solarenergy.mnre.gov.in

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Interactive lectures.
2. Problem-based learning.
3. Case studies of green buildings.
4. Flipped classroom.
5. Guest lectures from industry professionals (green building consultants, LEED APs).
6. Tutorials on rating systems and calculations.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

**Suggested Learning Activities may include (but are not limited to):**

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | Assignments on green building design, energy calculations, water system design; mini-projects on MEP system integration; | 24 |
| 2. | Case study analysis of certified green buildings; industrial visits to LEED/GRIHA certified projects; | 24 |
| 3. | Seminar and presentations. | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | NPTEL/SWAYAM courses on sustainable design; self-initiated project exploring local sustainable building; | 24 |
| 2. | software tutorials (Sketch Up, RET Screen, ECBC compliance tools); | 24 |
| 3. | Literature review on emerging technologies; reflective learning journal | 24 |

**A. Rubrics for Students learning activities -TW/SL - (Samples)**

**1 Green Building Design Project -- Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Problem definition & project scope | Clear project definition with complete building data (type, area, location, climate); all MEP systems scoped with sustainability goals | Mostly clear; minor data gaps or incomplete system definition | Vague or incomplete; key building parameters or systems missing | Problem definition & project scope |
| Sustainable design strategies (Modules 1-5) | Comprehensive integration of passive design, energy-efficient HVAC, water conservation, renewable energy, and sustainable materials with proper justification | Most strategies covered with reasonable justification; minor gaps in integration | Strategies mentioned but poorly justified; weak integration across systems | Sustainable design strategies (Modules 1-5) |
| Calculations and technical analysis | Accurate calculations for energy loads, water demand, RWH tank sizing, solar PV capacity; proper use of ECBC guidelines and rating system criteria | Generally correct calculations; a few minor errors; most technical aspects covered | Frequent calculation errors or major omissions; inadequate technical depth | Calculations and technical analysis |
| Green rating system application | Correct identification and documentation of applicable LEED/GRIHA credits with point calculations and supporting evidence | Most credits identified with minor documentation gaps | Limited credit analysis or incorrect application of rating criteria | Green rating system application |
| Report quality & sustainability metrics | Well-structured report with clear drawings, energy savings quantified, water savings calculated, carbon reduction estimated, cost-benefit analysis; excellent presentation | Acceptable structure and metrics; minor clarity issues; presentation adequate | Disorganized report; missing key metrics or drawings; weak presentation | Report quality & sustainability metrics |

**2. Energy Audit and Retrofit Analysis – Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Audit data collection | Comprehensive building data, utility bills analysis, equipment inventory, occupancy patterns documented with photos and measurements | Most data collected; minor gaps in documentation | Incomplete data; key information missing or not verified | 15% |

| | | | | |
|---|---|---|---|---|
| Energy consumption analysis | Detailed breakdown by end-use (HVAC, lighting, equipment); benchmarking against standards; identification of peak loads and inefficiencies | General analysis with some end-use breakdown; basic benchmarking | Limited analysis; weak or missing benchmarking | 25% |
| Retrofit recommendations | Specific, feasible recommendations covering HVAC upgrades, lighting retrofit, renewable integration, controls; prioritized by impact and feasibility | Multiple recommendations with general descriptions; basic prioritization | Few recommendations; vague descriptions; no prioritization | 30% |
| Cost-benefit analysis | Detailed cost estimates, energy savings calculations, simple payback period, NPV/IRR analysis; sensitivity analysis included | Basic cost and savings estimates; payback calculated; limited financial analysis | Weak or missing financial analysis; unrealistic assumptions | 20% |
| Communication and presentation | Professional report format; clear graphs and tables; executive summary; confident oral presentation | Acceptable format; presentation adequate | Disorganized; poor visual aids; weak presentation | 10% |

**Continuous Internal Evaluation (CIE)**

(i)The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii)Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks **(out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40** marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| GREEN BUILDING TECHNOLOGIES AND SUSTAINABLE INFRASTRUCTURE DEVELOPMENT | | | |
|---|---|---|---|
| Course Code | 1BIF505B | Scheme | 2025 |
| Type of Course | Profession Elective Course (PEC) | Semester | V |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90 (42:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1(L2–Understand):** Explain sustainability concepts, green building principles and the environmental impacts of buildings and infrastructure
2. **CO2 (L3 – Apply):** Identify and select green and sustainable materials and construction technologies for buildings and infrastructure projects.
3. **CO3 (L4 – Analyze):** Analyze global warming potential, embodied energy/carbon and life-cycle impacts of materials, components and building systems.
4. **CO4 (L3&L4 – Apply &Analyze):** Interpret and apply the basic framework of green building rating systems (LEED, IGBC, GRIHA, etc.) to assess building performance.
5. **CO5 (L3 – Apply):** Propose strategies for integrating renewable energy, water efficiency, waste management and urban green infrastructure in sustainable infrastructure development.

**Module-1**

**Sustainability, Green Buildings and Infrastructure**

- Concept of sustainability and sustainable development
- Global energy scenario, climate change, greenhouse gases and carbon footprint; contribution of construction and building sector to environmental degradation.
- Introduction to sustainable infrastructure and green buildings; objectives and need for green building and sustainable infrastructure development.
- Definitions and features of green buildings; environmental, economic, health and social benefits of green buildings and sustainable infrastructure.
- Overview of cost-effective and resource-efficient construction; linkage between cost-effective technologies and sustainability goals.

**Linked COs**: **CO1** **Number of Hours Required (CI)**: **8 hours**

**Module-2**

**Green and Sustainable Materials and Cost-Effective Building Technologies**

- Sustainable alternatives to conventional materials: low-carbon binders and blended cements, supplementary cementitious materials (fly ash, GGBS, calcined clays).
- Recycled aggregates, industrial by-products, construction and demolition waste utilization in concrete, masonry and road works.
- Stabilized earth blocks, laterite blocks, bamboo and other natural fibres; polymer composites and fibre-reinforced sustainable materials.
- Concept of cost-effective construction: use and availability of stone, burnt bricks, concrete blocks, stabilized mud blocks, lime-pozzolana cements, gypsum boards, lightweight sections and green composites.
- Environment friendly and cost-effective technologies: Flemish and rat-trap bonds, cavity walls, arches, precast wall and roof panels, filler slabs, composite beam-panel roofs and pre-engineered building elements.
- Environmental issues related to extraction, processing and transportation of building materials; sustainable sourcing and certification of materials.

**Linked COs: CO1, CO2, CO3** **Number of Hours Required (CI): 9 hours**

**Module-3**

**Life-Cycle Assessment, Energy and Carbon in Buildings**

- Life Cycle Assessment (LCA) concepts and stages
- Embodied energy and embodied carbon in building materials and components; operational versus embodied impacts.
- Carbon accounting, greenhouse gas emission factors

- Material efficiency and circular economy concepts; reuse, recycling, design for disassembly and adaptability in building/infrastructure design.
- Comparison of conventional versus sustainable materials and systems using LCA and performance indicators (qualitative and simple quantitative illustrations only).

**Linked COs: CO1 & CO3** **Number of Hours Required (CI): 8 hours**

**Module-4**

**Green Building Rating Systems and Sustainable Design Strategies**

- Principles of sustainable building design: site planning, orientation, climate responsive design, daylighting, natural ventilation and passive thermal comfort concepts.
- Overview of major international rating systems: BREEAM, LEED, GREEN STAR – purpose, key categories and high level criteria.
- Indian rating systems for buildings and campuses: IGBC, GRIHA – structure, key highlights, point/weightage system (awareness level).
- Integration of sustainable materials, water efficiency, energy efficiency, indoor environmental quality and waste management in rating frameworks.
- Role of national codes and policies: National Building Code, Energy Conservation Building Code, relevant green building guidelines and local bylaws (awareness level).

**Linked COs: CO1, CO2, CO4 & CO5.** **Number of Hours Required (CI): 8 hours**

**Module-5**

**Emerging Green Technologies and Sustainable Urban Infrastructure**

- Utility of solar energy in buildings: overview of active (PV, solar water heaters) and passive (solar passive heating/cooling) strategies; low-energy cooling concepts; case studies of solar passive buildings.
- Energy-efficient materials and systems: high-performance glazing, cool roofs, insulation materials, shading devices and daylighting technologies (overview only).
- Green composites and geosynthetics for buildings and infrastructure; role in durability, resource efficiency and environmental performance.
- Water utilization and conservation in buildings and infrastructure: low-energy approaches to water supply and distribution, rainwater harvesting, efficient fixtures, reuse of greywater and treated sewage
- Urban environment and green infrastructure: urban heat island, green cover, open spaces, permeable surfaces, blue-green infrastructure and their integration with green buildings; linkages to SDG 6, 7, 9, 11 and 13 (qualitative)

**Linked COs: CO2, CO3, CO5** **Number of Hours Required (CI): 9 hours**

**Suggested Learning Resources Textbooks:**

1. Harhara Iyer G., Green Building Fundamentals, Notion Press.
2. Dr. Adv. Harshul Savla, Green Building: Principles & Practices.
3. IGBC Green New Building Rating System – Version 3.0, Abridged Reference Guide.
4. GRIHA Council, the Sustainable Habitat Handbook (GRIHA Version 2019).

**Reference Books:**

1. National Building Code 2016, Vol. 1 & 2, Bureau of Indian Standards.
2. Energy Conservation Building Code 2017 (with amendments), Bureau of Energy Efficiency

**Web links and e-Resources:**

- NPTEL: Green Buildings – IIT Roorkee.
- NPTEL: Sustainable Construction Materials – IIT Madras.
- NPTEL: Life Cycle Assessment – IIT Bombay.
- NPTEL: Energy Efficient Buildings – IIT Kharagpur.
- Curated YouTube lectures on green buildings, rating systems and passive design (e.g., links similar to those in the reference syllabi).

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.
Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:**
The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks.**
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks.**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | **Green building / campus case study**: Visit/virtual audit of a green-rated or sustainable campus/building; document key features, energy/water strategies | 24 |
| 2. | **Sustainable material / tech application note**: Comparative note on conventional vs sustainable material/technology used in a real project | 24 |
| 3. | **Integrated green design mini-project:** Team-based conceptual design of a small green building or streetscape with basic calculations and rating mapping | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | **MOOC + GATE/Data- Driven Track**: Complete mapped NPTEL/MOOC modules, solve GATE-style and open-ended analysis problems involving probability and statistics in civil Engineering, culminating in an integrated open-book test. | 24 |
| 2. | Literature review on emerging tools; reflective learning journal | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

**1. Sample Rubrics -Integrated Design Mini-Project**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Problem definition & data | Clear, relevant civil-engineering question; data source and Limitations documented. | Mostly clear; minor gaps in context or data description. | Vague question or poorly documented data. | 10% |
| Data processing & descriptive statistics | Correct cleaning, visualization, and computation of key measures; patterns clearly highlighted. | Mostly correct; minor computational/formatting errors. | Significant errors, missing key measures or plots. | 25% |
| Probabilistic modelling (distributions, inference) | Appropriate distributions and tests used; assumptions stated; results interpreted in context. | Reasonable choice of models; some assumptions implicit; interpretation mostly sound. | Inappropriate or poorly justified models; limited interpretation. | 30% |

| | | | | |
|---|---|---|---|---|
| Civil engineering insight / risk framing | Clear link to design/assessment decisions, safety and uncertainty; limitations discussed. | Some discussion of implications; limited treatment of limitations. | Minimal civil-engineering interpretati on beyond numbers. | 20% |
| Report & communication | Well-structured report, clear figures/tables, reproducible calculations; effective brief presentation. | Acceptable structure; some clarity issues; presentation adequate. | Disorganised or incomplete report; weak presentation. | 15% |

**Continuous Internal Evaluation (CIE):**

(i) The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii) Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| URBAN MASS TRANSIT INFRASTRUCTURE SYSTEMS | | | |
|---|---|---|---|
| Course Code | 1BIF505C | Scheme | 2025 |
| Type of Course | Professional Elective Course (PEC) | Semester | V |
| Teaching Hours/Week(L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type(SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2 – Understand)**: Identify and Explain urban mass transit systems, planning processes, and infrastructure components.
2. **CO2 (L3 – Apply):** Analyze travel demand modeling, surveys, and capacity assessment for transit systems
3. **CO3 (L3 – Apply):** Design mass transit infrastructure like alignments, stations, and integration with urban land use
4. **CO4 (L3 – Apply)**: Evaluate operations, scheduling, and economic aspects of transit systems including BRTS and Metro.
5. **CO5 (L4 – Analyze):** Assess sustainable transit solutions, ITS applications, and policy frameworks for Indian cities.

**Module-1**

**Urban Transit Planning:**

- Urbanization trends, class groups, transit problems identification, impacts on economy/environment. Urban transport planning process, modeling techniques.
- Mass transit needs in India: BRTS, Metro rails; capacity concepts; merits/comparison of systems; public-private coordination.

**Linked COs: CO1, CO2, CO4, CO5** **Number of Hours Required (CI): 8 hrs**

**Module-2**

**Mass Transit Systems:**

- Types: Public (bus/rail), para-transit, rapid transit (LRT/MRT); travel demand characteristics.
- Infrastructure overview: Tracks, signaling, rolling stock; case studies (Bengaluru Metro, Ahmedabad BRTS).

**Linked COs: CO2, CO3, CO4, CO5** **Number of Hours Required (CI): 8 hrs**

**Module-3**

**Demand Modeling & Surveys:**

- Trip generation/distribution: Zonal/category analysis, gravity models (numerical); OD surveys.
- Modal split, traffic assignment (all-or-nothing, capacity restraint); screen line analysis for corridors.

**Linked COs: CO3, CO4, CO5** **Number of Hours Required (CI): 8 hrs**

**Module-4**

**Infrastructure Design**

- Alignments, stations/terminals design; vertical/horizontal geometry for elevated/underground systems.
- Integration with land use: TOD principles; corridor identification, network coding.

**Linked COs: CO1, CO2, CO4, CO5** **Number of Hours Required (CI): 9 hrs**

**Module-5**

**Operations & Sustainability:**

- Routing/scheduling, performance metrics (headway, load factor); fleet management.[2]
- ITS applications, economic evaluation (CBA); sustainable policies, NMT integration, urban goods movement
-

**Linked COs: CO1, CO2, CO4, CO5** **Number of Hours Required (CI): 9 hrs**

**Suggested Learning Resources**

**Textbooks:**


1. Kadiyali, L.R., Traffic Engineering and Transportation Planning, Khanna Publishers, New Delhi
2. Hutchinson, B.G., Introduction to Urban System Planning, McGraw-Hill Education
3. Khisty, C.J., Transportation Engineering – An Introduction, Prentice-Hall
4. Papacostas, C.S., Fundamentals of Transportation Planning, Tata McGraw-Hill
5. Sharma, S., Urban Transport in India: A Comprehensive Review, Springer Publications


**Reference Books**:


1. Mayer, M. and Miller, E., Urban Transportation Planning: A Decision-Oriented Approach, McGraw-Hill
2. Bruton, M.J., Introduction to Transportation Planning, Hutchinson of London
3. Dickey, J.W., Metropolitan Transportation Planning, Tata McGraw-Hill
4. Cervero, R., The Transit Metropolis: A Global Inquiry, Island Press
5. Litman, T., Transportation Demand Management: Strategies and Tactics, Victoria Transport Policy Institute
6. Banister, D., Sustainable Transport: Planning for 21st Century, Routledge


**Web links and e-Resources:**

1. NPTEL Courses on Urban Transportation: https://onlinecourses.nptel.ac.in/
2. Sustainable Urban Mobility Plans (SUMP): https://www.sutp.org/
3. Smart City Mission – MoUD: https://smartcities.gov.in/

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.
Suggested Innovative Delivery Methods may include(but are not limited to):

- Flipped Classroom
- Problem-Based Learning(PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:**
The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**..

**Continuous Comprehensive Assessments (CCA)+Internal Assessment Test (IA)= Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Industrial Visit reports.
- Micro projects.
- Internship reports
- Field surveys for real time assessmentt
- Video analysis of transit analysis.
- Case Study Presentation
- Seminars/Quizz (To assist in GATE Preparations)
- Assignment(at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farm work (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW)and Self Learning (SL)components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours/Semester |
|---|---|---|
| 1. | **Transit Corridor Survey:** Groups conduct 2-4 hour manual/manual volume & OD survey at Mysuru BMTC bus stops/corridors; classify modes (bus, auto), record peak loads, analyze capacity gaps using Excel. | 24 |
| 2. | **Metro Alignment Design:** Design 5km elevated/underground Metro alignment for Mysuru urban corridor using IRC:SP:48; prepare cross-sections, station layouts in AutoCAD; evaluate geometrics & cost. | 24 |
| 3. | **BRTS Case Study:** Analyze Ahmedabad/Delhi BRTS success/failures; document infrastructure (stations, signals), ridership data; suggest Mysuru adaptations with sustainability metrics. | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours/Semester |
|---|---|---|
| 1. | **MOOC + GATE/Data- Driven Track**: Complete mapped NPTEL/MOOC modules, solve GATE-style and open-ended analysis problems involving probability and statistics in civil Engineering, culminating in an integrated open-book test. | 24 |
| 2. | Literature review on emerging tools; reflective learning journal. | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

**1. Sample Rubrics-Integrated Design Mini-Project**

| Criterion | Exemplary (4) | Proficient (3) | Basic (2) | Needs Improvement (1) | Weight |
|---|---|---|---|---|---|
| Data Collection | Comprehensive, systematic, full docs | Adequate, minor gaps | Limited, disorganized | Incomplete/missing | 20% |
| Technical Analysis | Accurate calcs, IRC correct | Mostly accurate, minor errors | Several errors | Wrong/incomplete | 25% |
| Engineering Interpretation | Insightful, multi-factor justification | Reasonable, partial justification | Descriptive, weak | No justification | 25% |
| Presentation/Docs | Professional, labeled, referenced | Generally organized | Minor clarity issues | Disorganized | 15% |

| | | | | | |
|---|---|---|---|---|---|
| Sustainability (SDG) | Explicit links (11,13) | General mentions | Minimal | None | 15% |

**Continuous Internal Evaluation (CIE):**

i. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

ii. Out of 50marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

iii. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

iv. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| SMART CITIES AND CIVIL INFRASTRUCTURE MANAGEMENT | | | |
|---|---|---|---|
| Course Code: | 1BIF505D | Scheme | 2025 |
| Type of course | Professional Elective Course (PEC) | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | Semester | V |
| Total Hours of Pedagogy per semester CI(L/T): LI (P): SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 03 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2 – Understand):** Explain the fundamental concepts, components, and frameworks of smart cities, including sustainable infrastructure, digital technologies, and urban resilience in line with India's Smart Cities Mission and global standards.
2. **CO2 (L3 – Apply):** Apply principles of smart mobility, intelligent transportation systems (ITS), and public transit planning to design solutions for urban transportation challenges and sustainable mobility networks.
3. **CO3 (L3 – Apply):** Integrate IoT, GIS, BIM, and data analytics technologies into civil infrastructure design and management for real-time monitoring and optimization of smart urban systems.
4. **CO4 (L4 – Analyze):** Analyze green building design, renewable energy systems, and environmental management strategies to develop sustainable and resilient urban infrastructure aligned with SDG 9, 11, and 13.
5. **CO5 (L3 – Apply):** Apply disaster management principles, climate adaptation strategies, and resilience frameworks to plan infrastructure that mitigates hazards and enhances urban safety.
6. **CO6 (L4 – Analyze/Evaluate):** Evaluate smart city project feasibility using project management tools, financial models, and governance frameworks considering social, economic, and environmental sustainability metrics.

**Module-1**

**Introduction to Smart Cities:**

- Definition, characteristics, and evolution of smart cities globally and in India
- India's Smart Cities Mission: objectives, scope, and achievements
- Core infrastructure elements: water supply, electricity, sanitation, solid waste management

**Smart City Components and Frameworks:**

- Pillars of smart cities: governance, infrastructure, economy, society, environment
- Role of Information and Communication Technology (ICT) in urban management
- Integrated Command and Control Centres (ICCCs): architecture, functions, and real-time data integration
- E-governance systems, citizen engagement platforms, and data-driven decision-making

**Urban Planning and Land Use:**

- Smart urban planning principles and strategies
- Resilience and sustainability in city planning
- Alignment with Sustainable Development Goals (SDG 9, 11, 13)
- Case studies: Smart city development in India (Pune, Indore, Surat) and globally

**Linked COs: CO1, CO6** **Number of Hours Required (CI):8 hours**

**Module-2**

**Smart Mobility and Transportation Systems**

**Basics of Urban Mobility and Transportation:**

- Urban mobility patterns, challenges, and sustainability considerations
- Public transit systems: types, capacity, and efficiency analysis
- Integrated mobility-as-a-service (MaaS) and multimodal transportation networks

**Intelligent Transportation Systems (ITS):**

- Components of ITS: sensors, communication networks, traffic management systems
- Real-time traffic monitoring and adaptive signal control
- Parking management systems and congestion pricing strategies
- Application of AI and machine learning in traffic prediction and optimization

**Smart Mobility Solutions:**

- Electric vehicles (EVs) and charging infrastructure planning
- Shared mobility systems and micromobility solutions (bikes, scooters)

- Non-motorized transport: walkability, cycling infrastructure, and pedestrian safety
- Last-mile connectivity and feeder services

**Linked COs: CO2, CO4, CO5** **Number of Hours Required (CI):8 hours**

**Module-3**

**Digital Technologies and Infrastructure Management**

**Internet of Things (IoT) and Sensor Networks:**

- IoT architecture and components in smart cities
- Sensor types: environmental, structural, traffic, utility monitoring sensors
- Wireless sensor networks (WSN) and communication protocols (5G, LoRaWAN)
- Real-time data collection and transmission systems

**Geospatial Information Systems (GIS) and Digital Twins:**

- GIS applications in urban planning and infrastructure mapping
- 3D modelling and spatial analysis for city planning
- Digital twins: creation, simulation, and virtual city management
- Geospatial data integration with IoT and BIM systems

**Building Information Modelling (BIM):**

- BIM fundamentals, principles, and workflows in smart building design
- 5D BIM: integration of cost, schedule, and sustainability parameters
- Smart building systems: HVAC automation, lighting control, energy management
- BIM applications in facility management and lifecycle costing

**Data Analytics and Artificial Intelligence:**

- Urban data analytics: collection, storage, and processing frameworks
- Predictive analytics for infrastructure maintenance and demand forecasting
- Machine learning applications in utility optimization and resource management
- Big data platforms and cloud computing in smart cities
- Cybersecurity considerations in smart infrastructure systems

**Linked COs: CO3, CO4, CO5** **Number of Hours Required (CI):8 hours**

**Module-4**

**Green Infrastructure and Environmental Sustainability**

**Water Management Systems:**

- Smart water supply systems: demand forecasting, leakage detection, and loss reduction
- Water treatment technologies: conventional and advanced treatment methods
- SCADA (Supervisory Control and Data Acquisition) systems for pipeline management
- Wastewater treatment, recycling, and reuse in urban areas
- Decentralized water systems and rainwater harvesting (qualitative overview)

**Solid Waste Management:**

- IoT-based waste collection and monitoring systems
- Segregation, processing, and disposal technologies
- Waste-to-energy conversion and circular economy principles
- Smart landfill operations and resource recovery

**Air Quality and Environmental Monitoring:**

- Air quality monitoring sensors and networks
- Pollution source identification and mitigation strategies
- Urban heat island effect and green cooling strategies
- Environmental impact assessment of urban infrastructure projects

**Green Infrastructure and Urban Spaces:**

- Green roofs, vertical gardens, and urban parks
- Urban forestry and tree canopy management
- Permeable pavements and stormwater management
- Biodiversity conservation in urban environments

**Climate Resilience and Sustainability Metrics:**

- Climate change impacts on urban infrastructure
- Urban heat island mitigation strategies
- Flood management and stormwater control systems
- Carbon footprint calculation and net-zero city concepts
- Linkage to SDG 6, 9, 11, 13, and 15

**Linked COs: CO4, CO1, CO5, CO6** **Number of Hours Required (CI):8 hours**

**Module-5**

**Smart Infrastructure Projects: Planning, Management, and Resilience**

**Smart Infrastructure Project Planning:**

- Needs assessment and demand forecasting for urban infrastructure
- Feasibility studies: technical, economic, social, and environmental analysis
- Cost-benefit analysis and financial modeling for smart projects
- Stakeholder analysis and participatory planning approaches

**Project Management Tools and Techniques:**

- MS Project and Primavera: scheduling, resource allocation, and cost tracking
- Gantt charts, PERT/CPM analysis for smart city projects
- Risk assessment and mitigation planning
- Quality management and performance monitoring frameworks

**Disaster Management and Urban Resilience:**

- Earthquake, flood, and cyclone impact on urban infrastructure
- Seismic zoning and hazard mapping (India context)
- Resilient infrastructure design principles
- Early warning systems and disaster response coordination
- Business continuity and recovery planning for critical infrastructure

**Linked COs: CO2, CO4, CO5, CO6** **Number of Hours Required (CI):10 hours**

**Suggested Learning Resources**

Text books:


1. Cisco. (2024). Smart Cities Connected Living – Leveraging Digital Technologies for Urban Development.
2. Lazaroiu, G. C., & Roscia, M. (2023). Smart Cities: Design, Building, and Management. Springer.
3. Albino, V., Berardi, U., & Dangelico, R. M. (2022). Smart Cities in Europe. Journal of Urban Technology, 22(2), 65-82.
4. Sharma, S. K., & Sharma, P. K. (2023). Smart Cities and Internet of Things. Academic Press India.


Reference Books:


1. Khosla, S. (2021). Smart City Development Framework – India Context. NITI Aayog Publication.
2. Townsend, A. M. (2020). Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia. W. W. Norton & Company.
3. Gehl, J. (2019). Life Between Buildings: Using Public Space. Island Press.
4. Hollands, R. G. (2020). Critical interventions into the corporate smart city. Cambridge Journal of Regions, Economy and Society, 8(1), 61-77.


**Web links and Video Lectures (e-Resources):**

1. NPTEL Course: Smart Cities – https://nptel.ac.in/courses/105106832
2. World Economic Forum – Smart Cities Initiative: https://www.weforum.org/
3. UN-Habitat – World Smart Cities Outlook: https://unhabitat.org/
4. India Smart Cities Mission: https://smartcities.gov.in/
5. IEEE Smart Cities: https://smartcities.ieee.org/
6. ISO/IEC 30182:2022 – Smart city definitions and concepts
7. OpenStreetMap for GIS learning: https://www.openstreetmap.org/
8. Coursera – Smart Cities and Urban Planning specialization

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom – Pre-class videos/notes; in-class discussion and mini design tasks.
- PBL – Group work on real urban problems (congestion, flooding, waste, etc.) with smart solutions.
- Case-Based Teaching – Analyze Indian and global smart city case studies.
- Simulation/Virtual Labs – Simple tools to model traffic, water, energy, or control systems.
- Industry Expert / Visits – Sessions by SPV/consultants and visits/virtual tours to ICCC or smart sites.
- ICT-Enabled Teaching – Use LMS, live dashboards, open data, online quizzes/polls.
- Role Play – Simulated stakeholder meeting for a smart-city project.

**Assessment Structure:** The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

**Course Project** – Mini smart-city intervention plan for a selected area (problem, data, smart solution, basic feasibility).

- **Case Study Presentation** – Group presentation on an Indian or global smart city / smart project.
- **Programming Assignment** – Simple data analysis of smart-city related data in Excel/Python/R (e.g., traffic, AQI, water).
- **Tool/Software Exploration** – Hands-on with GIS/BIM/project-management or dashboard tools, with brief technical note.
- **Literature Review** – Review of emerging smart-city topics (IoT, digital twins, AI in mobility, EV, SCADA, etc.).
- **Open Book Test** – Scenario-based, higher-order questions using smart-city data/policy documents.
- **GATE-based Aptitude Test** – GATE-style questions linked where possible to smart-city/civil contexts.
- **Assignment** – Analytical/reflective write-up comparing or critiquing smart-city initiatives.
- **Innovative Activity** – e.g., stakeholder role-play, campus smart-infrastructure audit, mini hackathon.
- **MOOCs / Online Platforms** – Completion of mapped NPTEL/MOOC modules with short reflection.

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI- 42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | Smart City Infrastructure Data Mini-Project: Collect or obtain a dataset related to smart city infrastructure (e.g., smart water meters, traffic sensor data, air quality sensors, energy consumption in buildings) and perform basic analysis and visualization. Prepare a short report linking the findings to smart city performance indicators such as mobility efficiency, resource optimization, or citizen services. | 24 |
| 2 | Smart Mobility / Green Infrastructure Case Study Portfolio: Prepare concise case studies on selected smart city initiatives such as intelligent transportation systems, EV charging networks, non-motorized transport corridors, smart water/waste systems, or green infrastructure projects in Indian or global cities, highlighting objectives, key technologies (IoT, ITS, GIS, BIM where relevant), implementation challenges, and outcomes in terms of sustainability, resilience, and SDG alignment. | 24 |
| 3 | Digital Tools and Platforms Workbook for Smart Cities: Develop a digital workbook using tools such as GIS software, simple BIM viewers, dashboards, or spreadsheet-based templates to document and analyze smart city components, including mapping of smart elements (sensors, green spaces, mobility hubs), basic project tracking sheets, simple performance or risk metrics, and reflections on how digital technologies support planning, monitoring, and decision-making in smart cities. | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | MOOC + GATE / Urban-Data Track: Complete mapped NPTEL/MOOC modules related to smart cities, urban infrastructure, or digital technologies (e.g., Smart Cities, Integrated Waste Management for a Smart City, IoT/Urban Planning). Solve GATE-style and application-oriented problems linked to smart mobility, water, waste, energy and resilience; culminate in a short open-book online test or reflection quiz. | 24 |
| 2 | Literature Review on Emerging Smart-City Tools + Reflective Learning Journal: Review recent literature and professional reports on emerging tools such as BIM, digital twins, IoT platforms, GIS-based dashboards, SCADA systems and AI for infrastructure management. Maintain a reflective journal connecting these tools to course modules (mobility, green infrastructure, disaster resilience, project management) and noting possible applications in Indian smart cities. | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

**Integrated Design Mini-Project**

**1. Sample Rubrics -Integrated Design Mini-Project**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Field data collection & coverage (smart infrastructure, sensors, green elements, mobility features) | Visits multiple representative sites; records smart city elements (IoT sensors, green spaces, traffic systems, EV stations) systematically with locations, dates, and functionality notes; safety considered. | Visits at least two sites; records main smart elements and some infrastructure features; minor gaps in documentation. | Limited sites or desk-based only; observations incomplete or unsystematic. | 10% |
| Technical description & accuracy (CO1, CO3) | Correct identification of smart city components (IoT, GIS markers, green roofs, ITS) and infrastructure; clear descriptions of technology, integration, condition using appropriate terms. | Mostly correct identification; minor misclassification or weak terminology, but intent is clear. | Frequent misidentification; very limited or incorrect terminology. | 25% |
| Engineering interpretation (mobility, resilience, resource mgmt) (CO2, CO4) | Clearly relates local smart infrastructure to mobility efficiency, climate resilience, resource optimization (water/waste/energy), and urban suitability; gives realistic qualitative comments. | Provides some links to mobility or resilience; comments partly relevant but not always well-justified. | Little/no engineering interpretation; mostly descriptive. | 30% |
| SDG linkage & reflection (SDG 9, 11, 13; CO6) | Explicitly connects observations to sustainable/resilient smart infrastructure (e.g., data-driven governance, climate adaptation, inclusive mobility) with thoughtful reflection. | Mentions sustainability or smart city issues briefly; links somewhat general. | No or very superficial mention of sustainability or resilience. | 20% |
| Portfolio organization & presentation | Well-structured document (or digital portfolio) with clear sections, labelled photos/figures, maps, system diagrams and references; language clear. | Generally organised; some missing labels or minor clarity issues. | Disorganised, hard to follow, photos/figures poorly labelled or missing. | 15% |

**Continuous Internal Evaluation (CIE):**

(i)The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii) Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| INTEGRATED SOLID WASTE MANAGEMENT AND INFRASTRUCTURE DESIGN | | | |
|---|---|---|---|
| Course Code | 1BIF505E | Scheme | 2025 |
| Type of Course | Professional Elective Course (PEC) | Semester | V |
| Teaching Hours/Week (L:T:P) | 3:0:0 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | 42:0:0:48 | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

**At the end of the course, the student will be able to:**

1. CO1 (L2 - Understand): Explain the sources, types, composition and generation mechanisms of solid waste in urban and infrastructure contexts, and relate them to statutory frameworks and SDG 11, SDG 12 and SDG 13.
2. CO2 (L3 - Apply): Design on-site storage, collection and transportation systems for municipal solid waste using optimization principles for routes, vehicles and transfer stations.
3. CO3 (L4 - Analyze): Analyze and evaluate waste processing technologies including composting, vermicomposting, anaerobic digestion, incineration, and pyrolysis and material recovery facilities for resource recovery and energy generation.
4. CO4 (L5 - Evaluate): Evaluate and design sanitary landfill systems including site selection, liners, leachate collection, gas management and closure plans in accordance with environmental regulations.
5. CO5 (L3 - Apply): Apply integrated solid waste management principles incorporating 3R concepts (Reduce, Reuse, Recycle) and develop waste management plans for infrastructure projects including smart cities, highways and industrial complexes.
6. CO6 (L4 - Analyze): Assess special waste streams including construction and demolition waste, biomedical waste, e-waste and hazardous industrial waste, and design appropriate treatment and disposal infrastructure.

Module-1

Introduction to solid waste management and regulatory framework

- Definition, classification and scope of solid waste management in urban infrastructure, industrial zones and smart city contexts.
- Global perspective on solid waste issues - challenges in developing vs. developed nations, circular economy concepts.
- Functional elements of integrated solid waste management - generation, handling and separation, storage, collection, transfer and transport, processing, resource recovery and disposal.
- Indian regulatory framework - Municipal Solid Waste Management Rules 2016, Construction and Demolition Waste Management Rules 2016, Plastic Waste Management Rules 2016, E-Waste Management Rules 2016, Biomedical Waste Management Rules 2016.
- Government initiatives - Swachh Bharat Mission, Smart Cities Mission, role of Urban Local Bodies (ULBs) and infrastructure development agencies.
- Sustainable development linkages - SDG 11 (Sustainable Cities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), role of waste management in resilient infrastructure.

**Linked COs: CO1, partial CO5, CO6** **Number of Hours: 09 Hrs**

Module-2

Waste generation, characterization and storage systems

- Sources of solid waste - residential, commercial, institutional, construction and demolition, street sweeping, industrial, agricultural and treatment plant residues.
- Types and engineering classification of solid waste - biodegradable, non-biodegradable, recyclable, hazardous, inert.
- Composition and characteristics - physical properties (moisture content, density, particle size distribution), chemical composition (proximate analysis, ultimate analysis, energy content, C:N ratio), biological characteristics (biodegradability, pathogen content).
- Waste generation rates - factors affecting generation (socio-economic status, seasons, festivals), per capita generation rates in Indian cities, prediction models and forecasting methods.
- On-site storage systems - types of containers (bins, dumpsters, compactors), materials used (plastic, metal, concrete), dual-bin system for source segregation.
- Processing at source - home composting, vermiculture pits, biogas plants, waste minimization strategies.

**Linked COs: CO1, CO2, partial CO5.** **Number of Hours: 08 Hrs**

Module-3

Collection, transfer and transportation infrastructure

- Principles of waste collection - primary and secondary collection, frequency of collection, collection crew size and productivity.
- Collection systems - house-to-house collection, community bin system, curbside collection, underground container systems, pneumatic collection systems in high-rise and smart city developments.
- Collection equipment and vehicles - handcarts, tricycles, tippers, compactors, hydraulic lifters, GPS-enabled vehicles for route monitoring.
- Design and analysis of collection systems - Hauled Container System (HCS) theory, design parameters, economic analysis; Stationary Container System (SCS) theory, design and comparison with HCS.
- Transfer stations - need and advantages, types (direct discharge, storage discharge), location selection using facility location models, design considerations (capacity, equipment, environmental controls), economic feasibility analysis.
- Transportation methods - open trucks, covered trucks, compactor trucks, containerized transport, rail and water transport for long-distance transfer.

**Linked COs: CO2, partial CO5.** **Number of Hours:08 Hrs**

Module-4

Waste processing and resource recovery technologies

- Waste processing objectives - volume reduction, resource recovery, energy generation, residue stabilization for safe disposal.
- Material Recovery Facilities (MRF) - design and operation, manual and automated segregation, conveyor systems, magnetic separators, air classifiers, quality control of recovered materials.

  Biological processing technologies:
- Composting - principles of aerobic decomposition, C:N ratio, moisture and temperature control; windrow composting, aerated static pile composting, in-vessel composting, mechanical composting plants; compost quality standards (FCO norms).
- Vermicomposting - vermiculture species, bed preparation, operational parameters, product quality and applications.
- Anaerobic digestion - principles, single-stage and two-stage digesters, biogas composition and purification, energy recovery potential, digestate management.

  Thermal processing technologies:
- Incineration - principles of combustion, types of incinerators (mass burn, modular, fluidized bed), energy recovery through waste-to-energy plants, air pollution control systems (scrubbers, filters, electrostatic precipitators), ash management.
- Pyrolysis and gasification - principles, operating conditions, product streams (char, oil, syngas), applications in waste-to-energy and chemical recovery.
- Chemical and mechanical processing - pelletization, densification, shredding, pulverization.

**Linked COs: CO3, partial CO5.** **Number of Hours:10 Hrs**

Module-5

Disposal infrastructure and integrated waste management systems

- Sanitary landfill design and operation:
  - Site selection - technical criteria (geology, hydrology, soil characteristics, topography), environmental criteria (proximity to settlements, water bodies, airports), social and economic factors, site screening and ranking methods.
  - Landfill types - area method, trench method, canyon method; bioreactor landfills for enhanced stabilization.
  - Leachate management - characterization, collection, treatment technologies (biological, physicochemical, membrane processes), recirculation in bioreactors.
  - Landfill gas management - composition, generation models, extraction systems, flaring, energy recovery through gas engines and turbines.
- Secure landfills for hazardous waste - design specifications, multiple liner systems, groundwater monitoring wells.
- Waste management plans for infrastructure projects:
  - Smart cities - decentralized waste processing, smart bins with sensors, real-time monitoring and optimization, citizen engagement through apps.
  - Highway projects - construction waste management, rest area waste facilities, bio-toilet waste management.
  - Industrial estates and SEZs - common waste treatment facilities, hazardous waste management, industrial symbiosis.

**Linked COs: CO4, CO5, CO6.** **Number of Hours: 08 Hrs**

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:


1. Tchobanoglous, G., Theisen, H., and Vigil, S. Integrated Solid Waste Management: Engineering Principles and Management Issues. McGraw-Hill Education.
2. Vesilind, P.A., Worrell, W., and Reinhart, D. Solid Waste Engineering. Cengage Learning.
3. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G. Environmental Engineering. McGraw-Hill Education.
4. Nemerow, N.L., and Dasgupta, A. Industrial and Hazardous Waste Treatment. Van Nostrand Reinhold.


Reference Books:


1. Central Public Health and Environmental Engineering Organisation (CPHEEO). Municipal Solid Waste Management Manual. Ministry of Urban Development, Government of India.
2. Gupta, S.K., and Vaidya, D.B. Solid Waste Management. Scientific Publishers.
3. IS 2490 (Part 1 to 4): Code of Practice for Solid Waste Management.
4. Bureau of Indian Standards codes on sanitary landfills and waste processing.
5. Municipal Solid Waste Management Rules, 2016 and other relevant environmental regulations.


Web links and Video Lectures (e-Resources):

1. NPTEL course: Municipal Solid Waste Management by IIT Guwahati / IIT Kharagpur.
2. NPTEL course: Integrated Waste Management for Smart Cities by IIT Roorkee.
3. NPTEL course: Solid Waste Engineering and System Design by IIT Kanpur.
4. Central Pollution Control Board (CPCB) website: https://cpcb.nic.in - Annual reports on solid waste management.
5. Swachh Bharat Mission portal: https://swachhbharatmission.gov.in
6. Ministry of Housing and Urban Affairs - Best practices and case studies.
7. World Bank Urban Development resources on waste management infrastructure.

Teaching-Learning Process (Innovative Delivery Methods):
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure:
The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the CIE, a student must score at least 40% of 50 marks, i.e., 20 marks.
- To pass the SEE, a student must score at least 35% of 50 marks, i.e., 18 marks.
- Notwithstanding the above, a student is considered to have passed the course, provided the combined total of CIE and SEE is at least 40 out of 100 marks.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted, carrying a total of 25 marks.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

It is recommended to include a maximum of two learning activities as part of the CCA to foster the holistic development of students. These activities shall be:

Students' Learning activities: These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Students' activities for TW/SL under NCrF: Samples only

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

| **Term Work (TW) and Self Learning (SL) components in Number of Hours per semester** | | |
|---|---|---|
| Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.) | | |
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| 1. | Develop comprehensive waste management plan for a real or hypothetical infrastructure project (smart city ward, highway, industrial park) covering generation estimates, collection system design, processing technology selection, disposal infrastructure and economic analysis with compliance to regulations. | 24 |
| 2. | Detailed comparative analysis of waste processing technologies (composting vs. anaerobic digestion vs. incineration vs. RDF) for a specific context, including technical, economic, environmental and social feasibility assessment with recommendations. | 24 |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| 1 | Self-learning modules on NPTEL/SWAYAM; completion of online certification courses. | 24 |
| 2 | Literature review on emerging technologies; reflective learning journal. | 24 |

**Rubrics for Students learning activities -TW/SL - (Samples)**

**1. Integrated Design Mini-Project – Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Data collection and waste characterization (CO1, CO2) | Comprehensive data on waste sources, generation rates with statistical analysis, composition analysis, seasonal variations; all relevant to project context. | Adequate data collected; generation rates estimated using standard methods; some gaps in characterization or seasonal analysis. | Limited or generic data; generation rates not specific to project; weak characterization. | 20% |
| Collection and transportation system design (CO2) | Detailed design with route maps, vehicle specifications, crew requirements, frequency schedule; route optimization demonstrated using appropriate methods; transfer station location justified. | Basic collection system design present; routes identified but limited optimization; vehicle and crew requirements estimated; transfer station considered. | Incomplete collection system; routes unclear or not optimized; missing key design elements. | 25% |
| Processing technology selection and justification (CO3) | Appropriate technologies selected with detailed technical, economic and environmental comparison; capacity calculations correct; resource recovery and energy generation quantified; aligns with waste characteristics. | Technology selection reasonable with basic justification; some technical calculations present; limited comparison of alternatives. | Technology selection not well justified; missing technical analysis or capacity calculations. | 25% |
| Disposal infrastructure and regulatory compliance (CO4, CO5) | Complete landfill or alternative disposal design with site selection criteria, engineering specifications; full compliance with Municipal Solid Waste Rules 2016 and other regulations demonstrated. | Basic disposal plan with landfill specifications; regulatory requirements mentioned but limited detail on compliance mechanisms. | Disposal plan superficial; regulatory compliance not adequately addressed. | 15% |
| Economic analysis and sustainability assessment (CO5, CO6) | Detailed cost-benefit analysis with capital and O&M costs, revenue projections; financial viability assessed; environmental benefits quantified; SDG linkages clearly articulated. | Basic economic analysis with cost estimates; some revenue considerations; sustainability mentioned with limited quantification. | Economic analysis missing or very superficial; no sustainability assessment. | 15% |

**Continuous Internal Evaluation (CIE)**

(i)The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii)Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| Smart Watershed Management and Urban Drainage Systems | | | |
|---|---|---|---|
| Course Code: | 1BIF505F | Scheme | 2025 |
| Type of Course | Profession Elective Course (PEC) | Semester | V |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90 (42:0:0:48) | SEE Marks | 50 |
| Credits | 03 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

1. CO1 (L2 – Understand): Explain fundamental concepts of watershed hydrology, hydrologic cycle, characteristics, and runoff processes.
2. CO2 (L3 – Apply): Apply hydrologic analysis methods for rainfall, abstractions, runoff estimation, and unit hydrographs in watershed and storm-water contexts.
3. CO3 (L3 – Apply): Design and analyze urban storm-water drainage systems, including minor/major components and regulations.
4. CO4 (L4 – Analyze): Analyze watershed management practices for soil conservation, water harvesting, erosion control, and planning.
5. CO5 (L5 – Evaluate): Evaluate modern tools like GIS, remote sensing, and modeling for watershed characterization and storm-water options.
6. CO6 (L5 – Evaluate): Assess integrated approaches to watershed-storm-water management, including case studies, water quality, flood control, and sustainability.

**Module-1**

**Introduction to watershed hydrology :**

- Definition of watershed and drainage basin; watershed classification and delineation; overview of major river basins and typical urban catchments.
- Components of the hydrologic cycle – precipitation, interception, infiltration, evapotranspiration, runoff and storage; water balance concept.
- Watershed characteristics – area, shape, slope, drainage density, land use.
- Land cover, soils and geology; qualitative effect on runoff response.
- Introduction to watershed development and management concepts; objectives, stakeholders and typical activities.

**Linked COs: CO1, CO2.** **Number of Hours (CI) = 8 hrs**

**Module-2**

**Hydrologic analysis for watershed and storm water design:**

- Rainfall data – types, consistency checking, averaging, mass curves; depth–area–duration and intensity–duration–frequency (IDF) relationships; design storms.
- Abstractions – interception, infiltration and initial losses (qualitative description and simple estimation).
- Runoff estimation methods: empirical formulas, Rational Method, time of concentration, runoff coefficients for different land uses.
- Concepts of hydrograph and unit hydrograph; SCS-CN method for event runoff estimation; basics of flood routing through channels and reservoirs (qualitative).

**Linked COs: CO1, CO2, CO5.** **Number of Hours (CI): 8 hours**

**Module-3**

**Urban hydrology and drainage systems:**

- Characteristics of urban catchments – imperviousness, reduced infiltration, quick response and changed runoff pattern; comparison with natural catchments.
- Minor drainage system: street gutters, inlets, lateral and trunk storm sewers; layout principles, design flow, velocity and gradient considerations.
- Major drainage system: open channels, roadside drains, culverts and outfalls; qualitative design criteria and capacity checks.
- Overview of storm water regulations and guidelines; concepts of design return period and acceptable level of service for urban drainage.

**Linked COs: CO2, CO3, CO5.** **Number of Hours (CI): 8 hours**

**Module-4**

**Watershed management practices:**

- Soil erosion – types and factors; qualitative description of sheet, rill and gully erosion; impacts on water and land resources.
- Soil and water conservation measures – contour bunds, check dams, terraces, vegetative measures and farm ponds (functional description and simple design ideas).
- Water harvesting and groundwater recharge structures – percolation tanks, recharge trenches and roof rainwater harvesting; selection criteria.
- Planning of watershed management activities – problem identification, prioritisation of sub-watersheds, participation and monitoring.

**Linked COs: CO2, CO3, CO4.** **Number of Hours (CI): 8 hours.**

**Module-5**

**Integrated watershed and storm water management:**

- Concept of integrated watershed management; surface water and groundwater interactions; conjunctive use of water resources.
- Storm water and flood management in watersheds – design flood, detention. Retention concepts, qualitative aspects of flood routing and reservoir operation.
- Water quality issues in watersheds and urban runoff – types and sources of pollution, simple indicators and control measures.
- Use of modern techniques – applications of GIS and remote sensing in watershed characterization, mapping, and selection of management measures; introduction to decision support systems and basic hydrologic modeling tools.
- Brief case studies of watershed and urban stormwater management projects from India and abroad.

**Linked COs: CO1, CO2, CO5, CO6.** **Number of Hours (CI): 10 hours**

**Suggested Learning Resources:**

**Text books:**


1. K. Subramanya, Engineering Hydrology, Tata McGraw-Hill, latest edition.
2. Madan Mohan Das and Mimi Das Saikia, Watershed Management, PHI Learning.
3. T.I. Eldho (NPTEL), Watershed Management – course material.


**Reference Books:**


1. Hydrology and the Management of Watersheds, Brooks et al.
2. Standard manuals and guidelines on watershed and stormwater management as recommended by national and international agencies.


**Web links and Video Lectures (e-Resources):**

1. NPTEL courses on Engineering Hydrology, Watershed Management and Urban Hydrology
2. Storm water Management (IITs).
3. NPTEL and other MOOC resources on Surface Water Hydrology and Watershed Hydrology.
4. Open-access manuals on watershed and flood management from agencies such as WMO.

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching- learning process and facilitate the achievement of course outcomes.

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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**Assessment Structure:** The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks.**
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks..**

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

| **Term Work (TW) and Self Learning (SL) components in Number of Hours per semester** | | |
|---|---|---|
| **Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)** | | |
| **Sl.No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| 1 | Watershed Characterization Min:-Project - Delineate a watershed using maps/GIS, analyse slope, land use, drainage, and interpret runoff response | 24 |
| 2 | Urban Stormwater Drainage Case Study : Study a real drainage problem (flooding/waterlogging), estimate runoff (Rational/SCS-CN), suggest improvements | 24 |
| 3 | GIS/Remote Sensing Tool Exercise : Use QGIS/ArcGIS for watershed mapping, land use classification and drainage planning | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | MOOC / NPTEL Learning Track : Complete modules on hydrology, watershed or urban drainage; solve application-based problems | 24 |
| 2 | Literature Review + Reflective Journal: Review recent watershed/drainage project (India/global) and write analytical summary | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

**2. Sample Rubrics - Watershed / Storm water Mini-Project Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Problem Definition & CO Mapping | Clear engineering problem with linkage to hydrology, drainage & sustainability | Mostly clear; partial linkage | Vague problem | 15% |
| Hydrologic Analysis | Accurate runoff estimation, hydrographs, watershed interpretation | Minor errors in application | Incorrect/limited understanding | 25% |
| Design / Drainage Solutions | Practical, justified engineering solutions | Reasonable but incomplete | Weak or unrealistic solutions | 25% |
| Use of Tools (GIS/RS/Data) | Effective use of GIS/maps/data visualization | Moderate use of tools | Minimal or incorrect use | 20% |
| Report & Presentation | Structured, clear, professional | Adequate | Poorly organized | 15% |

**Continuous Internal Evaluation (CIE):**

i. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

ii. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

iii. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

iv. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| CONCRETE AND HIGHWAY MATERIALS TESTING LABORATORY | | | |
|---|---|---|---|
| Course Code | 1BIFL507 | Scheme | 2025 |
| Type of Course | Professional Core Course (Laboratory) | Semester | V |
| Teaching Hours/Week (L :T : P) | 28 (0:0:2) | CIE Marks | 50 |
| Total Hours of Pedagogy CI( L :T):LI(P):SL:TW | 30 (0:0:2:2) | SEE Marks | 50 |
| Credits | 1 | Total Marks | 100 |
| Type of Examination | Practical | Exam Hours | 03 |

**Course outcome (Course Skill Set)**
**At the end of the course, the student will be able to:**

1. CO1 (L2 -- Understand): Describe properties and standard test procedures of cement, aggregates, concrete, bitumen, and subgrade soil used in pavements.
2. 2. CO2 (L3 -- Apply): Perform laboratory tests on concrete and highway materials as per relevant IS/IRC standards and record data systematically.
3. 3. CO3 (L3 -- Apply): Design concrete mix (and demonstrate self-compacting concrete/bituminous mix design where applicable) using codal provisions.
4. 4. CO4 (L4 -- Analyze): Interpret test results to assess quality, suitability, and performance of materials for different concrete and pavement applications.
5. 5. CO5 (L3 -- Apply): Prepare clear laboratory reports and communicate conclusions relevant to structural and highway design practice.

## SET OF EXPERIMENTS (LI =28 hours)

1. Tests on Cement: Normal consistency, Initial and final setting time, Compressive strength, Fineness (air permeability or sieve).
2. Tests on Fresh Concrete: Slump test, Compaction factor test, Vee-Bee consist meter test.
3. Tests on Hardened Concrete: Compressive strength, Flexural strength (modulus of rupture).
4. Tests on Aggregates: Aggregate crushing value, Los Angeles abrasion test, Aggregate impact value.
5. Tests on Bituminous Materials: Penetration test, Ductility test, Softening point test. 6. Tests on Soil for Pavement: California Bearing Ratio (CBR)test
6. Concrete Mix Design: Design M25/M30 mix as per IS 10262, perform trial batches and tests; justify adjustments for local aggregates.
7. Demonstration on Bituminous Mix Characterization: Select aggregates and bitumen grade, determine Marshall stability/flow; recommend for low/medium traffic road.

**Suggested Learning Resources**
**Text books:**


1. Neville A.M.,"Properties of Concrete", Pearson.
2. Khanna S.K., Justo C.E.G., Veeraragavan A.,"Highway Engineering", Nem Chand Bros.


Reference Books:


1. Kadiyali L.R., Lal N.B.,"Principles and Practice of Highway Engineering", Khanna Publishers.
2. BIS Codes (IS 10262, IS 383, IRC 37) for mix design and material testing

**Web links and Video Lectures (e-Resources):**

1. NPTEL "Advanced Concrete Technology" -- Lectures on mix design and tests.
2. · YouTube: "Highway Materials Testing" by IRC/AK Kayess -- Bitumen and aggregate demos. · VTU resource portals for lab manuals and IS codes.

**NCrF – TW/SL Activities (2 hours) -Any one activity**

- Watching and summarizing NPTEL videos on concrete mix design or CBR testing. · Self-paced practice: Vary w/c ratio in slump test and note effects.
- · Reflection note on role of material testing in sustainable pavements and earthquake-resistant concrete.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average marks for report and test shall be out of 50 marks.
**Eligibility for SEE:**

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

**Rubrics for CIE- Continuous Assessment for practical courses**

| Performance Indicator | CO/PO Mapping | Superior (5) | Good (4) | Fair (3) | Needs Improve ment (2) | Unacceptable (1) |
|---|---|---|---|---|---|---|
| P1: Regularity & Participation | CO1/PO5 (Lab discipline) | Always punctual, fully engaged, leads peers. | Regular, actively participates . | Moderately regular, some participation . | Irregular, minimal effort. | Absent/frequent disruptions. |
| P2: Understanding Objectives & Setup | CO2/PO2 (Problem analysis) | Fully comprehend s, independently sets up accurately. | Good grasp, sets up with minor help. | Partial understanding, basic setup. | Struggles with setup/aims. | No understanding , incorrect setup. scribd+1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| P3: Execution & Results | CO3/PO4 (Investigatio n) | Flawless conduction, precise results with error analysis. | Correct execution, accurate results. | Partial success, some errors. | Major errors in procedur e/results. | Fails to conduct properly. |
| P4: Record Writing | CO4/PO10 (Communicat ion) | Neat, complete, analytical beyond requirement s. | Complete, neat, includes calculations . | Basic record, some omissions. | Incomplet e/untidy. | Not submitted/ille gible |
| P5: Viva Voce & Presentation | CO5/PO12 (Lifelong learning) | Confident, deep insights, relates to applications. | Answers most questions correctly. | Basic responses, some hesitation. | Few correct answers. | Unable to respond. |

**Rubrics for SEE / CIE Test:**

| **Performance Indicator (CO/PO Mapping)** | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| PI-1: Experimental Skill / Technique (CO-1 / PO-5) | Executes procedure flawlessly, handles equipment with confidence, completes work within time, and shows initiative in troubleshooting. | Performs procedure correctly; equipment handling is safe but with minor hesitation; completes most steps on time. | Follows procedure but with intermittent errors; needs frequent guidance; time management is poor. | Makes repeated procedural errors; unsafe handling; requires continuous supervision; incomplete work. | Fails to follow basic steps; unsafe practices; work not attempted or abandoned. |
| PI-2: Observation & Data Recording (CO-2 / PO-2) | Records all required observations systematically; data is accurate, well-labeled, and presented in prescribed format. Scribd. | Records most observation s correctly; data is readable but with minor omissions or formatting issues. | Records incomplete or inconsistent data; units/labels missing; entries are disorganized. | Data recording is haphazard; major omissions; units/labels largely absent. | No meaningful data recorded; or copied/incorrect entries without any understanding. |

| | | | | | |
|---|---|---|---|---|---|
| PI-3: Computation / Analysis (CO-3 / PO-4) | Applies correct formulas, computes results accurately, interprets graphs/tables meaningfully, and identifies sources of error. | Computes results correctly with minor arithmetic errors; graph/plot is acceptable; interpretation on is partial. | Uses correct method but makes significant calculation errors; graph/plot is poorly drawn; interpretation is weak. i | Incorrect method or formula; computations are mostly wrong; no clear interpretation n. | No attempt at computation/analysis; blank or nonsensical entries. |
| PI-4: Safety, Discipline & Professionalism (CO-4 / PO-12) | Maintains strict adherence to lab safety, SOPs, and instructions; respects peers and equipment; works independently. | Generally follows safety rules and instructions ; Acceptable conduct; needs minimal supervision. | Occasionally ignores minor safety precautions; requires reminders on discipline. | Repeated lapses in safety/behavior ; disturbs others; needs constant monitoring. | Gross violation of safety norms; disruptive or negligent behavior; unsafe for self/others. |
| PI-5: Viva-Voce / Conceptual Understanding (CO-5 / PO-1) | Demonstrates deep understanding of concepts, objectives, and methodology; answers questions confidently and precisely. | Shows clear understanding of key concepts; answers most questions satisfactoril y. | Understands basics but struggles with detailed or application-bas ed questions. | Limited understanding g; answers are vague or incorrect on fundamental points. | Unable to answer basic questions; shows no understanding of the experiment. |

**Rubrics suggested for Practical continuous assessment**

| **Performance Indicators** | **Excellent** | **Very Good** | **Good** | **Satisfactory** |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |

| | | | | |
|---|---|---|---|---|
| | design with proper reason (5) | | | |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output. (3) | Student will be able to run the program but not able to analyze the output. (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

# VI Semester Syllabus

| INFRASTRUCTURE BIM AND DIGITAL TWINS | | | |
|---|---|---|---|
| Course Code | **1BIF601** | Scheme | 2025 |
| Type of course | Integrated Professional Core Courses (IPCC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | 70 (3:0:2 ) | CIE Marks | 50 |
| Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL | 120 (42:0:28:50) | SEE Marks | 50 |
| Credits | 4 | Total Marks | 100 |
| Type of Examination (IPCC): | Theory- CIE +SEE, and Lab- CIE only. | Exam Hours | 03 |

**Course outcome (Course Skill Set):**

At the end of the course, the student will be able to:

1. **CO1 (L2 – Understand):** Explain BIM fundamentals, levels of development (LOD), standards, and digital twin concepts relevant to infrastructure projects**.**
2. **CO2 (L3 – Apply):** Apply BIM authoring tools to create 3D/4D/5D models for infrastructure elements like roads, bridges, and utilities.
3. **CO3 (L4 – Analyze):** Analyze model interoperability, clash detection, and simulation for constructability and risk in infrastructure systems.
4. **CO4 (L4 – Analyze):** Analyze digital twins for real-time monitoring, predictive maintenance, and lifecycle management in civil assets.
5. **CO5 (L2 – Understand**): Explain integration of BIM with GIS, IoT, AI for sustainable infrastructure planning and GeoBIM applications.
6. **CO6 (L5 – Evaluate**): Evaluate BIM execution plans, digital twin strategies, and their role in resilient, sustainable infrastructure aligned with SDG 9 and SDG 11.

**Module-1**

**BIM Fundamentals**

- Introduction to BIM: Definition, history, benefits, maturity levels (1-3), LOD, stakeholders' roles.
- Standards and protocols: ISO 19650, national BIM guidelines (India), BIM Execution Plan (BEP).
- BIM v/s traditional methods; applications in infrastructure (roads, bridges, utilities).
- Basics of digital twins: Definition, types (static/dynamic), evolution from BIM

**CO linkage: CO1**. **Number of Hours (CI ): 9 hours**

**Module-2**

**BIM Modeling & Dimensions**

- BIM authoring: Revit/AutoCAD Civil 3D for 3D geometry, families, infrastructure components.
- BIM: 4D (scheduling), 5D (cost), site logistics, earthworks optimization.
- Data exchange: IFC, CO reality capture (laser scanning, photogrammetry).
- Simple model creation for linear infrastructure (pipelines, highways). Walk throughs, and through animations.

**CO linkage: CO2.** **Number of Hours (CI ): 9 hours**

**Module-3**

**Collaboration & Coordination**

- 4D BIM fundamentals – integration of time dimension with 3D model; linking construction flash detection: Navis works/Solibri; interdisciplinary coordination.
- Common Data Environment (CDE), cloud collaboration (BIM 360).
- Construction sequencing, quantity takeoff, cost estimation.

IPD, contractual aspects, risk allocation in BIM projects.

**CO linkage: CO3.** **Number of Hours (CI ): 8 hours**

**Module-4**

**Digital Twins Basics**

- Digital twin framework: IoT sensors, real-time data, AI/ML integration.
- Types: Physical-virtual hybrids; applications in asset monitoring.
- Simulation: Predictive analytics, scenario testing for infrastructure resilience.
- Interoperability with BIM; case studies in bridges/urban infra.

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**CO linkage: CO4.** **Number of Hours (CI ): 8 hours**

**Module-5**

**Advanced Applications & Sustainability**

- Geo BIM: GIS-BIM integration for urban planning, 3D city models.
- Sustainability: Energy analysis, LCA with BIM; digital twins for FM.
- Emerging tech: VR/AR, digital twins for O&M, retrofit projects.

Sustainable infra: Alignment with SDGs, resilient design via simulations

**CO linkage: CO5, CO6.** **Number of Hours (CI ): 8 hours**

**PRACTICAL COMPONENTS OF IPCC**

**PART – A: FIXED SET OF EXPERIMENTS**

1. BIM model creation for simple beam/column; LOD validation.
2. 4D simulation for infrastructure sequencing.
3. Flash detection in multi-disciplinary model.
4. Quantity takeoff and cost estimation from BIM model.
5. Digital twin setup with sample IoT data visualization.
6. Geo BIM integration for site analysis.
7. Reality capture import (point cloud) into BIM.
8. VR walkthrough of infrastructure model

**PART – B: OPEN ENDED EXPERIMENTS**

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on problem statements aligned with Infrastructure BIM and Digital Twin concepts defined by the course coordinator. It encourages creativity, critical thinking, innovation, and inquiry-based learning in digital and data-driven environments.

1. BIM-based earthworks optimization for road project.
2. Digital twin for predictive maintenance simulation.
3. Sustainable design analysis using BIM tools.
4. Clash resolution in complex utility network.
5. AR application for on-site verification.
6. Lifecycle cost assessment via 5D BIM

**Suggested Learning Resources: (Textbook/ Reference Book/ Manuals): Textbooks:**

1. Eastman et al., BIM Handbook, Wiley.
2. Succar, Building Information Modeling, Routledge.

**Reference books / Manuals:**

1. ISO 19650 series on BIM.
2. Autodesk Revit/Civil 3D manuals.

**Web links and Video Lectures (e-Resources):**

1. NPTEL courses on Building Information Modeling and Construction Project Management.
2. Autodesk University – Free online courses on Revit, Navisworks, BIM 360, and infrastructure design: https://www.autodesk.com/autodesk-university
3. NPTEL/SWAYAM on BIM; Bentley Twin courses

**Teaching-Learning Process (Innovative Delivery Methods):**

Teaching–Learning Process (Innovative Delivery Methods): The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching–learning process and facilitate the achievement of course outcomes.

1. Concept-oriented lectures emphasizing BIM fundamentals, digital twin frameworks, and real-world infrastructure case studies with visual simulations and model walkthroughs.
2. Hands-on modelling sessions focused on infrastructure projects (roads, bridges, buildings, water systems) using BIM tools, including clash detection, 4D scheduling, and 5D cost estimation.
3. Flipped-classroom segments for selected topics (e.g., BIM workflows, interoperability, digital twin integration, IoT-enabled infrastructure) using pre-class tutorials and in-class collaborative model development.
4. Mini-projects and open-ended lab tasks involving creation of BIM models and digital twins that integrate SDG-9 (Industry, Innovation, Infrastructure), SDG-11 (Sustainable Cities), SDG-13 (Climate Action), Industry 5.0 (AI, IoT, automation), and NEP 2020 emphasis on experiential, multidisciplinary, and technology-driven learning.

**Assessment Structure:**
The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks.**
The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks.**
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

**Students' activities for TW/SL under NCrF: Samples only:** As per National credit farmwork (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/ Selfe learning (TW/Sl-50 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | **Activity 1 (CO2, CO3, CO6):** Mini-project on campus infrastructure (building/road/water system) using BIM – data collection, 3D modeling, basic clash detection, and sustainability analysis aligned with SDG-9, SDG-11, SDG-13. | 25 |
| 2. | **Activity 2 (CO3, CO4):** Open-book assignment on BIM workflows and digital twin concepts using software tools/spreadsheets, including comparison of design alternatives, interoperability issues, and lifecycle cost optimization (4D/5D BIM) | 25 |
| 3. | **Activity 3 (CO5, CO6):** Short group task on development of a basic digital twin for an infrastructure system (e.g., smart building or utility network), considering IoT integration, performance monitoring, and sustainability aspects (Industry 5.0 perspective). | 25 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | **MOOC + Open-Book Track:** Complete selected BIM/Digital Twin MOOC modules (e.g., modeling tools, interoperability, smart infrastructure) along with assessments and at least one integrated open-book evaluation on conceptual/design-based problems.. | 25 |
| 2. | **Case Study & Literature Portfolio:** Prepare 3–4 case studies on real-world BIM and Digital Twin applications (e.g., smart cities, infrastructure lifecycle management) along with brief reviews of 3–5 research papers/standards (e.g., ISO BIM standards, digital twin frameworks). | 25 |

| Performance Indicator | 4 – Excellent | 3 – Good | 2 – Fair | 1 – Needs Improvement |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Conceptual understanding(CO1 ,CO4) | Demonstrates accurate understanding of BIM/Digital Twin concepts, work flows, standards (ISO 19650, LOD), And technologies with correct terminology. | Mostly correct concepts; few minor gaps in standards Or work flow understanding. | Partial understanding; important gaps in fundamentals but some correct ideas about BIM/Digital Twin. | Significant misconceptions; confused BIM vs. Digital Twin; key concepts missing. |
| Application And analysis (CO2,CO3,CO5) | Correctly applies BIM authoring principles, 4D/5D methods, or Digital Twin analytics; logical solution approach; demonstrates ability to analyze infrastructure scenarios. | Application mainly correct with minor procedural gaps; analysis generally sound but may lack depth | Partially correct application; several errors in modeling/ scheduling/analytics approach; limited analysis | Wrong or no application method; cannot analyze scenarios ; lacks practical understanding. |
| Tool and technology knowledge (CO2, CO4) | Clear understanding of BIM software capabilities (Revit, Navis works), Digital Twin platforms, IoT sensors, and data integration methods. | Good understanding of tools with minor gaps in advanced features or integration methods | Basic tool awareness; Significant gaps In functionality or integration understanding. | Minimal or no understanding of software tools or. Digital Twin technologies |
| Standards and industry practices(CO1,CO6) | Excellent knowledge of ISO 19650, LOD framework, CDE, industry implementation practices, and SDG alignment. | Good knowledge of standards with in or details missing; adequate Industry practice awareness. | Limited knowledge of standards; basic awareness of practices ;weak SDG connection. | Poor understanding of standard s and industry practices; no SDG awareness |

**Rubric – Mini-Project - (sample)**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) |
|---|---|---|---|
| Model/ system definition and scope (CO1, CO4) | Clear project scope; complete geometric and information requirements defined; LOD specified; all disciplines covered appropriately.. | Scope mostly clear; minor gaps in requirements or LOD specification; most disciplines addressed. | Vague scope; key requirements missing; incomplete discipline coverage; LOD not specified |
| BIM model Quality and accuracy(CO2)or Digital Twin architecture(CO 4) | Accurate, well-structured BIM model with correct families/components; or comprehensive Digital Twin architecture with sensor network, data flow, and analytics frame work clearly defined. | Generally accurate model with minor errors; or Digital Twin architecture mostly complete with some gaps in integration or data handling. | Significant modeling Errors ,missing elements, poor structure; or incomplete Digital Twin design with major architectural gaps.. |
| Clash detection and coordination(CO 2,CO3) or IoT integration (CO4) | Comprehensive clash detection performed; Clashes categorized ,prioritized, and resolved with documentation; or complete IoT sensor strategy with data acquisition and communication protocols | Clash detection performed with most clashes identified; Some resolution documentation; or IoT strategy present but with gaps in sensor types or data flow | Minimal clash detection ;poor documentation; or incomplete IoT. integration with major gaps. |
| Technical analysis and insights (CO3,CO5) | Excellent 4D/5Danalysis or predictive analytics; quantitative results with Engineering interpretation; demonstrates understanding Of scheduling/cost/asset Management principles.. | Good analysis with minor gaps; results mostly interpreted; basic understanding of principles demonstrate d.. | Limited analysis; weak interpretation; minimal understanding of advanced concepts.. |
| Documentation and Professional presentation(CO 6) | Comprehensive report with clear drawings, schedules, clash reports, or Digital Twin dashboards; professional presentation; explicit SDG 9/11 linkage and sustainability discussion. | Adequate documentation with minor organizational issues; Acceptable presentation; brief SDG/sustainability mention.. | Poor documentation; disorganize d or incomplete; weak or missing presentation; no SDG linkage. |

**Suggested rubrics for Practical continuous assessment**

| Performance Indicators | Excellent | Very Good | Good | Satisfactory |
|---|---|---|---|---|
| Fundamental Knowledge (PO1) Demonstrates deep understanding of BIM/digital principles and connects lab to infrastructure applications (e.g., LOD, IFC, sensor fusion). | Deep understanding; connects experiments to full lifecycle theory/field apps (10). | Good understanding; minor gaps in theory/field links (8-9). | Basic understanding; limited theoretical connection (5-7). | Weak conceptual grasp; significant gaps (1-4). |

| | | | | |
|---|---|---|---|---|
| Experimental Planning & Setup (PO2, PO3) Independently describes BIM/twin workflow, identifies parameters, sets up software correctly with data validation/safety. | Independently plans Civil 3D/Revit setup, validates inputs, considers interoperability (10). | Plans with minor guidance; understands key steps (8-9). | Follows instructions; moderate guidance needed (5-7). | Requires significant guidance; workflow confusion (1-4). |
| Implementation & Data Quality (PO3, PO8) Executes modeling/simulation systematically; obtains reliable BIM/twin outputs; records completely. | Systematic execution; consistent meshes/clashes/data; neat BIM files/logs (8-10). | Executes well; minor data/recording lapses (6-7). | Noticeable procedural/data issues (4-5). | Basic execution only; poor data/files (1-3). |
| Result Analysis & Inference (PO4) Correct clash/4D analysis, simulations; compares with standards; discusses errors. | Correct calculations/graphs; interprets vs ISO 19650; error analysis (10). | Mostly correct; minor interpretation issues (8-9). | Partly correct; limited discussion (5-7). | Minimal analysis; little result understanding (1-4). |
| Demonstration, Reporting & Teamwork (PO9, PO10) Clear walkthrough of twin dashboard; organized report; strong team roles. | Clear oral/written demo; structured report; excellent teamwork (8-10). | Good explanation/record; teamwork evident (6-7). | Understandable but unstructured; uneven teamwork (4-5). | Poor explanation/record; weak teamwork (1-3). |

Note: Can add Engineering & IT tool usage based on the nature of the course

**Continuous Internal Evaluation (CIE):**

**(i) Theory component**

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

**(ii) Laboratory component**

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus. The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

| **Table – ICs/IPCCs 1 Distribution of marks** | | |
|---|---|---|
| **Component** | **Description** | **Marks** |
| **Allotment of marks for regular class work** | | |
| Ability in Conducting Experiments | Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions. | 5 marks |
| Laboratory Record / Journal | Regular and neat maintenance of lab record, accuracy of results, and timely submission. | 10 marks |
| **Subtotal** | | **15** |
| **Allotment of marks for CIE practical test** | | |
| Laboratory Test / Experiment Performance | Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment. | 5 marks |
| Viva-Voce | Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions. | 5 marks |
| **Subtotal** | | **10** |
| **Total** | | **25** |

Passing requirement in SEE:
For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| QUANTITY SURVEYING, CONTRACT AND INFRASTRUCTURE ASSET VALUATION | | | |
|---|---|---|---|
| Course Code | 1BIF602 | Scheme | 2025 |
| Type of Course | Profession Core Course (PCC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | (3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90 (CI-42 + TW/SL-48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

- **CO1 (L2 – Understand):** Explain the principles of quantity surveying, measurement standards, and taking out quantities preparation of detailed estimates infrastructure projects.
- **CO2 (L3 – Apply):** Prepare detailed and abstract estimates for various road works, structural works and water supply and sanitary works.
- **CO3 (L4 – Analyze):** Prepare the specifications and analyze the rates for various items of work.
- **CO4 (L2 – Understand):** Assess contract and tender documents for various construction works.
- **CO5 (L3 – Apply):** Apply valuation principles for infrastructure assets including depreciation methods (straight-line, written down value, sinking fund, annuity), capitalization approaches, rental methods, and determine distress value and salvage value for buildings and infrastructure components.
- **CO6 (L5 – Understand):** Assess public-private partnership (PPP) financial models, concession agreements, and relate sustainable infrastructure valuation to SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities).

## Module-1

**Quantity Surveying and Estimation Fundamentals**

**Introduction to Quantity Surveying**

- Role and responsibilities of quantity surveyor in infrastructure projects; evolution from traditional estimation to BIM-based quantity takeoff awareness
- Types of estimates: preliminary/approximate estimate (plinth area method, cubic content method, unit base method), detailed estimate/ revised estimate, supplementary estimate, annual repair estimate.
- Basic terminology: schedule of rates, analysis of rates, premium, contingencies, work-charge establishment, tools and plants (T&P), lump sum provision, cent age charges.
- Prime cost (PC) sum, provisional sum, provisional quantities, day work, escalation clauses.

**Units of Measurement and Measurement Principles**

- Standard units of measurement as per IS 1200 (Part 1-27) and CPWD specifications: earthwork (cubic meter), concrete (cubic meter), masonry (cubic meter), plastering and finishing (square meter), steel (kilogram/tonne), painting (square meter), roadwork (square meter, cubic meter, running meter).
- Measurement principles: center-line method, long-wall short-wall method, mid-section formula, trapezoidal formula, prismoidal formula for earthwork.
- Net measurement v/s gross measurement; deductions for openings (doors, window ventilators)
- Estimate of R.C.C structures including Slab, beam, column, footings.

**Linked COs**: **CO1, CO2,CO5** **Number of Hours Required (CI)**: **8 hours**

## Module-2

- Estimate of Steel truss, manhole and septic tanks and slab culvert
- Quantity Estimation for Roads: Computation of volume of earthwork fully in banking, cutting, partly
- Cutting and partly Filling by mid-section, trapezoidal and Prismoidal Methods.
- Earthwork in road embankment and cutting: compaction in layers with specifications.
- Sub-base course: granular sub-base (GSB), Wet Mix Macadam (WMM) as per MORTH specifications.
- Base course: Water Bound Macadam (WBM), Dense Bituminous Macadam (DBM).

**Abstract of Estimate and Cost Statement**

- Preparation of abstract of estimate: grouping items trade-wise or work-wise.
- Addition of contingencies (typically 3-5%), work-charge establishment (1-2%), contractor's profit (10-15%).
- Goods and Services Tax (GST) applicability on construction works (awareness of current rates and exemptions).

- 

**Linked COs: CO1, CO2,C05** **Number of Hours Required (CI): 9 hours**

**Module-3**

**Specification for Civil Engineering Works**

- Material specifications as per IS codes: cement (IS 269, IS 8112, IS 12269), aggregates (IS 383), steel (IS 1786, IS 2062), bricks (IS 1077), timber, sand, stone, bitumen (IS 73).
- Labor productivity norms and minimum wages as per state labor departments; equipment rental rates.
- Rate Analysis for Building Works
- Detailed rate analysis for: Earthwork excavation in foundation (ordinary soil, hard soil, rock), Plain Cement Concrete (PCC) 1:2:4, 1:3:6, 1:4:8; Reinforced Cement Concrete (RCC) M20, M25, M30 grades.
- Brick masonry in cement mortar (1:4, 1:5, 1:6), hollow block masonry, stone masonry (rubble, ashlar).
- Plastering (internal, external, ceiling) 12mm, 15mm, 20mm thick in cement mortar; painting (oil paint, emulsion, distemper); flooring (cement concrete, tiles, marble, granite).
- Roofing: RCC slab, roof trusses (steel, timber), roofing sheets (AC, GI, tile).
- **Analysis of Rates** : Factors Affecting Cost of Civil Works , Concept of Direct Cost , Indirect Cost and Project Cost
- Rate analysis and preparation of bills, Data analysis of rates for various items of Works, Sub-structure components, Rate analysis for R.C.C. slabs, columns and beams.

**Linked COs: CO3, CO5** **Number of Hours Required (CI): 8 hours**

**Module-4**

**Contract Management-Tender and its Process:**

- Invitation to tender, Prequalification, administrative approval& Technical sanction. Bid submission and Evaluation process.
- Contract Formulation: Letter of intent, Award of contract, letter of acceptance and notice to proceed. Features / elements of standard Tender document (source: PWD / CPWD / International Competitive Bidding – NHAI / NHEPC / NPC).
- Law of Contract as per Indian Contract act 1872, Types of Contract, Joint venture.
- Contract Forms: FIDIC contract Forms, CPWD, NHAI, NTPC, NHEPC
- Tender Process and Procedures
- Types of tenders: open tender, limited tender, single tender, two-stage tender, two-bid system (technical bid + financial bid), e-tendering.
- Notice Inviting Tender (NIT): essential contents, eligibility criteria, scope of work, time schedule, earnest money deposit (EMD), tender fee.
- Bid preparation: understanding tender documents, site visit, clarifications, bid submission (technical + financial), bid opening procedures.
- Security deposit, performance guarantee, retention money (typically 5-10% withheld until defect liability period).

**Linked COs: CO3, CO4, CO5.** **Number of Hours Required (CI): 8 hours**

**Module-5**

**Infrastructure Asset Valuation and Sustainability and SDG Linkages**

**Principles of Valuation**

- Definition and purpose of valuation: market value, replacement value, distress value, salvage value, scrap value.

**Methods of Valuation**

- Cost method (depreciation method), (capitalization method): Rental/comparative method, Development method (residual method):

**Depreciation Methods for Infrastructure Assets**

- **Sinking Fund method:** Annual depreciation invested in sinking fund earning compound interest; accumulates to replacement cost at end of life; suitable for infrastructure assets requiring lump-sum replacement.
- **Annuity method:** Depreciation increases annually such that total depreciation plus interest equals annuity; considers time value of money and interest on capital.

**Valuation of Buildings and Infrastructure Components**

- Determination of building age, effective age, and remaining useful life; distress classification (good, fair, poor, dilapidated).
- Calculation of depreciation for buildings: age-based depreciation tables, condition-based adjustments (structural damage, obsolescence).
- Valuation of land: market value approach using comparable sales, guidance value (ready reckoner rates), land use and zoning impact..

**Linked COs: CO5, CO6.** **Number of Hours (CI+TWSL): = 9hours..**

**Suggested Learning Resources Textbooks:**


1. Dutta, B. N. Estimation and Costing in Civil Engineering (27th Edition). UBS Publishers.
2. Chakraborti, M. Estimation, Costing and Specification in Civil Engineering. Laxmi Publications.
3. Patil, B. S. Civil Engineering Contracts and Estimates. Universities Press.
4. Rangwala, S. C. Estimation and Costing (Civil, Architectural and Mechanical). Charotar Publishing House.
5. Pollock, A., & Watt, D. S. Valuation of Real Property. Estates Gazette.


**Reference Books:**


1. CPWD Delhi Schedule of Rates (DSR) – Latest Edition with updated rates and specifications.
2. CPWD Delhi Analysis of Rates (DAR) Vol. I & II – Material, labor, and machinery analysis for civil works.
3. IS 1200 (Part 1 to 27) Method of Measurement of Building and Civil Engineering Works – Bureau of Indian Standards.
4. MORTH (Ministry of Road Transport and Highways) Specifications for Road and Bridge Works (5th Revision).
5. FIDIC Conditions of Contract: Red Book, Yellow Book, Silver Book – International Federation of Consulting Engineers.
6. Indian Contract Act, 1872 and Arbitration and Conciliation Act, 1996 (with amendments).
7. National Building Code of India (NBC) 2016 – Bureau of Indian Standards.
8. Model Concession Agreements (MCA) – PPP in India portal ( www.pppinindia.gov.in).

**Web links and e-Resources:**

1. NPTEL Course: Construction Project Management (IIT Madras) – https://nptel.ac.in – Contract management, claims, arbitration modules.
2. NPTEL Course: Quantity Surveying and Costing (awareness course on estimation principles).
3. CPWD Logical Website: https://cpwd.gov.in – DSR, DAR, specifications, contract documents download.
4. PPP in India Portal: https://www.pppinindia.gov.in – Model concession agreements, PPP guidelines, project toolkits.
5. FIDIC Logical Website: https://fidic.org – International contract documentation, procurement procedures.
6. Ministry of Road Transport and Highways (MoRTH): https://morth.nic.in – Road and bridge specifications, IRC codes.
7. LinkedIn Learning / Course: Construction Contract Administration, Construction Claims and Disputes Management.
8. YouTube channels: "Civil Engineering Delhi" (DSR/DAR tutorials), "Engineering Made Easy" (estimation practice problems).
9. Bureau of Indian Standards (BIS): https://www.services.bis.gov.in – IS codes for materials, measurement methods.
10. Autodesk University / BIM Corner: BIM-based quantity takeoff and 5D cost estimation workflows (awareness).

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.
Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Site Visit
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:**
The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks.**
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks.**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | BOQ Preparation Mini-Project: Collect building/infrastructure drawings, perform quantity takeoff using BIM/Excel, calculate rates for sustainable features (e.g., green materials, water conservation), and prepare a Bills of Quantities (BOQ) report with cost analysis. | 24 |
| 2. | Contract Dispute Case Study Portfolio: Analyze real-world contract disputes or valuation cases (e.g., delays, variations, green premium claims), apply contract clauses, compute financial impacts, and present risk statements with a short seminar on resolution strategies. | 24 |
| 3. | Valuation Tools Workbook: Develop a digital workbook in Excel/Python implementing core computations: depreciation schedules, green building premium calculations, lifecycle carbon costing, NPV for resilient infrastructure, and sensitivity analysis for SDG-aligned social returns. | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | Study online modules on LEED/GRIHA certification valuation impacts and sustainable materials costing through NPTEL/Coursera. | 24 |
| 2. | Explore RICS/IVS standards for infrastructure asset valuation via webinars and spoken tutorials. | 24 |
| 3. | Complete self-paced tutorials on BIM for quantity takeoff and AI tools for contract risk analysis. | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

**1. Sample Rubrics -Integrated Design Mini-Project**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Quantity calculation accuracy(CO1, CO2) | All quantities calculated correctly using appropriate measurement methods (center-line, long-wall short-wall, mid-section, prismoidal);proper deductions for openings; units correct as per IS 1200; abstract of quantities well-organized. | Most quantities correct; minor calculation errors or deduction mistakes ;units mostly correct; abstract reasonably organized. | Significant quantity errors; incorrect measurement methods applied; wrong units; disorganized abstract or missing items. | 30% |

| | | | | |
|---|---|---|---|---|
| Rate analysis quality (CO2) | Detailed rate analysis for all major items using CPWD DSR/DAR or market rates; material specifications accurate (IS codes referenced); labor and equipment costs realistic; overhead and profit included appropriately ;calculations error-free. | Rate analysis performed for most items; minor errors in material specs or labor rates; overhead/profit of it calculations reasonable; some computational mistakes. | Incomplete rate analysis; incorrect material specification ns; unrealistic labor/equipment costs; major calculation errors or missing component s.. | 25% |
| BOQ preparation and presentation( CO1,CO) | Professional BOQ with correct item numbering, clear descriptions ,accurate units, quantities, rates ,and amounts; abstract of estimate complete with contingencies, T&P, contractor's profit, GST; final cost statement well-presented.. | BOQ Generally complete ;minor formatting issues or missing descriptions; abstract includes most components(contingencies, T&P,profit); final cost statement adequate. | Poor BOQ format; missing or incorrect descriptions; units/quantities/rates in consistent; abstract incomplete unprofessional presentation. | 20% |
| Use of standards and specifications( CO2) | Appropriate use of CPWD DSR/DAR, MORTH specifications (for roads/bridges), IS codes for materials; specifications clearly stated for all major items; compliance with measurement standards demonstrated - | General use of standard references; some specification s stated; minor gaps in referencing codes or standards | Minimal or incorrect use of standards; specification s vague or missing; no reference to DSR/DAR or IS codes. | 15% |
| Technical documentation and clarity(CO1,CO2,CO6) | Comprehensive report with drawings reviewed, assumptions stated, calculations shown step-by-step, references cited; neat and professional presentation; aligned with sustainable construction principles where applicable(material select drawings reviewed, assumptions stated, calculations shown step-by step, references cited; neat and professional presentation; aligned with sustainable construction principles where applicable(material selection, waste minimization). minimization). | Generally complete. documentation; most calculations shown; adequate presentation; brief mention sustainability considerations. | Incomplete documentation; calculations not shown or unclear; poor presentation quality; no sustainability or SDG linkage. | 10% |

**Continuous Internal Evaluation (CIE):**

i. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
ii. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
iii. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
iv. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| WATER RESOURCE AND IRRIGATION ENGINEERING | | | |
|---|---|---|---|
| Course Code | 1BIF603 | Scheme | 2025 |
| Type of Course | Profession Core Course (PCC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | 42(3: 0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**
**At the end of the course, the student will be able to:**

1. CO1 (L2 -- Understand): Explain the hydrologic cycle, precipitation processes, evaporation, transpiration, infiltration, and their role in water resource planning and management aligned with SDG 6.
2. CO2 (L3 -- Apply): Analyze rainfall data, compute runoff using different methods, develop unit hydrographs, and perform flood frequency analysis for watershed management and infrastructure design.
3. CO3 (L3 -- Apply): Determine crop water requirements, design efficient irrigation systems including surface, sprinkler, and drip irrigation methods, and calculate irrigation scheduling for sustainable agriculture.
4. CO4 (L3 -- Apply): Design canal irrigation systems including canal alignment, cross-sections, hydraulic structures and distribution networks following IS codes and best practices.
5. CO5 (L4 -- Analyze): Design diversion structures (weirs and barrages), storage reservoirs, groundwater wells, and assess their performance for sustainable water resource development.
6. CO6 (L5 -- Evaluate/Create): Integrate water resource systems with infrastructure planning, evaluate water resource projects using economic and environmental criteria, and propose sustainable solutions addressing SDG 6, SDG 9, SDG 11, and SDG13.

**Module-1**

**Hydrology fundamentals and precipitation analysis**

- Introduction to water resources -- global water resources, water availability in India, water stress and scarcity; role of water in sustainable development; linkage to SDG 6 (clean water and sanitation).
- Hydrologic cycle -- components (precipitation, evaporation, transpiration, infiltration, runoff, groundwater flow); water balance equation; systems concept in hydrology.
- Precipitation -- forms and types of precipitation; mechanisms of precipitation formation (convective, orographic, cyclonic); rainfall measurement -- rain gauges (non-recording and recording types), rain gauge network design.
- Analysis of rainfall data -- estimation of missing rainfall data(arithmetic mean, normal ratio, inverse distance methods); test for consistency of rainfall records (double mass curve);representation of rainfall data..
- Average areal rainfall -- arithmetic mean method, Thiessen polygon method, isohyet method; depth-area-duration (DAD) curves; maximum depth-area-duration relationship

**Linked COs: CO1** **Number of Hours: 08**

**Module-2**

**Evaporation Infiltration and Runoff flood frequency analysis**

- Evaporation and transpiration -- factors affecting evaporation; measurement (evaporation pans, lysimeters); estimation methods (Meyer's formula, Penman's equation -- qualitative); evapotranspiration -- actual and potential ET; estimation of ET (Blaney-Criddle method awareness).
- Infiltration -- process and factors affecting infiltration; measurement (infiltrometers); infiltration indices (φ-index, W-index); infiltration capacity curves; Horton's equation
- Runoff -- factors affecting runoff; runoff coefficient; rational method for peak discharge estimation; limitations of rational
- Hydrographs -- definition, components of hydrograph (base flow, direct runoff, rising limb, peak, recession limb); factors affecting hydrograph shape; separation of base flow (straight line, fixed base, variable slope methods).
- Unit hydrograph theory -- definition, assumptions, derivation of unit hydrograph from isolated storm; application of unit hydrograph for different storm durations (S-curve method); limitations of unit hydrograph.
- Synthetic unit hydrographs -- Snyder's method, SCS dimensionless unit hydrograph (awareness); application for ungagged catchments Building automation and controls -- BMS (Building Management System.
- Flood routing -- definition, types (reservoir routing, channel routing); reservoir routing by level pool method; Muskingum method for channel routing (awareness level)

**Linked COs: CO2, CO6.** **Number of Hours: 09**

**Module-3**

**Crop water requirements and irrigation methods**

- Need and benefits of irrigation -- agricultural productivity, food security; irrigation development in India -- major, medium, and minor irrigation projects; National Water Policy and irrigation sector reforms.
- Soil-water-plant relationship -- soil moisture characteristics (field capacity, permanent wilting point, available water); soil moisture tension; soil-water movement in root zone.
- Irrigation water requirements -- effective rainfall, leaching requirement, water application efficiency; net and gross irrigation requirements; duty and delta concepts; irrigation frequency and scheduling. Hot water systems -- solar water heaters (flat plate, evacuated tube collectors), heat pump water heaters; efficient hot water distribution -- insulated piping, recirculation systems.
- Classification of irrigation systems -- surface irrigation, sprinkler irrigation, drip (micro) irrigation; selection criteria based on topography, soil, crop, and water availability.
- Surface irrigation methods, Drip irrigation system ,Water use efficiency and conservation , Sprinkler irrigation

**Linked COs: CO3, CO6.** **Number of Hours:08**

**Module-4**

**Canal irrigation systems and reservoirs**

- Canal irrigation systems -- classification (inundation canals, perennial canals); components of canal system (head works, main canal, branch canal, distributary, minor, field channels); command area and cultural command area.
- Alignment of irrigation canals -- factors affecting alignment(topography, soil, command area, economy); watershed and ridge line concepts; contour alignment vs. side slope alignment; canal losses (seepage, evaporation)..
- Design of irrigation canals -- Kennedy's theory and Lacey'stheory for stable channel design; comparison of Kennedy's and Lacey's methods; design procedure for unlined and lined canals (concrete, brick lining).
- Reservoirs and dams -- classification of dams (gravity, earth, rock-fill, arch); functions of reservoirs (irrigation, power generation, flood control, water supply); reservoir planning and site selection.
- Storage zones in reservoir -- dead storage, live storage, flood storage, surcharge storage; reservoir capacity determination; capacity-elevation curve and area-elevation curve; reservoir sedimentation and life estimation.
- Reservoir yield and storage determination -- mass curve analysis (Rippl's method); sequent peak algorithm; storage-yield-reliability relationships; reservoir operation rules (qualitative).

**Linked COs: CO2, CO5, CO6.** **Number of Hours:08**

**Module-5**

**Gravity Dams, Earthen dam and Spillways**

- Forces acting on a gravity dam, causes of failure of a gravity dam, elementary profile, and practical profile of a gravity dam, limiting height of a low gravity dam, Factors of Safety – Stability Analysis, Foundation for a Gravity Dam, drainage and inspection galleries
- Types of Earth dams, causes of failure of earth dam, criteria for safe design of earth dam, seepage through earth dam-graphical method, measures for control of seepage.
- Spillways: types of spillways, Design principles of Ogee spillways – Spillway gates

**linked COs: CO5, CO6.** **Number of Hours:09**

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Subramanya, K Engineering Hydrology Tata McGraw-Hill
2. Garg, S.K.Irrigation Engineering and Hydraulic Structures Khanna Publishers...
3. Punmia, B.C., Ashok Kumar Jain, and Arun Kumar Jain. Irrigation and Water Power Engineering. Laxmi Publications
4. Arora, K.R.Irrigation, Water Resources and Water power Engineering Standard Publishers Distributors.
5. Michael, A.M. and Ojha, T.P.Principles of Agricultural Engineering Volume II Jain Brothers

Reference Books:

1. Raghunath, H.M. Hydrology: Principles, Analysis and Design New Age International Publishers.
2. Sharma, R.K. and Sharma, T.K.Irrigation Engineering S. Chand Publishing.
3. IS 4745:1968 -- Code of Practice for Design of Cross Drainage Works. Bureau of Indian Standards.
4. IS 7112:1973 -- Criteria for Hydraulic Design of Barrages and Weirs. Bureau of Indian Standards
5. IS 9912:1992 -- Criteria for Design of Bunds for Water Storage Structures. Bureau of Indian Standards
6. Modi, P.N.Irrigation, Water Resources and Water Power Engineering Standard Book House.
7. Central Water Commission (CWC) manuals on canal design and dam safety.

Web links and Video Lectures (e-Resources):

1. NPTEL courses on Hydrology, Irrigation Engineering, and Water Resources Engineering.
2. Central Water Commission (CWC) --https://cwc.gov.in
3. Central Ground Water Board (CGWB) --https://cgwb.gov.in
4. Ministry of Jal Shakti, Department of Water Resources -- https://jalshakti-dowr.gov.in
5. India Meteorological Department (IMD) -- https://www.imd.gov.in
6. FAO Irrigation and Drainage Papers -- https://www.fao.org/land-water/
7. National Water Academy -- https://nwa.cewacw.gov.in

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Case Study Presentation
- Partial Delivery of course by Industry expert/ industrial visits

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the CIE, a student must score at least 40% of 50 marks, i.e., 20 marks.
- To pass the SEE, a student must score at least 35% of 50 marks, i.e., 18 marks.
- Notwithstanding the above, a student is considered to have passed the course, provided the combined total of CIE and SEE is at least 40 out of 100 marks.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted, carrying a total of 25 marks.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

It is recommended to include a maximum of two learning activities as part of the CCA to foster the holistic development of students. These activities shall be:

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | Complete hydrologic analysis of a watershed including rainfall-runoff analysis, unit hydrograph development, flood frequency analysis, and design flood estimation with GIS/software support | 24 |
| 2 | Comprehensive design of irrigation system for a given crop pattern and command area including crop water requirement calculation, irrigation scheduling, canal network design, and water distribution planning | 24 |
| 3 | Case studies, Seminar and presentations. | 24 |
| 4 | Reservoir site selection, storage capacity determination using mass curve analysis, dam type selection, sediment analysis, spillway design considerations, and economic analysis | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1 | NPTEL/SWAYAM courses on sustainable design; self-initiated project exploring local sustainable building; | 24 |
| 2 | self-initiated project on local water resource issues; software tutorials (HEC-HMS, EPANET, ArcGIS for watershed analysis) | 24 |
| 3 | Literature review on sustainable irrigation practices; reflective learning journal on field observations | 24 |

**Rubrics for Students learning activities -TW/SL - (Samples)**

**1 Watershed Hydrologic Analysis Project -- Rubric**

| **Criterion** | **Exemplary (3)** | **Proficient (2)** | **Basic (1)** | **Weight** |
|---|---|---|---|---|
| Data collection &watershed characterization | Complete watershed data collected (area, slope, land use, rainfall); proper delineation and characterization; GIS maps prepared | Mostly complete data; minor gaps in characterization; basics outputs | Incomplete data; poor watershed characterization; missing GIS analysis | 15% |
| Rainfall- runoff analysis | Accurate rainfall analysis (average areal rainfall, missing data estimation); correct runoff computation using multiple methods; proper justification Correct derivation | Generally correct analysis; minor computational errors; limited method comparison | Significant errors in analysis; single method used; weak justification | 30% |
| Unit hydro graph development | Correct derivation of unit hydrograph from observed data; proper application for design storm; Curve correctly developed | Unit hydrograph derived with minor errors; application mostly correct | Incorrect unit hydrograph improper application or missing S-curve | 25% |
| Flood frequency analysis | Proper frequency analysis using appropriate distribution; design flood for different return periods correctly estimated; plotting positions appropriate | Frequency analysis attempted; Mini statistical errors; design | Incorrect frequency analysis; wrong distribution used; unrealistic | 20% |
| Report quality & presentation | Well-structured report with clear maps, graphs, tables; proper documentation; excellent presentation with recommendations | Acceptable report structure; most graphics clear; presentation adequate | Disorganized report; poor graphics; weak presentation; missing conclusions | 10% |

**2. Irrigation System Design Project -- Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Crop water requirement assessment | Accurate determination of crop water requirements for all crops; proper consideration of climate, soil, crop stage; irrigation scheduling correctly developed | Most crops analyzed correctly; minor errors in ET calculation; scheduling reasonable | Incomplete crop analysis; signicant errors in water requirement; poor scheduling | 25% |

| | | | | |
|---|---|---|---|---|
| Irrigation method select ion & design | Appropriate irrigation method selected with proper justification; detailed design (sprinkler/drip/surf ace) with correct spacing, discharge, deficiency | Method selection reasonable; design mostly correct; minor parameter errors | Poor method selection; incomplete design; major parameter errors | 30% |
| Canal system layout & hydraulics | Optimal canal alignment; correct hydraulic design using Kennedy/Lacey; proper cross-sections; structures identified | Canal layout reasonable; hydraulic design mostly correct; minor errors in cross-sections | Poor alignment; incorrect hydraulic design; structures missing or wrong | 25% |
| Water budget & efficiency | Complete water budget (source, requirement, losses); irrigation efficiency calculated; water conservation measures identified | Basic water budget; efficiency estimated; limited conservation measures | Incomplete water budget; | 10% |
| Economic & sustainability analysis | Detailed cost estimation; benefit cost analysis; environmental impacts assessed; SDG linkages explicit | Basic cost estimation; limited economic analysis; sustainability mentioned | No economic analysis; environmental aspects ignored; no sustainability perspective | 10% |

**Continuous Internal Evaluation (CIE)**

(i)The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii)Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| RAILWAY, HARBOUR AND AIRPORT INFRASTRUCTURE ENGINEERING | | | |
|---|---|---|---|
| Course Code | 1BIF604 | Scheme | 2025 |
| Type of Course | Profession Core Course (PCC) | Semester | VI |
| Teaching Hours/Week(L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type(SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2 – Understand**): Explain the significance of multi-modal transportation systems, permanent way components, railway alignment design, and geometric design principles.
2. **CO2 (L3 -- Apply):** Design and analyze railway track construction, material requirement calculations, and evaluate track maintenance strategies for different soil conditions.
3. **CO3 (L4 -- Analyze):** Understand harbour planning, design principles, coastal structures, and apply tunneling methods in harbour and underground infrastructure.
4. **CO4 (L4 -- Analyze):** Design airport runway and taxiway systems using ICAO standards, conduct wind rose diagram analysis, and apply geometric design principles.
5. **CO5 (L4 -- Analyze):** Integrate sustainable transportation concepts across railway, harbour, and airport infrastructure to achieve SDG objectives.

**Module-1**

**Railway Infrastructure Planning:**

- Significance of Road, Rail, Air and Water transports – Coordination of all modes to achieve sustainability.
- Elements of permanent way – Rails, Sleepers, Ballast, rail fixtures and fastenings, – Track Stress, coning of wheels, creep in rails, defects in rails
- Route alignment surveys, conventional and modern methods- – Soil suitability analysis – Geometric design of railways, gradient, super elevation, widening of gauge on curves- Points and Crossings (Explanation & Sketches of Right and Left hand turnouts only).

**Linked COs: CO1,C05** **Number of Hours Required (CI): 8 hrs**

**Module-2**

**Railway Construction and Infrastructure Maintenance:**

- Earthwork – Stabilization of track on poor soil,
- Calculation of Materials required for track laying
- Construction and maintenance of tracks – Modern methods of construct ion & maintenance
- Railway stations and yards and passenger amenities
- Urban rail – Infrastructure for Metro, Mono and underground railways.

**Linked COs: CO1, CO2,CO5** **Number of Hours Required (CI): 8 hrs**

**Module-3**

**Harbour and Tunnel Infrastructure Engineering:**

- Definition of Basic Terms: Planning and Design of Harbours: Requirements, Classification, Location and Design Principles.
- Harbour Layout and Terminal Facilities, Coastal Structures, Inland Water Transport.
- Wave action on Coastal Structures and Coastal Protection Works.
- Tunneling: Introduction, size and shape of the tunnel, tunneling methods in soils, tunnel lining, tunnel drainage and ventilation.

**Linked COs: CO3,CO5** **Number of Hours Required (CI): 8 hrs**

**Module-4**

**Airport Infrastructure Planning:**

- Air transport characteristics, airport classification,
- air port planning: objectives, components, layout characteristics, and socio-economic characteristics of the catchment area,
- criteria for airport site selection and ICAO stipulations,
- Typical airport layouts, Parking and circulation area.

**Linked COs: CO4, CO5** **Number of Hours Required (CI): 9hrs**

**Module-5**

**Airport Infrastructure Design:**

- Runway Design: Orientation, Wind Rose Diagram,
- Runway length, Problems on basic and Actual Length,
- Geometric design of runways, Configuration and Pavement Design Principles,
- Elements of Taxiway Design,
- Airport Zones, Passenger Facilities and Services,
- Runway and Taxiway Markings and lighting.

**Linked COs: CO4, CO5** **Number of Hours Required (CI): 9 hrs**

**Suggested Learning Resources**

**Textbooks:**

1. Srinivasan, R. (2012). Highway, Railway and Airport Engineering. Charotar Publishing House.
2. Khanna, S.K., & Justo, C.E.G. (2016). Railway Engineering. Nem Chand Bros.
3. Saxena, R., & Baghaee Moghaddam, A. (2017). Principles of Transportation Engineering. Phi Learning.
4. Horonjeff, R., & McKelvey, F.X. (2020). Planning and Design of Airports (5th ed.). McGraw-Hill.
5. Sinha, A.K., & Singh, P. (2015). Harbour, Dock and Tunnel Engineering. Khanna Publishers.

**Reference Books:**

1. Vijaykumar, K. (2018). Railway and Airport Engineering with Harbour Design. Khanna Publishers.
2. Verma, M.P. (2014). Tunnelling in Difficult Ground Conditions. Oxford University Press.
3. ICAO (2023). Aerodrome Design Manual (Doc 9157). International Civil Aviation Organization.
4. MoRTH (2023). Manual of Specifications and Standards for Two-Laning with Paved Shoulders. Ministry of Road Transport and Highways, Government of India.
5. IRC:37-2018. Guidelines for Design of Flexible Pavements. Indian Roads Congress.

**Web links and e-Resources:**

- NPTEL: Railway Engineering, Airport Engineering, Transportation Engineering (https://nptel.ac.in)
- ICAO website: Aerodrome standards and recommended practices (https://www.icao.int)
- IRC website: Indian Roads Congress standards and guidelines (https://www.ircweb.org

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.
Suggested Innovative Delivery Methods may include(but are not limited to):

- Flipped Classroom
- Problem-Based Learning(PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:**
The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks.**
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks..**

**Continuous Comprehensive Assessments (CCA)+Internal Assessment Test (IA)= Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Industrial Visit to railway workshops.
- Industrial visit reports (railway workshops, airport operations, port facilities)
- Field surveys for track condition and runway pavement assessment
- Video analysis of accident investigations
- Case study presentations (major infrastructure projects: Western Dedicated Freight Corridor, Bangalore Airport T2, Jawaharlal Nehru Port)
- Case Study Presentation
- Seminars/Quizz (To assist in GATE Preparations)
- Assignment(at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farm work (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW)and Self Learning (SL)components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours/Semester |
|---|---|---|
| 1. | **Railway Geometric Design Project:** Groups design 5-10 km railway corridor including alignment, gradients, curves, super-elevation calculations, and material quantification using IRC guidelines. | 24 |
| 2. | **Airport Runway Design with Wind Analysis:** Design runway orientation using wind rose diagram, calculate runway length for given aircraft and conditions, prepare typical cross-sections and marking layout. | 24 |
| 3. | **Harbour Layout Planning:** Develop harbour layout with breakwaters, berths, and terminal facilities; assess wave action and coastal protection requirements. | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours/Semester |
|---|---|---|
| 1. | **MOOC + GATE/Data- Driven Track**: Complete mapped NPTEL/MOOC modules, solve GATE-style and open-ended analysis problems involving probability and statistics in civil Engineering, culminating in an integrated open-book test. | 24 |
| 2. | Literature review on emerging tools; reflective learning journal | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

**1. Sample Rubrics-Integrated Design Mini-Project**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| **Survey Data & Field Work** | Comprehensive field survey using modern instruments; systematic collection; complete documentation | Adequate field work; mostly systematic; minor data gaps | Limited field work; incomplete data; disorganized | 20% |
| **Technical Analysis & Design Calculations** | Accurate calculations; correct IRC/ICAO application; proper alignment and geometric design | Mostly accurate; minor errors; generally correct standards | Several errors; incomplete standards application | 25% |
| **Engineering Drawings & CAD** | Professional cross-sections, plans, profiles; properly labeled; accurate to scale; clear representation | Generally accurate drawings; minor clarity issues | Incomplete drawings; missing labels; scale issues | 20% |
| **Design Justification & Alternatives** | Clear theory linkage; realistic recommendations; considers safety and sustainability; multiple options analyzed | Reasonable justifications; partial analysis | Mostly descriptive; weak justification | 20% |

| | | | | |
|---|---|---|---|---|
| **Presentation & Documentation** | Well-organized report; labeled figures/tables; professional layout; proper references; compliance with guidelines | Generally organized; minor clarity issues | Disorganized; incomplete documentation | 15% |

**Continuous Internal Evaluation (CIE):**

i. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

ii. Out of 50marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

iii. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

iv. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

# Profession Elective Course –II Syllabus

| DEEP FOUNDATION ENGINEERING FOR INFRASTRUCTURE | | | |
|---|---|---|---|
| Course Code | 1BIF605A | Scheme | 2025 |
| Type of Course | Profession Elective Course (PEC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90 (42:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2–Understand):** Explain types, construction methods, load transfer mechanisms and design philosophies of deep foundations used in infrastructure projects.
2. **CO2 (L3 – Apply):** Apply static analysis methods to determine axial load capacity of single piles and pile groups in various soil conditions.
3. **CO3 (L4 – Analyze):** Analyze lateral load resistance, group efficiency and settlement behavior of pile foundations under infrastructure loading.
4. **CO4 (L4 –Analyze):** Analyze design requirements for deep foundations in challenging soil conditions, seismic zones and expansive soils for resilient infrastructure.
5. **CO5 (L3 – Apply):** Design and proportion deep foundation systems for bridges, high-rise buildings and other infrastructure considering codes and sustainability.

**Module-1**

**Pile types, construction methods and load transfer**

- Classification of deep foundations: piles (displacement vs non-displacement, end-bearing, friction, combination), drilled shafts, well foundations.
- Pile materials and types: timber, concrete (precast/prestressed, cast-in-situ), steel (H-sections, tubular), composite piles; advantages, limitations and selection criteria for infrastructure.
- Construction methods: driven piles (drop hammer, diesel hammer, hydraulic hammer, vibratory), bored piles (auger boring, rotary drilling, slurry stabilization), sequence, equipment, quality control.
- Load transfer mechanisms: end-bearing, skin friction (shaft resistance), negative skin friction (down drag); factors affecting load transfer (soil type, installation method, pile surface)
- Load testing: static load test, dynamic load test (PDA), integrity testing (PIT, CSL); interpretation and acceptance criteria (IS: 2911).

**Linked COs**: **CO1,CO2 & CO5** **Number of Hours Required (CI)**: **8 hours**

**Module-2**

**Axial capacity of single piles**

- Static pile capacity formulas: IS:2911 method, α-method (cohesive soils), β-method (cohesion less soils), λ-method; end-bearing and shaft resistance components
- Soil-pile interaction: adhesion factor (α) for clays, friction angle reduction (K, δ) for sands; effect of pile installation on soil properties.
- Pile capacity in layered soils, soft clay deposits, karstic formations; limiting values and empirical correlations.
- Factor of safety in pile design: static analysis, dynamic analysis, load test results; group reduction factors

**Linked COs: CO2 & CO3** **Number of Hours Required (CI): 8 hours**

**Module-3**

**Pile groups, settlement and lateral load resistance**

- Pile groups: efficiency, spacing requirements, block failure concept; capacity of pile groups in clays and sands (IS: 2911).
- Settlement of pile groups: elastic settlement, consolidation settlement, group settlement ratio; methods for estimation.
- Negative skin friction and downdrag: causes (fill settlement, organic soil compression
- Lateral load capacity: p-y curves method (conceptual), Broms' method for short and long piles; lateral resistance in cohesive and cohesion less soils.
- Pile load-deflection characteristics, fixity conditions, design for lateral loads in bridges and buildings.

**Linked COs: CO3 & CO4** **Number of Hours Required (CI): 8 hours**

**Module-4**

**Well foundations, caissons and drilled shafts**

- Well foundations: components (dredge hole, cutting edge, steining, bottom plug, topping), sinking methods (open, double wall).
- Forces acting on wells: self-weight, skin friction, earth pressure, water current forces; scour depth estimation (IS: 6403).
- Tilt and shift of wells: causes, permissible limits, remedial measures (jetting, compressed air, eccentric loading
- Pneumatic caissons and box caissons: construction procedure, dewatering, compressed air effects (caisson disease).
- Drilled shafts (bored piles): construction sequence, casing, concreting, integrity testing; design considerations for large diameter shafts

**Linked COs: CO1, CO2 & CO4** **Number of Hours Required (CI): 9 hours**

**Module-5**

**Design in special conditions, instrumentation and case studies**

- Deep foundations in expansive soils, collapsible soils and seismic zones: special provisions (IS: 14593, IS: 6403), batter piles, soil improvement integration.
- Offshore and marine foundations: scour protection, cyclic loading, corrosion protection; monopoles for wind turbines.
- Instrumentation in deep foundations: strain gauges, inclinometers, piezometers; monitoring tilt, settlement and pore pressure.
- Case studies: bridge piers, high-rise buildings, metro tunnels; lessons on failures and sustainable practices (SDG 9, 11).

**Linked COs: CO4 & CO5** **Number of Hours Required (CI): 9 hours**

**Suggested Learning Resources Textbooks:**

1. V.N.S. Murthy, Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering.
2. Braja M. Das, Principles of Foundation Engineering (SI Edition)
3. Swami Saran, Analysis and Design of Substructures.

**Reference Books:**

1. IS: 2911 (Parts 1–4) – Design and Construction of Pile Foundations.
2. IS:14593 – Design of Well Foundations.

**Web links and e-Resources:**

1. NPTEL Foundation Engineering (IIT Madras).
2. NPTEL Advanced Foundation Engineering (IIT Kharagpur).

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.
Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:**
The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | **Integrated Deep Foundation Mini-Project**: Design pile foundation for a bridge pier/high-rise column using given soil data; calculate single/group capacity, settlement, check lateral capacity. Include sustainability reflection (e.g., recyclable pile materials). | 24 |
| 2. | **Case Study**: Analyze 2–3 real deep foundation projects | 24 |
| 3. | **Site Observation Portfolio:** virtual/field visit to piling site; report on construction challenges, instrumentation and lessons | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | **MOOC + GATE/Data- Driven Track**: Complete mapped NPTEL/MOOC modules, solve GATE-style and open-ended analysis problems involving probability and statistics in civil engineering, culminating in an integrated open-book test. | 24 |
| 2. | Literature review on emerging tools; reflective learning journal | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

**1. Sample Rubrics -Integrated Design Mini-Project**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Problem definition & data | Clear, relevant civil-engineering question; data source and Limitations documented. | Mostly clear; minor gaps in context or data description. | Vague question or poorly documented data. | 10% |
| Data processing & descriptive statistics | Correct cleaning, visualization, and computation of key measures; patterns clearly highlighted. | Mostly correct; minor computational/formatting errors. | Significant errors, missing key measures or plots. | 25% |
| Probabilistic modelling (distributions, inference) | Appropriate distributions and tests used; assumptions stated; results interpreted in context. | Reasonable choice of models; some assumptions implicit; interpretation mostly sound. | Inappropriate or poorly justified models; limited interpretation. | 30% |

| | | | | |
|---|---|---|---|---|
| Civil engineering insight / risk framing | Clear link to design/assessment decisions, safety and uncertainty; limitations discussed. | Some discussion of implications; limited treatment of limitations. | Minimal civil-engineering interpretation on beyond numbers. | 20% |
| Report & communication | Well-structured report, clear figures/tables, reproducible calculations; effective brief presentation. | Acceptable structure; some clarity issues; presentation adequate. | Disorganized or incomplete report; weak presentation. | 15% |

**Continuous Internal Evaluation (CIE):**

i. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
ii. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
iii. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
iv. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| CIVIL AND INFRASTRUCTURE ENGINEERING CODES, QUALITY, AND COMPLIANCE | | | |
|---|---|---|---|
| Course Code: | 1BIF605B | Scheme | 2025 |
| Type of Course | Profession Elective Course (PEC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90 (42:0:0:48) | SEE Marks | 50 |
| Credits | 03 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. CO1 (L2 – Understand): Understand key Indian Standards (IS codes), National Building Code (NBC), and their application in civil and infrastructure projects.
2. CO2 (L3 – Apply): Apply quality control, assurance, and testing procedures for construction materials and processes.
3. CO3 (L4 - Analyze): Analyze compliance requirements for safety, environmental regulations, and sustainable infrastructure development.
4. CO4 (L5 - Evaluate): Evaluate case studies of code non-compliance and quality failures in real projects.
5. CO5 (L6 – Create): Develop compliance checklists and audit reports for infrastructure projects.
6. CO6 (L6 – Create): Design sustainable quality management plans integrating codes and green standards.

**Module-1**

**Introduction to Codes & Standards:**

- Scope and evolution of codes in civil/infra engineering.
- Bureau of Indian Standards (BIS): organization, role, code development process.
- National Building Code (NBC 2016): structure, parts (planning, fire safety).
- Regulatory bodies: CPWD guidelines, state PWDs, local bylaws.
- Infrastructure codes: IRC (roads IRC:37, bridges IRC:SP), CPHEEO water supply manual.
- IS code classification: cement (IS 269 OPC), aggregates (IS 383/2386), concrete mix (IS 10262), steel (IS 800).
- Basic code reading and amendments.

**Linked COs: CO1.** **Number of Hours (CI) = 8 hours.**

**Module-2**

**Building & Structural Codes**

- NBC detailed parts: structural safety (Part 6), fire safety (Part 4), services (plumbing/electrical).
- RCC design: IS 456:2000 limits, durability, workmanship.
- Steel structures: IS 800:2007 design philosophy, connections.
- Masonry: IS 1905 materials, stability.
- Seismic provisions: IS 1893 (response spectrum), IS 13920 (ductile detailing).
- Wind loads: IS 875 Part 3 velocity/pressure coefficients.
- Code interpretation: examples, software aids (STAAD), compliance checklists.

**Linked COs: CO1, CO3.** **Number of Hours (CI) = 8 hours.**

**Module-3**

**Quality Management Systems**

- Quality control (QC) vs assurance (QA): definitions, differences.
- ISO 9001:2015 for construction: clauses, certification process.
- Total Quality Management (TQM): principles, PDCA cycle implementation.
- Six Sigma basics: DMAIC, defect reduction in projects.
- Statistical QC: control charts, acceptance sampling (IS 2500).
- Material acceptance criteria: batch testing, vendor qualification.
- Case studies: TQM in Indian infra projects.

**Linked COs: CO2.** **Number of Hours (CI) = 8 hours.**

**Module-4**

**Testing & Compliance Procedures**

- Concrete testing: compressive (IS 516), flexural, cube/cylinder prep.
- Soil tests: grain size (IS 2720 Part 4), compaction (Part 8), CBR.
- Bitumen tests: penetration/softening (IS 1201-1220 series).
- Non-Destructive Testing (NDT): rebound hammer (IS 13311), ultrasonic pulse velocity (UPV IS 516), core extraction (IS 456 Cl 17).
- Compliance documentation: test formats, proformas, digital logs.
- Third-party audits: NABL labs, frequency, reporting.

**Linked COs: CO2, CO3, CO5.** **Number of Hours (CI) = 8 hours.**

**Module-5**

**Infrastructure Regulations & Sustainability**

- Environmental regulations: EIA 2006 notification, scoping/process.
- Pollution control: CPCB air/water standards, noise limits.
- Waste management: C&D waste rules 2016, hazardous waste.
- Green buildings: IGBC/LEED rating systems, criteria (energy/water).
- Resilient infrastructure: SDG 9/11 alignment, climate adaptation.
- Safety codes: OSHA guidelines, NBC fire (Part 4), labour laws (BOCW Act).
- Life Cycle Assessment (LCA) basics: embodied energy, ISO 14040.
- Case studies: IIT/NIT projects (e.g., green campuses), failures/lessons.

**Linked COs: CO1, CO3, CO4, CO5, CO6.** **Number of Hours (CI) = 10 hours.**

**Suggested Learning Resources**

**Text books:**

1. National Building Code of India 2016 (BIS).
2. IS 456:2000 - Plain and Reinforced Concrete (BIS).
3. Construction Quality Management by Paul I. Chinowsky.

**Reference Books**

1. SP 16: Design Aids for IS 456 (BIS).
2. IRC Codes for Roads and Bridges.
3. ISO 9001:2015 Standards.

**Web links and Video Lectures (e-Resources):**

1. NPTEL: Construction Quality Control & Management.
2. BIS Portal: https://www.bis.gov.in for IS codes.
3. NBC 2016 PDF downloads from official sites.

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching- learning process and facilitate the achievement of course outcomes.

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**
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- Literature Review
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- Assignment (at RBL3, RBL4, or RBL5 levels)
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**Students' activities for TW/SL under NCrF: Samples only**

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| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | **Civil Data Analytics Mini-Project**: Collect or obtain a civil dataset (e.g., concrete strength, rainfall, traffic, settlement), perform descriptive statistics, fit distributions, and formulate at least one reliability-based engineering question with a report. | 24 |
| 2 | **Hydrologic / Traffic / Infrastructure Case Study**: Analyze real-world problems (floods, drainage, traffic demand, or code compliance issues), apply probability tools, return period analysis, and present risk-informed conclusions. | 24 |
| 3 | **Programming & Tools Workbook / Technical Exercise**: Develop a digital workbook using Excel/Python/MATLAB/GIS tools for statistical analysis, regression, confidence intervals, and engineering decision-making. | 24 |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| 1 | **MOOC / NPTEL / GATE Track**: Complete structured online modules and solve application-oriented civil engineering problems (probability, hydrology, quality, etc.), including an open-book or practice test. | 24 |
| 2 | **Literature Review + Reflective Journal**: Study recent research papers, IIT/NIT case studies, or emerging tools (AI, GIS, reliability engineering) and document insights in a structured report. | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

1. **Sample Rubrics - Code Compliance Audit Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Conceptual understanding | Accurate prefab good with SDG (CO1). | Mostly correct, minor errors. | Partial gaps. | 15 % |
| Design coverage | Joins components (CO2). | Some parts, errors. | Partial. | 20 % |
| Analysis depth | In-depth with sketches (CO3). | Some explanation. | Descriptive. | 20 % |
| Sustainability linkage | Links prefab SDG 9/11 infra reflection (CO4). | Brief mention. | No link. | 15 % |
| Portfolio | Well-structured modules. | Generally organized. | Disorganized. | 15 % |

| | | | | |
|---|---|---|---|---|
| Techno-economic feasibility | Logical prefab steps (CO5, CO6). | Mainly correct. | Partial/wrong. | 15 % |

**Continuous Internal Evaluation (CIE):**

i. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
ii. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
iii. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
iv. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| SUSTAINABLE GROUND IMPROVEMENT TECHNIQUES FOR BUILDINGS & INFRASTRUCTURE PROJECTS | | | |
|---|---|---|---|
| Course Code: | 1BIF605C | Scheme | 2025 |
| Type of Course | Profession Elective Cours (PEC) | Semester | VI |
| Teaching Hours/Week (L: T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI(L/T): LI (P): SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 03 | Total Marks | 100 |
| Examination type (SEE) | **Theory** | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2 – Understand):** Understand the need, classification, and sustainability aspects of ground improvement techniques for infrastructure projects.
2. **CO2 (L3 – Apply):** Apply mechanical and hydraulic modification methods for densifying and stabilizing weak soils in buildings and roads.
3. **CO3 (L3 – Apply):** Analyze chemical and thermal stabilization techniques suitable for sustainable urban infrastructure.
4. **CO4 (L4 – Analyze):** Implement geosynthetic reinforcement systems for embankments, retaining walls, and foundations.
5. **CO5 (L3 – Apply):** Evaluate case studies of ground improvement in Indian infrastructure aligning with environmental sustainability.
6. **CO6 (L4 – Analyze/Evaluate):** Apply concepts from ground improvement case studies in Indian infrastructure for sustainable design practices.

**Module-1**

**Weak Soils and Need for Ground Improvement:**

- Nature of weak deposits: soft clays, loose sands, reclaimed land, uncontrolled fills, collapsible and expansive soils; typical problems (settlement, instability, liquefaction, bearing failure).
- Engineering properties relevant to ground improvement: compressibility, shear strength, permeability, in-situ density; overview of characterization and site investigation.
- Need and objectives of ground improvement; classification of ground modification techniques (mechanical, hydraulic, physical/chemical, inclusions/reinforcement, bio- and nature-based).
- Sustainability concepts in ground improvement: embodied energy, carbon footprint, use of industrial by-products (fly ash, GGBS, cementitious wastes), circular use of materials.

**Linked COs: CO1, partial CO2** **Number of Hours Required (CI):8 hours**

**Module-2**

**Mechanical and Densification Techniques:**

- Shallow and deep compaction: principles of compaction, field compaction methods, dynamic compaction, vibro-compaction/flotation, compaction piles; applications for highways, yards, and shallow foundations.
- Preloading and surcharge methods: concepts of consolidation, preloading, staged construction; field performance and limitations.
- Stone columns and sand compaction piles: mechanism, layout, load sharing, settlement reduction, basic design considerations and simple charts.
- Sustainability aspects: energy consumption of densification, re-use of local granular materials, noise and vibration impacts on built environments.

**Linked COs: CO2, CO3, CO4** **Number of Hours Required (CI):8 hours**

**Module-3**

**Hydraulic and Electro-kinetic Methods:**

- Groundwater and seepage behavior relevant to dewatering and drainage; filter requirements and drainage criteria.
- Dewatering methods for excavations and tunnels: well points, deep wells, vacuum dewatering, cutoffs; design principles at introductory level, construction and monitoring.
- Vertical drains and preloading: sand drains, prefabricated vertical drains (PVDs), spacing and time-rate of consolidation concepts (no derivations beyond basics).
- Electro-osmosis and electro-kinetic enhancement for fine-grained soils: basic principles, applications, limitations.
- Sustainability and resilience: impact of long-term pumping on aquifers, energy use, combining drainage with nature-based solutions (bio-drainage, recharge).

**Linked COs: CO2, CO3, CO4** **Number of Hours Required (CI):8 hours**

**Module-4**

**Chemical, Thermal and Bio-based Techniques**

- Soil stabilization by admixtures: cement, lime, fly ash, industrial by-products; reaction mechanisms, mix design concepts, quality control, durability.
- Grouting: objectives, types of grouts (suspension, chemical), injection principles, groutability, pressure criteria, equipment, typical applications under foundations, in tunnels and dams.
- Ground freezing (intro): principle, temporary support for shafts/tunnels, energy and environmental considerations.
- Bio- and nature-based ground improvement: overview of microbial-induced calcite precipitation (MICP), vegetation and root reinforcement, bio-polymers; opportunities and limitations in Indian context.
- Sustainability and life-cycle perspective: comparison of carbon intensity, resource use and end-of-life issues for chemical vs bio- and mechanical methods.

**Linked COs: CO2, CO3, CO4** **Number of Hours Required (CI):8 hours**

**Module-5**

**Reinforcement, Geosynthetics, Instrumentation and Case Studies**

- Reinforced soil and inclusions: concept of soil reinforcement, inclusions and confinement; applications for retaining walls, embankments on soft ground, and building foundations.
- Geosynthetics for ground improvement: geotextiles, geogrids, geomembranes, geocells, geocomposites; functions (separation, reinforcement, filtration, drainage, barrier) and typical design considerations.
- Ground improvement below buildings and infrastructure: shallow and deep foundations on improved ground, tank farms, rails, pavements, coastal and port structures; integration with seismic and liquefaction mitigation measures.
- Field instrumentation and monitoring of improved ground: settlement plates, piezometers, inclinometers, load tests; interpretation of data to check performance and update designs.
- Case studies with sustainability focus: Indian and global examples where ground improvement enabled brownfield redevelopment, coastal protection, flood-resilient transport corridors, and reduced material consumption; explicit linkages to SDG 9, 11, 13.

**Linked COs: CO2, CO3, CO4, CO5** **Number of Hours Required (CI):10 hours**

**Suggested Learning Resources**

Text books:

1.Purushotham Raj, P., “Ground Improvement Techniques.” Laxmi Publications.
2.Moseley, M.P. & Kirsch, K., “Ground Improvement.” 2nd Ed., CRC Press.
3.Bowles, J.E., “Foundation Analysis and Design.” McGraw Hill.

Reference Books:

1.Hausmann M.R., Engineering Principles of Ground Modification, McGraw Hill.
2.IS 1498:1970, “Classification and Identification of Soils for General Engineering Purposes,” Bureau of Indian Standards, New Delhi.
3.IS 2131:1981, “Method for Standard Penetration Test for Soils,” BIS, New Delhi.
4.IS 8009 (Part 1):1976, “Code of Practice for Calculation of Settlement of Foundations,” BIS, New Delhi.

**Web links and Video Lectures (e-Resources):**

1.D.K.Baidya,Ground Improvement, NPTEL, IIT Kharagpur, India, 2021. [Online].
Available: https://nptel.ac.in/courses/105105210
2.G. L. Sivakumar Babu, *Ground Improvement Techniques*, NPTEL, IISc Bangalore, India. [Online].
Available: https://nptel.ac.in/courses/105108075.

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- **Flipped Classroom** – Pre-class videos/notes; in-class GIT problem solving.
- **PBL** – Group work on real weak-soil project scenarios with GIT selection.
- **Case-Based Teaching** – Analyze Indian and global ground-improvement success/failure cases.
- **Simulation / Virtual Labs** – Simple tools/demos to visualize settlement and pore-pressure response.
- **Industry Expert / Visits** – Talks and visits/virtual tours to ground-improvement project sites.
- **ICT-Enabled Teaching** – LMS, NPTEL GIT courses, IS codes, design aids, Excel and quizzes.
- **Role Play** – Simulated multi-stakeholder discussion on choosing a sustainable GIT scheme.

**Assessment Structure:** The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**..

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**
A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.
In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**
It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**
**Students' Learning activities:** These activities shall be:
**Course Project** – Mini smart-city intervention plan for a selected area (problem, data, smart solution, basic feasibility).

- **Course Project** – Conceptual GIT scheme for a selected project with method selection, basic sizing and sustainability comparison.
- **Case Study Presentation** – Group presentation on Indian/global GIT projects highlighting soils, methods, performance and sustainability.
- **Programming / Calculation Assignment** – Excel-based calculations for consolidation, settlement and simple stone-column parameters.
- **Tool / Software Exploration** – Guided use of demo PLAXIS/Geo5 (or similar) for idealised GIT problems with a short note.
- **Literature Review** – Study of emerging/bio-based GIT, industrial by-products and nature-based solutions with SDG 9, 11, 13 links.
- **Open Book Test** – Scenario-based questions using soil profiles, IS code excerpts and design charts to justify GIT options.
- **GATE-style / Aptitude Test** – Numericals on consolidation, compaction and bearing capacity on improved ground.
- **Assignment** – Reflective comparison of deep foundations vs GIT for a project in terms of cost and sustainability.
- **Innovative Activity** – "Sustainability audit" comparing GIT options for a corridor on materials, energy and carbon.
- **MOOCs / Online Platforms** – NPTEL Ground Improvement courses with reflection linked to Indian case studies.

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which inclu Course instructions (CI- 42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must comp minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | Sustainable GIT Portfolio Document: Document 2–3 local/regional projects using GIT (e.g., stone columns for metro viaducts, PVDs for highways, lime stabilization for buildings) with photos/sketches, soil conditions, GIT details, performance data and sustainability notes. | 24 |
| 2 | GIT Case Study: Short case on an infrastructure project on weak soils (embankment on soft clay, building on loose sand) describing GIT scheme, qualitative settlement/stability improvement and monitoring. | 24 |
| 3 | GIT Reflection Note: Literature-based note on a significant Indian failure/issue due to poor ground, focusing on causes, suggested GIT mitigation and lessons for sustainable design. | 24 |

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | MOOC + GIT Track: Complete mapped NPTEL/SWAYAM modules on Ground Improvement; solve associated quizzes and a short open-book task applying them to a real/assumed project. | 24 |
| 2 | Literature Review on GIT + Reflective Journal: Review IS codes, NPTEL notes and recent papers on sustainable GIT; maintain a journal linking them to course modules and SDG 9, 11, 13. | 24 |

**A. Rubrics for Students learning activities -TW/SL - (Samples)**

**1.Integrated Design Mini-Project – Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Field/Literature Data Collection & Coverage (CO1, CO2) | Reviews multiple real projects/sites; systematically records soil profiles, GIT details (e.g., spacing, materials), performance data with references/locations/dates; safety/ethics considered. | Reviews 2–3 projects; main soil/GIT details present; minor gaps in data/sources. | Limited projects or desk-based only; observations/sources incomplete or unsystematic. | 10% |
| Technical Description & Accuracy (CO1, CO3) | Correct identification of weak soils, GIT types/mechanisms; clear descriptions of properties, design parameters, performance using appropriate terms (e.g., area replacement ratio). | Mostly correct; minor misclassification or weak terminology, but intent clear. | Frequent misidentification; very limited or incorrect terminology. | 25% |

| | | | | |
|---|---|---|---|---|
| Engineering Interpretation (GIT selection, design, performance) (CO2, CO3) | Clearly relates site conditions to GIT choice, settlement/stability reduction, monitoring; realistic quantitative/qualitative comments with basic checks. | Provides some links to design/performance; comments partly relevant but not fully justified. | Little/no engineering interpretation; mostly descriptive. | 30% |
| Sustainability/SDG Linkage & Reflection (CO4; SDG 9, 11, 13) | Explicitly connects to low-carbon/resilient infra (e.g., by-product use, life-cycle, climate adaptation) with thoughtful analysis/reflection. | Mentions sustainability/SDG briefly; links somewhat general. | No or very superficial mention of sustainability/resilience. | 20% |
| Portfolio Organisation & Presentation | Well-structured document/digital portfolio; clear sections, labelled figures/charts (e.g., settlement plots), maps, references; language clear/concise. | Generally organised; some missing labels or minor clarity issues. | Disorganised; hard to follow; figures poorly labelled or missing. | 15% |

**Continuous Internal Evaluation (CIE):**

(i)The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii) Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| WORKPLACE SAFETY, HAZARDS ANALYSIS AND MITIGATION IN BUILDINGS & INFRASTRUCTURECONSTRUCTION | | | |
|---|---|---|---|
| Course Code | 1BIF605D | Scheme | 2025 |
| Type of Course | Professional Elective Course (PEC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | 3:0:0 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | 42:0:0:48 | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

**At the end of the course, the student will be able to**:

1. CO1 (L2) Understand safety policies, hazard identification, and accident causation in construction environments.
2. CO2 (L3) Apply ergonomic principles and human error analysis to mitigate workplace risks in infrastructure projects.
3. CO3 (L3) Identify fire, electrical, and health hazards specific to buildings and infrastructure sites.
4. CO4 (L4) Analyze PPE requirements and health management for sustainable construction safety.
5. CO5 (L3) Evaluate construction-specific hazards like excavations, scaffolding, and heavy equipment in buildings/infrastructure.
6. CO6 (L4) Assess risk mitigation strategies, safety audits, and compliance with ISO/OSHA/BIS for resilient infrastructure (SDG 9, 11).

**Module-1**

**Safety Fundamentals & Hazards**

- Scope of workplace safety in buildings & infrastructure construction; history, national safety policy (India), OSHA/BIS/ISO standards.
- Accident causation theories, investigation methods (root cause, fault tree), supervisory role; cost of accidents in construction.
- Hazard identification in sites: slips/trips, falls, struck-by; infrastructure-specific (cranes, excavations, tunnels)

**Linked COs: CO1, partial CO5, CO6** **Number of Hours: 08 Hrs**

**Module-2**

**Ergonomics & Risk Analysis**

- Ergonomics: task analysis, workspace design, visual/ergonomic standards; preventing musculoskeletal hazards in construction.
- Hazard cognition, human error (fault tree analysis), emergency response; job hazard analysis (JHA) for infrastructure tasks.
- Risk assessment: qualitative/quantitative; safe work permits, safety programs for buildings/bridges/roads.

**Linked COs CO2, CO6.** **Number of Hours: 08 Hrs**

**Module-3**

**Fire, Electrical & Health Safety**

- Fire prevention: triangle, classification, extinguishers; detection in enclosed infrastructure (tunnels, buildings).
- Electrical safety: hazards, grounding, PPE; product safety in construction equipment.
- Health at workplace: disease spread, emergencies; chemical/biological hazards in construction (dust, silica, wastewater)

**Linked COs CO3, partial CO4.** **Number of Hours: 08 Hrs**

**Module-4**

**PPE & Occupational Health**

- PPE types/selection/advantages for civil works (helmets, harnesses, respirators); maintenance, training.
- Exposure effects/treatment: noise, vibration, chemicals in cement/RMC plants, infrastructure sites.
- Environment management plans (EMP) for safety/sustainability; industrial hygiene in water treatment/construction.

**Linked COs CO4, CO6.** **Number of Hours: 08 Hrs**

**Module-5**

**Construction Hazards & Mitigation**

- Site hazards: scaffolding/ladders, excavations, cranes, demolition, tunnels; work at height, fragile roofs.
- Safety organization: audits, training, zero-accident concepts; lead/lag indicators for infrastructure projects.
- Mitigation: slope stability, seismic/landslide risks, resilient design (SDG 11/13); case studies on buildings/bridges.

**Linked COs CO1, CO5, CO6.** **Number of Hours: 08 Hrs**

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Construction Safety Management – Neeraj Jha, Pearson Education
2. Occupational Health and Safety in Construction Project Management – Helen Lingard & Steve Rowlinson, Routledge
3. Construction Safety Engineering Principles: Designing & Managing Safer Job Sites – Richard J. Coble, Jimmie Hinze, Theo C. Haupt.
4. Introduction to Health and Safety in Construction – Phil Hughes & Ed Ferrett (NEBOSH endorsed)

**Reference Books**:

1. Safety Management in Construction (Principles and Practice) – Khanna Publishers
2. Construction Safety Management Systems – Steve Rowlinson (ed.), Taylor & Francis
3. Health and Safety in Construction (HSG150) – UK HSE
4. Disaster Prevention and Mitigation of Infrastructure – Springer

**Web links and Video Lectures (e-Resources):**

1. NPTEL course: Safety in Construction (Prof. J. Uma Maheswari, IIT Delhi)/ nptel.ac.in/noc/courses/105102206.
2. NPTEL course: Safety In Construction Industry (Swayam2)
3. NPTEL course: Natural Hazards (IIT Roorkee).
4. NPTEL: Construction Safety & Hazard Management.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the CIE, a student must score at least 40% of 50 marks, i.e., 20 marks.
- To pass the SEE, a student must score at least 35% of 50 marks, i.e., 18 marks.
- Notwithstanding the above, a student is considered to have passed the course, provided the combined total of CIE and SEE is at least 40 out of 100 marks.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted, carrying a total of 25 marks.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

It is recommended to include a maximum of two learning activities as part of the CCA to foster the holistic development of students. These activities shall be:

Students' Learning activities: These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

| Term Work (TW) and Self Learning (SL) components in Number of Hours per semester | | |
|---|---|---|
| Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.) | | |
| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
| 1 | Document hazards (falls, excavations, scaffolding, electrical, PPE non-compliance) at a local building/infrastructure site (bridge, metro, dam) with photos, hazard identification via JHA, risk ratings, and proposed mitigations (engineering/administrative/PPE); include compliance with BIS/OSHA. | 24 |
| 2 | Visit operational construction site or safety training facility, observe safety practices (audits, emergency drills, equipment checks), document with photos/flow diagrams, analyze a real incident (e.g., scaffolding collapse), critique root causes and lessons for resilient infrastructure. | 24 |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
| 1 | Self-learning modules on NPTEL/SWAYAM; completion of online certification courses. | 24 |
| 2 | Literature review on emerging technologies; reflective learning journal | 24 |

**Rubrics for Students learning activities -TW/SL - (Samples)**

**1. Integrated Design Mini-Project – Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Data collection and hazard identification (CO1, CO3) | Comprehensive site observations/photos, hazard catalog (falls, electrical, excavations) with JHA/fault tree, risk prioritization using matrix; context-specific to infrastructure project. | Adequate hazards identified via checklist; basic risk ratings; some gaps in documentation or analysis. | Limited/generic hazards listed; weak JHA or no risk prioritization. | 20% |
| Risk assessment and mitigation design (CO2, CO5) | Detailed controls (engineering, admin, PPE) with SOPs, feasibility (cost/time), implementation plan; optimized for site constraints demonstrated. | Basic mitigations proposed; SOPs outlined; limited optimization or feasibility checks. | Incomplete mitigations; missing key controls or plans. | 25% |
| Safety technology/standards selection (CO3) | Appropriate tools/methods (PPE, barriers, monitoring) selected with comparison (e.g., harness vs netting); compliance with OSHA/BIS justified technically. | Reasonable selection with basic justification; some standards referenced. | Selection unjustified; limited standards application. | 25% |
| Audit/compliance and reporting (CO4, CO6) | Full safety audit plan with checklists, regulatory gaps addressed (BIS/IS 3696); professional report with diagrams. | Basic audit elements; regulations mentioned. | Superficial audit; regulations overlooked. | 15% |
| Sustainability and reflection (CO6) | Links to resilient infrastructure/SDG 9/11; economic analysis, stakeholder reflection; innovative elements. | Basic sustainability noted; limited analysis. | No sustainability or reflection. | 15% |

Continuous Internal Evaluation (CIE)

(i)The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii)Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| ADVANCED REINFORCED CONCRETE STRUCTURES | | | |
|---|---|---|---|
| Course Code | 1BIF605E | Scheme | 2025 |
| Type of Course | Profession Elective Course (PEC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course Outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2 -- Understand):** Explain the fundamental principles of reinforced concrete design, including stress-strain relationships, failure modes, and limit state method as per Indian Standards (IS 456).
2. **CO2 (L3 -- Apply):** Design and analyse reinforced concrete beams under flexure, shear, and torsion using limit state design method and validate designs with code provisions.
3. **CO3 (L3 -- Apply):** Design reinforced concrete columns considering slenderness effects, biaxial bending, and various loading conditions as per Indian Standards.
4. **CO4 (L3 -- Apply):** Design and detail foundation systems including footings, pile foundations, and raft foundations for given soil and loading conditions.
5. **CO5 (L4 -- Analyze):** Analyse and design reinforced concrete structural systems including frames, slabs, and shear walls for combined loading conditions.
6. **CO6 (L4 -- Analyze/Evaluate):** Evaluate structural behaviour during earthquakes, design earthquake-resistant structures with special detailing, and ensure durability and sustainability in RC design (SDG 9, SDG 11, SDG 12, SDG 13).

**Module-1**

**Fundamental Principles and Limit State Design**

- **Introduction:** Overview of reinforced concrete structures; advantages and limitations; historical evolution from working stress design to limit state design.
- **Material Properties:** Concrete -- grades, strength characteristics, stress-strain relationships, partial safety factors. Steel reinforcement -- types, properties, surface deformation requirements, stress-strain behaviour.
- **Limit State Approach:** Concept of limit states (serviceability and ultimate); factored loads; material safety factors; load combinations as per IS 456:2000.
- **Elastic Theory vs Limit State Method:** Comparison; advantages of limit state design; assumptions in reinforced concrete analysis.
- **Stress-Strain Relationships:** Stress blocks for design (rectangular, parabolic-rectangular); neutral axis position; moment of resistance; lever arm calculations.
- **Code Provisions (IS 456:2000):** Design principles, safety considerations, partial safety factors for materials, load factors; permissible stress limits for serviceability.
- **Design Philosophy:** Ductility, redundancy, and factor of safety in RC design; concept of design life and durability.

**Linked COs: CO1, CO6 |** **Number of Hours Required (CI)**: 8 **hours**

**Module-2**

**Design of Beams: Flexure, Shear and Torsion**

- **Flexural Design:** Analysis of rectangular and T-beams under bending; determination of neutral axis and moment of resistance; design of singly reinforced beams; design of doubly reinforced beams; special cases.
- **Redistribution of Moments:** Concept of moment redistribution in continuous beams; code limits for redistribution; advantages and limitations.
- **Deflection Control:** Span-to-effective depth ratio; requirements for controlling deflection; analysis of deflection in RC beams.
- **Shear Design:** Shear stress distribution; diagonal tension and failure mechanisms; design of shear reinforcement (stirrups); minimum shear reinforcement requirements.
- **Anchorage and Bond:** Development length; lapped splice; anchorage bond stress; hooks and bends; code provisions for splicing and anchorage.
- **Torsional Design:** Torsional stress calculation; combined flexure and torsion; design of reinforcement for torsion; code provisions and detailing requirements.
- **Practical Design Examples:** Step-by-step design procedures with code applications; verification of results; detailing sketches for beams.

**Linked COs: CO2, CO5, CO6 |** **Number of Hours Required (CI)**: 8 **hours**

**Module-3**

**Design of Columns and Struts**

- **Column Fundamentals:** Classification of columns (short, long, slender); axial load carrying capacity; effect of slenderness ratio on column capacity.
- **Slenderness Effects:** Euler formula; Indian code approach for long columns; effective length determination; slenderness limits.
- **Uniaxial Bending:** Design of columns under axial load and uniaxial bending; interaction diagrams; design charts and approximations.
- **Biaxial Bending:** Biaxial bending of columns; failure surfaces; design methods (reciprocal load method, contour method); code provisions.
- **Design of Reinforcement:** Minimum and maximum reinforcement limits; spacing requirements; longitudinal and lateral reinforcement (spirals/ties); anchorage details.
- **Special Cases:** Design of edge columns, corner columns, columns with unsymmetrical reinforcement.
- **Pedestals and Short Columns:** Design of short columns with bearing plates; transfer of loads; stress concentration effects.
- **Practical Examples:** Design procedures with calculations and detailing sketches.

**Linked COs: CO3, CO5, CO6 |** **Number of Hours Required (CI)**: 8 **hours**

**Module-4**

**Design of Slabs and Two-way Slab Systems**

- **One-way Slabs:** Design of simply supported, continuous, and cantilever slabs; bending moment and shear force analysis; reinforcement design and detailing.
- **Two-way Slabs:** Behaviour of two-way slabs; effective span; BC method (Pigeaud's method) for slab analysis; moment and shear force distribution.
- **Yield Line Method:** Principle of virtual work; failure mechanism; yield line patterns for various support conditions; design using yield line theory.
- **Flat Slabs and Flat Plates:** Advantages and disadvantages; design considerations; shear around columns (punching shear); drop panels and column heads.
- **Punching Shear:** Design for punching shear around columns and concentrated loads; code provisions; reinforcement requirements.
- **Ribbed and Waffle Slabs:** Structural arrangement; analysis and design; efficiency in span and load capacity.
- **Thermal and Shrinkage Reinforcement:** Minimum reinforcement requirements; distribution steel; provisions for temperature effects.
- **Serviceability Considerations:** Deflection control for slabs; crack control measures; detailing requirements for durability.
- **Practical Design Examples:** Complete design of slabs with reinforcement details.

**Linked COs: CO2, CO4, CO5, CO6 |** **Number of Hours Required (CI)**: 8 **hours**

**Module-5:**

**Foundation Design and Structural Systems**

- **Shallow Foundations:** Design of isolated footings (square, rectangular, circular); combined footings; strap footings; eccentrically loaded footings.
- **Design Principles:** Bearing capacity determination; serviceability requirements; settlement considerations; depth and width optimization.
- **Footing Design Procedure:** Pressure distribution under footing; bending moment and shear force determination; reinforcement design in two directions.
- **Deep Foundations:** Pile foundations -- types, load carrying capacity, spacing, pile cap design. Design of pile groups; group efficiency; interaction effects.
- **Raft Foundations:** Analysis and design of rigid and flexible raft foundations; buoyancy considerations; design for combined loading.
- **Structural Systems:** Portal frames; multi-storey frames; shear wall systems; dual systems for earthquake resistance.
- **Frame Analysis:** Analysis of statically indeterminate frames using moment distribution or stiffness method; design of frame members.
- **Shear Wall Design:** Function in buildings; design for lateral loads; detailing for ductility; connection to floor slabs and columns.
- **Seismic Design:** Seismic demand; ductile detailing for earthquake resistance; special moment-resisting frames (SMRF); special structural walls; confinement details.
- **Durability and Sustainability:** Concrete cover requirements; reinforcement detailing for durability; sustainable design practices; service life design; linkage to SDG 11 and SDG 12.
- **Practical Examples:** Complete design of foundations and structural systems with detailing.
- **Linked COs: CO4, CO5, CO6 |** **Number of Hours Required (CI)**: **10 hours**

**Suggested Learning Resources**

**Text Books:**


1. Varghese, P. C. (2013). Limit State Design of Reinforced Concrete (3rd ed.). Prentice Hall India.
2. Krishna Raju, N. (2010). Design of Reinforced Concrete Structures (2nd ed.). CBS Publishers & Distributors.
3. Sinha, S. N. (2009). Reinforced Concrete Design: Theory and Design (2nd ed.). S. Chand & Company.
4. Indian Standard 456:2000. Code of Practice for Plain and Reinforced Concrete (4th ed.). Bureau of Indian Standards, New Delhi.

**Reference Books:**


1. Park, R., & Paulay, T. (1975). Reinforced Concrete Structures. John Wiley & Sons.
2. MacGregor, J. G., & Wight, J. K. (2005). Reinforced Concrete: Mechanics and Design (4th ed.). Prentice Hall.
3. Pillai, S. U., & Menon, D. (2009). Reinforced Concrete Design (2nd ed.). Tata McGraw-Hill.
4. IS 875:2015. Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures. Bureau of Indian Standards.
5. IS 1893:2016. Code of Practice for Earthquake Resistant Design and Construction of Buildings. Bureau of Indian Standards.


**Web Links and e-Resources:**

1. NPTEL Courses on Reinforced Concrete Design and Advanced Concrete Structures
2. Bureau of Indian Standards (BIS) website for Indian Standards codes
3. Design aids and software for RC design analysis
4. Case studies of notable RC structures in India
5. IITK-GSDMA Earthquake Engineering resources

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**..

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Course Project

- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity.

**Students' Activities for TW/SL under NCrF: Samples Only**

As per National Credit Framework (NCrF), students must spend 90 hours of study for 3 credit courses, which include Course Instructions (CI - 48 hours) and Teamwork/Self Learning (TW/SL - 48 hours). Hence, students must complete two activities as part of NCrF under CCA, which carries 25 marks. The evaluations of these activities will be done using a set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours/ Semester |
|---|---|---|
| 1. | **Integrated RC Design Mini-Project** -Design and detail a complete reinforced concrete structure (beam-column frame / multi-story building) with calculations, sketches, and sustainability report (CO2, CO3, CO4, CO5, CO6) | 24 |
| **2.** | **Case Study & Seminar Presentation** -Research and present a case study on (a) a notable RC structure failure and lessons learned, (b) earthquake-resistant RC design in Indian context, or (c) sustainable RC construction practices. Includes written report and 10-min presentation | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | **MOOC + GATE/Data- Driven Track**: Complete mapped NPTEL/MOOC modules, solve GATE-style and open-ended analysis problems involving probability and statistics in civil engineering, culminating in an integrated open-book test. | 24 |
| 2. | Literature review on emerging tools; reflective learning journal | 24 |

**Rubrics for Students' Learning Activities -- TW/SL**

**1. Integrated RC Design Mini-Project Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| **Problem Understanding & Approach (CO1, CO2, CO3)** | Clearly identifies design requirements, loads, and constraints; correctly applies limit state design approach; selects appropriate design | Generally understands problem; mostly correct approach; minor gaps in | Limited problem understanding; approach partially correct; some unjustified assumptions | 20% |

| | | | | |
|---|---|---|---|---|
| | method; all assumptions are justified and stated | problem analysis or assumptions | | |
| **Design Calculations & Accuracy (CO2, CO3, CO4, CO5)** | All calculations correct; uses appropriate code provisions (IS 456, IS 875, IS 1893); calculations well-documented; cross-checks performed; final design values verified | Mostly correct calculations; minor errors that don't affect final design; code provisions mostly correctly applied | Frequent calculation errors; incorrect or missing code provisions; final design questionable | 25% |
| **Detailing & Sketches (CO2, CO3, CO4)** | Reinforcement detailing complete and accurate; sketches clear, to-scale, with all necessary dimensions and notes; meets code requirements; ductility considerations included | Detailing mostly correct; sketches legible with most dimensions; minor omissions in detailing or sketch labels | Incomplete or poorly detailed sketches; missing dimensions or reinforcement details; hard to interpret | 20% |
| **Serviceability & Sustainability (CO6)** | Explicitly addresses deflection control, crack width limits, durability measures; discusses sustainable practices (material efficiency, eco-friendly alternatives, life-cycle considerations); linkage to SDG 9, 11, 12 clear | Addresses some serviceability requirements; brief mention of sustainability; limited deeper reflection | Minimal serviceability checks; no/superficial sustainability discussion | 15% |
| **Organization, Presentation & Report Quality** | Well-structured project report with clear sections, executive summary, all calculations annexed; professional presentation; language clear and concise; references cited | Generally well-organized; most sections clear; some missing organizational elements; adequate presentation | Disorganized presentation; hard to follow; many formatting/language issues; missing sections | 20% |

**2. Seminar/Case Study Presentation Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| **Content Knowledge & Relevance (CO5, CO6)** | Demonstrates deep understanding of case/topic; relevant to course concepts; provides technical insights; analysis is thorough; connections to RC design principles are clear and insightful | Good understanding of topic; mostly relevant to course; some technical depth; generally clear connections to course concepts | Limited depth of knowledge; topic somewhat relevant; surface-level analysis; weak connection to course concepts | 25% |
| **Critical Analysis & Learning Insights (CO5, CO6)** | Provides critical analysis (e.g., failure causes, design lessons, sustainability aspects); identifies key learning points; discusses implications for practice or future design | Some analysis provided; identifies main lessons; discusses implications to some extent | Minimal analysis; lessons not clearly identified; limited practical implications discussed | 25% |
| **Presentation Skills & Clarity** | Clear and engaging presentation; well-paced (10 min); effective use of visuals/slides; answers questions | Reasonably clear presentation; mostly well-paced; adequate use of visuals; answers most questions appropriately | Presentation somewhat unclear; pacing issues; limited visual support; difficulty answering questions | 20% |

| | | | | |
|---|---|---|---|---|
| | confidently; language professional and concise | | | |
| **Written Report Quality** | Well-structured report (3-4 pages); clear introduction, analysis, conclusions; proper citations; professional language; properly formatted references | Generally structured report; analysis present; adequate citations; minor language/formatting issues | Poor organization; weak analysis; missing citations; significant language/formatting problems | 20% |
| **Use of Visuals/Evidence** | High-quality diagrams, photographs, sketches or data; visuals directly support narrative; all visuals appropriately labeled and captioned | Visuals generally relevant; most well-labeled; some support narrative effectively | Few visuals; poorly labeled or irrelevant; minimal support to narrative | 10% |

**Continuous Internal Evaluation (CIE):**

(i) The CIE marks shall be decided based on internal tests and other outcome-based activities. The continu internal evaluation shall be carried out by the teacher handling the course.

(ii) Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) ma and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| MODERN CONSTRUCTION EQUIPMENT, PRODUCTIVITY AND ECONOMICS | | | |
|---|---|---|---|
| Course Code: | 1BIF605F | Scheme | 2025 |
| Type of Course | Profession Elective Course (PEC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI(L/T): LI (P): SL&TW: | 90(42:0:0:48) | SEE Marks | 50 |
| Credits | 03 | Total Marks | 100 |
| Examination type (SEE) | **Theory** | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2 – Understand):** Describe types, components, operations, and applications of modern construction equipment for earthwork, material handling, concreting, and finishing operations.
2. **CO2 (L3 – Apply):** Select appropriate construction equipment based on project requirements, site conditions, soil characteristics, and economic considerations.
3. **CO3 (L3 – Apply):** Estimate productivity, output cycles, capacity, and balanced fleet requirements for construction equipment under given operating conditions.
4. **CO4 (L4 – Analyze):** Analyze ownership costs, operating costs, and economic feasibility of equipment fleets including depreciation, replacement policies, and cost per unit production.
5. **CO5 (L3 – Apply):** Apply maintenance management principles, safety protocols, and productivity enhancement techniques for sustainable equipment operations.
6. **CO6 (L4 – Analyze/Evaluate):** Assess equipment management strategies and relate them to efficient project delivery, cost optimization, and sustainable construction practices in line with SDG 9 (Industry, Innovation & Infrastructure) and SDG 11 (Sustainable Cities).

**Module-1**

**Introduction to Construction Mechanization**

- Definition, need, advantages, limitations of mechanization in construction; Indian vs global scenario, factors affecting equipment selection (project size, site conditions, soil type, distance).
- Classification of construction equipment: earthmoving, material handling, concreting, hoisting, compaction, finishing; safety norms (IS standards).
- Equipment specifications: size, capacity, power ratings, attachments; role in productivity enhancement and sustainable construction.
- Overview of automation/robotics in construction equipment (e.g., GPS-guided dozers, telematics)

**Linked COs: CO1, CO2, partial CO5** **Number of Hours Required (CI):8 hours**

**Module-2**

**Earthmoving Equipment**

- Dozers, scrapers, rippers: types, components, operations, blade types, power shift vs torque converter; applications in site clearance, spreading.
- Excavators (hydraulic, backhoe, front shovel): components, attachments (buckets, hammers), digging cycles, output estimation.
- Graders, motor graders: blade adjustments, applications in road formation, surface finishing; factors affecting output.
- Basic productivity formulas: cycle time, job efficiency, output per hour/shift (dozer: $Q = V \times$ blade factor $\times$ efficiency).

**Linked COs: CO1, CO2, CO3** **Number of Hours Required (CI):8 hours**

**Module-3**

**Material Handling and Hauling Equipment**

- Loaders (wheel, front-end): bucket types, cycle times, capacity estimation; applications in loading/hauling.
- Trucks and haulers (dumpers, tippers): on-road/off-road, articulated, payload factors, matching with loaders/excavators.
- Cranes (mobile, tower, crawler): types, lifting capacity charts, stability factors; hoisting equipment (winches, derricks).
- Productivity balancing: interdependent machines (loader-truck cycles), queueing effects; output estimation (truck: $Q$ = payload $\times$ trips/hour).
- Electro-osmosis and electro-kinetic enhancement for fine-grained soils: basic principles, applications, limitations.
- Sustainability and resilience: impact of long-term pumping on aquifers, energy use, combining drainage with nature-based solutions (bio-drainage, recharge).

**Linked COs: CO1, CO3, CO2** **Number of Hours Required (CI):8 hours**

| Module-4 |
|---|
| **Concreting, Compaction and Finishing Equipment**<br>• Concrete production: batching/mixing plants (tilting drum, pan, ready-mix), transit mixers, pumps/placers.<br>• Compaction equipment: rollers (smooth wheel, vibratory, sheepfoot, pneumatic), plate compactors; applications for soil, asphalt, concrete.<br>• Finishing equipment: pavers (asphalt, slipform concrete), graders for surface finishing; vibrators (internal/external).<br>• Productivity and quality control: mix production rates, paving speeds, compaction passes; factors affecting output.<br>**Linked COs: CO1, CO3, CO2** **Number of Hours Required (CI):8 hours** |
| **Module-5** |
| **Equipment Economics, Maintenance and Management**<br>• Ownership costs: depreciation (straight-line, declining balance), interest, taxes, insurance; operating costs (fuel, lubricants, tyres, repairs).<br>• Cost per hour estimation: fixed + variable costs; breakeven analysis, replacement policies (age, condition-based).<br>• Maintenance management: preventive/predictive schedules, downtime analysis, repair vs replace; safety and regulations.<br>• Fleet management: productivity improvement (telematics, GPS), economics of owning vs renting/leasing; case studies (highway/bridge projects).<br>**Linked COs: CO2, CO3, CO4, CO5** **Number of Hours Required (CI):10 hours** |

**Suggested Learning Resources**

Textbooks:

1. Sharma, S.K., “Construction Equipment and Management.” S.K. Kataria & Sons.
2. Chitkara, K.K., “Construction Project Management.” Tata McGraw Hill.
3. Peurifoy, R.L. & Schexnayder, C.J., “Construction Planning, Equipment and Methods.” McGraw Hill

Reference Books:

1. IS 11800 (Selection of equipment), IS 2974 (Pile driving equipment).
2. Sengupta & Guha, “Construction Management and Equipment.”

**Web links and Video Lectures (e-Resources):**

1. NPTEL – Construction Methods and Equipment Management (IIT Kharagpur).
2. NPTEL – Construction Technology & Management (IIT Madras)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- **Flipped Classroom** – Pre-class videos/notes; in-class problem solving.
- **PBL** – Group work on real project scenarios using equipment planning.
- **Case-Based Teaching** – Analyze Indian and global project case studies.
- **Simulation / Virtual Labs** – Simple tools for equipment cycles and scheduling.
- **Industry Expert / Visits** – Expert talks and site/yard/plant visits or virtual tours.
- **ICT-Enabled Teaching** – LMS, NPTEL videos, spreadsheets, online quizzes.
- **Role Play** – Simulated contractor–client–supplier negotiation on equipment and costs.

**Assessment Structure:** The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks.**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

**Course Project** – Mini smart-city intervention plan for a selected area (problem, data, smart solution, basic feasibility).

- **Course Project** – Equipment planning study for a chosen project with fleet selection, productivity and basic cost analysis.
- **Case Study Presentation** – Group presentation on real projects highlighting equipment choice, fleet management and productivity issues.
- **Programming Assignment** – Excel/Python calculations for cycle time, output/hour, cost per unit, and breakeven.
- **Tool / Software Exploration** – Use of Excel/Primavera or similar tools for equipment scheduling and cost tracking.
- **Literature Review** – Study of automation, telematics, GPS-guided and sustainable equipment, linked to SDG 9 and 11.
- **Open Book Test** – Scenario-based questions using project data and equipment catalogues.
- **GATE-based Aptitude Test** – GATE-style numericals on productivity, cost and time–cost–resource trade-offs.
- **Assignment** – Reflective/analytical write-up on owning vs renting or evaluating equipment strategy.
- **Innovative Activity** – Site-based equipment audit, safety checklist or mini hackathon on utilization.
- **MOOCs / Online Platforms** – NPTEL/SWAYAM modules on construction methods/equipment with a short reflection.

### Students' activities for TW/SL under NCrF: Samples only

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI- 42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | Equipment Portfolio Document: Visit 2–3 local construction projects using modern equipment (e.g., excavator–dozer combination, cranes, pavers). Document equipment types, specifications, site conditions, observed productivity and safety practices, with photos/figures. | 24 |
| 2 | Equipment Case Study: Short case on equipment selection for a highway/bridge/building project, including fleet composition, productivity calculations, and cost comparison for alternative options (e.g., different truck–loader combinations). | 24 |
| 3 | Productivity Reflection Note: Literature or project-based reflection on an Indian project affected by equipment issues (under-utilised fleet, breakdowns, wrong selection). Discuss causes, cost/time impacts, mitigation through maintenance and better planning. | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | MOOC + GATE / Equipment Track: Complete mapped NPTEL/SWAYAM modules on Construction Methods and Equipment Management / Construction Technology and Management. Solve GATE-style and application-oriented problems on productivity, cost and fleet planning; conclude with a short online/open-book test or reflection quiz. | 24 |
| 2 | Literature Review on Equipment Technologies + Reflective Journal: Review recent literature and industry reports on telematics, GPS-guided equipment, automation/robotics in construction, and sustainable/energy-efficient machines. Maintain a reflective journal linking these to course modules and SDG 9 & 11. | 24 |

**Continuous Internal Evaluation (CIE):**

(i)The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

(ii) Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail)

| STRUCTURAL REPAIR, RETROFITTING, AND REHABILITATION OF INFRASTRUCTURE | | | |
|---|---|---|---|
| Course Code: | 1BIF605G | Scheme | 2025 |
| Type of Course | Profession Elective Course (PEC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | 42(3:0:0) | CIE Marks | 50 |
| Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW: | 90 (42:0:0:48) | SEE Marks | 50 |
| Credits | 03 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. CO1 (L2 - Understand): Explain causes of distress in concrete, steel, and geotechnical structures, including corrosion, cracking, settlement, and deterioration mechanisms.
2. CO2 (L3 - Apply): Apply condition assessment techniques like NDT, visual inspection, and select repair materials for surface and geotechnical defects.
3. CO3 (L4 - Analyze): Analyze retrofitting strategies such as FRP, jacketing, and post-tensioning for enhancing structural strength and resilience.
4. CO4 (L4 - Evaluate): Evaluate rehabilitation methods for infrastructure like bridges, dams, and buildings, including maintenance planning and seismic upgrades.
5. CO5 (L5 - Design): Design sustainable repair and retrofitting solutions incorporating eco-friendly materials and climate-resilient practices.
6. CO6 (L3 - Apply): Apply structural health monitoring and analyze case studies to link repairs to resilient, sustainable urban infrastructure.

**Module-1**

**Deterioration and Assessment:**

- Physical/chemical causes: Corrosion mechanisms (carbonation, chloride ingress), sulfate attack, alkali-silica reaction in concrete.
- Mechanical/environmental factors: Overload cracking, fatigue in steel, earthquake-induced damage, geotechnical issues like soil settlement, expansive clays, liquefaction.
- Assessment techniques: Visual inspection protocols, rapid preliminary surveys; NDT methods (rebound hammer, ultrasonic pulse velocity-UPV, half-cell potential); destructive core testing; crack pattern evaluation and mapping.

**Linked COs: CO1, CO2.** **Number of Hours Required (CI): 8 hours.**

**Module-2**

**Repair Materials and Techniques:**

- Materials: Polymers, epoxies, cementitious grouts, rust converters, fiber-reinforced mortars; selection criteria based on compatibility, durability.
- Surface preparation: Rust removal (abrasive blasting, chemical), substrate cleaning; application methods: Patching, gravity fill, dry pack, injection grouting, underwater repairs.
- Geotechnical repairs: Permeation/chemical grouting, soil stabilization (compaction grouting, jet grouting); serviceability limits, durability testing (ASTM standards).

**Linked COs: CO2, CO5.** **Number of Hours Required (CI): 8 hours.**

**Module-3**

R**etrofitting of Elements:**

- Concrete/steel jacketing: Steel plate/concrete encasement, section enlargement techniques.
- Advanced methods: External post-tensioning, FRP/FRCM systems (externally bonded-EB, near-surface mounted-NSM).
- Geotechnical retrofits: Micro-piles, soil nailing, ground anchors for foundations/slopes; performance monitoring post-retrofit.

**Linked COs: CO2, CO3, CO5.** **Number of Hours Required (CI): 8 hours.**

**Module-4**

**Rehabilitation Strategies:**

- Maintenance planning: Lifecycle assessment, predictive strategies for slabs/beams/columns.
- Infrastructure-specific rehab: Bridges (deck strengthening), tunnels/dams (seepage control), water tanks (lining repairs); slope stabilization, foundation underpinning.
- Integration with standards: IS 456, ACI 546R guidelines; techno-economic feasibility analysis.

**Linked COs: CO3, CO4, CO5** **Number of Hours Required (CI): 8 hours**

**Module-5**

**Seismic and Case Studies:**

- Seismic evaluation/retrofit: IS 13920 compliance, ductile detailing, base isolation, dampers (energy dissipation devices).
- Health monitoring: Sensors (strain gauges, accelerometers), IoT-based SHM systems; sustainable practices (recycled materials, low-carbon repairs.
- Case studies: Indian failures/rehabilitations (e.g., bridges post-earthquake, urban retrofits); geo-hazards like landslides; reflection on resilient infrastructure

**Linked COs: CO1, CO4, CO5, CO6** **Number of Hours Required (CI): 10 hours**

**Suggested Learning Resources**

**Textbooks:**

1. "Repair and Rehabilitation of Concrete Structures" by R.T. Allen.
2. "Concrete Structures: Protection, Repair and Rehabilitation" by R. Dodge Woodson.

**References:**

1. IS 456, 1904; ACI 546R; NPTEL "Retrofitting of Structures".

**Web links and e-Resources:**

1. NPTEL courses on Engineering Geology and Rock Engineering.

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching- learning process and facilitate the achievement of course outcomes.

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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**Assessment Structure:** The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development.**

**Students' Learning activities:** These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)

- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | **Structural Condition Assessment Mini-Project:** Conduct field/virtual assessment of a structure (building/bridge), identify distress (cracks, corrosion, settlement), and document using inspection methods and basic NDT techniques with a short report. | 24 |
| 2 | **Repair & Retrofitting Case Study Portfolio:** Prepare concise case studies on infrastructure rehabilitation (e.g., bridges, buildings, dams), analyze causes of failure, repair materials, retrofitting techniques (FRP, jacketing), and present findings with engineering justification. | 24 |
| 3 | **Tools / Materials & Techniques Workbook:** Develop a technical workbook covering repair materials, retrofitting methods, NDT data interpretation, and simple design/selection calculations using Excel/Python or standard guidelines (IS/ACI). | 24 |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | **MOOC / NPTEL + GATE / Data-Driven Track:** Complete mapped NPTEL/MOOC modules on structural repair, retrofitting, or infrastructure resilience; solve application-based problems and case-based questions. | 24 |
| 2 | **Literature Review & Reflective Learning Journal:** Review recent repair/rehabilitation technologies, sustainable materials, and real-world case studies (IIT/NIT/industry projects); document insights and learning reflections. | 24 |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

1. **Sample Rubrics - Integrated Repair & Retrofitting Mini-Project / Case Study**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| **Problem Definition & CO Mapping (CO1, CO2)** | Clearly identifies real structural distress problem; strong linkage to repair/retrofitting concepts and sustainability | Problem defined with minor gaps in clarity or linkage | Vague or poorly defined problem; weak CO linkage | 15% |
| **Field Data / Assessment (CO1, CO2)** | Detailed inspection (visual + NDT); accurate identification of cracks, corrosion, settlement with proper documentation | Adequate assessment with minor missing details | Limited or incorrect assessment; lacks evidence | 20% |
| **Material & Technique Selection (CO2, CO5)** | Appropriate repair/retrofit methods (FRP, grouting, jacketing) selected with strong technical justification | Mostly correct selection; minor mismatches in application | Incorrect or poorly justified selection | 20% |
| **Engineering Analysis & Design (CO3, CO4)** | Logical analysis of retrofitting strategy; | Basic analysis with partial justification | Mostly descriptive; lacks | 20% |

| | | | | |
|---|---|---|---|---|
| | considers strength, durability, seismic aspects; realistic design insights | | engineering reasoning | |
| **Sustainability & SDG Linkage (CO5, CO6)** | Clearly integrates sustainable materials, lifecycle thinking, and resilient infrastructure concepts | Mentions sustainability with limited depth | No meaningful sustainability consideration | 10% |

**Continuous Internal Evaluation (CIE):**

i. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

ii. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.

iii. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.

iv. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE:**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| URBAN AIR QUALITY AND NOISE MANAGEMENT IN INFRASTRUCTURE PLANNING | | | |
|---|---|---|---|
| Course Code | 1BIF605H | Scheme | 2025 |
| Type of Course | Professional Elective Course (PEC) | Semester | VI |
| Teaching Hours/Week (L:T:P) | 3:0:0 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | 42:0:0:48 | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2)** Understand sources, effects, and standards for urban air pollutants and noise in infrastructure contexts, linking to SDG 11**.**
2. **CO2 (L3)** Apply meteorological dispersion models for air quality prediction in urban planning.
3. CO3 (L3) Identify and analyze monitoring techniques for ambient/stack air quality and noise levels.
4. **CO4 (L4)** Analyze control technologies for particulate/gaseous emissions and noise barriers in infrastructure.
5. **CO5 (L3)** Apply air/noise mitigation in infrastructure projects (highways, airports, metro).
6. **CO6 (L4)** Assess regulatory compliance, indices, and sustainable planning for resilient urban infrastructure.

**Module-1**

**Air Pollution Fundamentals**

- Definition, sources (transport, industry, construction), classification (PM, NOx, SOx, VOCs, CO); effects on health, vegetation, materials, global warming/acid rain.
- Urban air issues: smog, inversion types; infrastructure links (smart cities, highways).
- NAAQS, emission standards (CPCB), AQI; noise basics (dB, Ldn)

**Linked COs CO1, partial CO6** **Number of Hours: 08 hrs**

**Module-2**

**Meteorology & Dispersion**

- Lapse rate, stability, wind rose, plume rise; Gaussian model (point/line/area sources, numerical).
- Mixing depth, urban meteorology for infrastructure siting.
- Dispersion in valleys/coastal areas; software intro (AERMOD)

**Linked COs CO2** **Number of Hours: 08 hrs**

**Module-3**

**Monitoring & Indices**

- Sampling (high-volume sampler, stack/ambient); analysis (PM10/2.5, gases via wet/dry methods).
- Noise monitoring (SLM, descriptors Leq, L90); network design for urban areas.
- AQI computation, emission inventory for projects.

**Linked COs CO3** **Number of Hours: 08 hrs.**

**Module-4**

**Control Technologies**

- Particulates: settling chambers, cyclones, ESP, fabric filters, scrubbers.
- Gases: adsorption, absorption, incineration; vehicle emission controls (catalytic converters).
- Noise control: barriers, mufflers, enclosures, vibration isolation

**Linked COs CO4** **Number of Hours: 10 hrs**

**Module-5**

**Infrastructure & Noise Management**

- Air quality in planning: site selection, EIAs for airports/highways/metro; green belts.
- Noise zoning, barriers for roads/rail; regulations (Noise Rules 2000), airport noise.
- Sustainable strategies: low-emission zones, EV infra, global protocols (SDG 11)

**Linked COs CO5, CO6.** **Number of Hours: 08 hrs**

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

Text books:

1. Air Pollution – M.N. Rao & H.V.N. Rao, Tata McGraw Hill.
2. Fundamentals of Air Pollution – Daniel Vallero, Elsevier
3. H. C. Perkins, "Air pollution". Tata McGraw Hill Publication.

Reference Books:

1. Air Pollution Control Engineering – Noel de Nevers, McGraw Hill.
2. Noise and Vibration Control – L.L. Beranek, Wiley.
3. CPCB Guidelines; EPA Manuals.

**Web links and Video Lectures (e-Resources):**

1. NPTEL course: Air Pollution and Control (Prof. Bhola Ram Gurjar, IIT Roorkee)/nptel.ac.in/noc23_ce14.
2. NPTEL course: Noise Management and Control (IIT Roorkee/Kharagpur)/ nptel.ac.in/courses/105107213

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.
In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.
It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

**Students' Learning activities: These activities shall be:**

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Students' activities for TW/SL under NCrF: Samples only**

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of

| **Term Work (TW) and Self Learning (SL) components in Number of Hours per semester** | | |
|---|---|---|
| Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.) | | |
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| 1 | Urban AQI Monitoring Portfolio, Monitor PM/noise at infrastructure site (highway/metro), analyze vs NAAQS, plot wind rose/AQI. | 24 |
| 2 | Noise Barrier Design Report, Visit road site, design barrier, economic analysis. | 24 |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| 1 | Self-learning modules on NPTEL/SWAYAM; completion of online certification courses. | 24 |
| 2 | Literature review on emerging technologies; reflective learning journal | 24 |

**Rubrics for Students learning activities -TW/SL - (Samples)**

**1. Integrated Design Mini-Project – Rubric**

| Criterion | Exemplary (3) | Proficient (2) | Basic (1) | Weight |
|---|---|---|---|---|
| Data collection and monitoring (CO1, CO3) | Comprehensive AQI/noise data (site logs, sensors), pollutant catalog (PM/NOx, Leq), trends vs NAAQS; infra-specific (highway/metro). | Adequate via apps/checklists; basic trends; some gaps. | Limited/generic data; weak monitoring. | 20% |
| Dispersion/risk assessment (CO2, CO5) | Gaussian model calcs accurate, plume plots, mitigation design (barriers/green belts); optimized for site. | Basic models; SOPs; limited feasibility. | Incomplete models/mitigations. | 25% |
| Control tech/standards selection (CO4) | Devices (ESP/scrubbers, silencers) compared (efficiency/cost); BIS/CPCB justified. | Reasonable with basics; standards noted. | Unjustified; limited. | 25% |
| Audit/compliance reporting (CO3, CO6) | Full EIA checklist, regulatory gaps (Noise Rules); diagrams/plots. | Basic audit; regs mentioned. | Superficial. | 15% |
| Sustainability/reflection (CO6) | SDG 11 links, LCA, resilient planning; innovative (EV zones). | Basic noted. | None. | 15% |

**Continuous Internal Evaluation (CIE)**

(i)The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
(ii)Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
(iii) The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
(iv) A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE**

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
ii. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

# Professional Core Course Laboratory Syllabus

| COMPUTER AIDED DESIGN AND DETAILING OF RC STRUCTURES LAB | | | |
|---|---|---|---|
| Type of Course | Professional Core course Laboratory (PCCL) | SCHEME | 2025 |
| Course Code | 1BIFL606 | Semester | VI |
| Teaching Hours/Week (L:T:P) | 28 (0:0:2) | CIE Marks | 50 |
| Total Hours of Pedagogy CI(L:T):LI(P):SLTW | 30 (0:0:2:2) | SEE Marks | 50 |
| Credits | 1 | Total Marks | 100 |
| Examination type (SEE) | **Practical** | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

1. CO1 (L3): Apply CAD software to create professional structural drawings.
2. CO2 (L3): Apply analysis software to model RC elements.
3. CO3 (L4): Detail reinforcement for beams, slabs, columns, footings per IS 456.
4. CO4 (L4): Analyze complete structural systems through CAD projects.
5. CO5 (L5): Evaluate drawings for constructability & code compliance.

**Note:**

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.

2. Both PART-A and PART-B are considered for CIE and SEE.

3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.

a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for 70 marks out of the maximum 100 marks.

b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 30 marks.

4. For continuous internal evaluation, during the semester, classwork, the typical open-ended questions shall be from PART-B, and any other similar questions to enhance the skill of the students.

**Part A – Fixed set of CAD Exercises (LI = 20 hours)**

1. **CAD Fundamentals:** AutoCAD interface, layers, coordinate systems, Create standard template with title block (IS 962), Draw simple structural plan (column grid 8x8m)
2. **RC Beam Detailing:** Design simply supported beam (span 5m, M20, Fe415), Longitudinal section (1:20), cross-sections (1:10), Complete BBS with bar codes
3. **Slab Reinforcement Plan:** One-way slab (3x6m panel), Main steel + distribution steel layout, Plan view (1:50)+sections(1:20)
4. **Column & Footing Detail:** 400x400mm column + 2x2m isolated footing, Column ties + footing reinforcement, Dowel bar connection

**Part B – Open-ended / Mini-project CAD Tasks (LI = 8 hours)**

1. **Integrated Mini-Project:**

G+1Building(400m$^2$):
• Floor plan with column grid,1 beam detail + 1 slab detail + 1 column-footing,3 complete A2 drawings + BB

**Suggested Learning Resources**
**Text books:**

1. Unnikrishna Pillai & Devdas Menon - Reinforced Concrete Design
2. N. Krishna Raju - Structural Design & Drawing: Reinforced Concrete & Steel
3. S. Unnikrishnan Pillai - Design of Reinforced Concrete Structures

**Reference Books:**

1. P.C. Varghese - Advanced Reinforced Concrete Design

**Code book:**

1. IS 456:2000 - Plain and Reinforced Concrete Code
2. SP 16:1980 - Design Aids for Reinforced Concrete to IS 456
3. SP 34:1987 - Handbook on Concrete Reinforcement and Detailing
4. IS 875 (Parts 1-5) - Code of Practice for Design Loads

**Web links and Video Lectures (e-Resources):**

- NPTEL - Design of RC Structures (IIT Madras)
- SWAYAM - Reinforced Concrete Design
- YouTube Channels (Verified)
- IIT Madras OCW (official lectures)
- Autodesk AutoCAD Tutorials (official)
- Structural Guide (RC detailing)

**NCrF – TWSL Activities for Lab**

- Watching and summarizing selected CAD video tutorials (commands, good practices).
- Self-paced practice problems assigned weekly
- Short reflection note on how CAD outputs can integrate with quantity estimation/digital site layout.

**Teaching–Learning Process**

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester

/after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

**Eligibility for SEE:**

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying 50% weightage (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 20 marks. For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

**Eligibility for SEE:**


- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.


**Rubrics for CIE- Continuous Assessment for practical courses**

| Performance Indicator | CO/PO Mapping | Superior (5) | Good (4) | Fair (3) | Needs Improvement (2) | Unacceptable (1) |
|---|---|---|---|---|---|---|
| P1: Regularity & Participation | CO1/PO5 (Lab discipline) | Always punctual, fully engaged, leads peers. | Regular, actively participat es. | Moderately regular, some participation. | Irregular, minimal effort. | Absent/frequent disruptions. |
| P2: Understanding Objectives & Setup | CO2/PO2 (Problem analysis) | Fully comprehen ds, independe ntly sets up accurately. | Good grasp, sets up with minor help. | Partial understand ing, basic setup. | Struggles with setup/aims. | No understanding , incorrect setup. scribd+1 |
| P3: Execution & Results | CO3/PO4 (Investigation) | Flawless conduction , preci se results | Correct execution , accurate results. | Partial success, some errors. | Major errors in procedure/res ults. | Fails to |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | with error analysis. | | | | conduct properly. |
| P4: Record Writing | CO4/PO10<br>(Communication) | Neat, complete, analytical beyond requirements. | Complete, neat, includes calculations. | Basic record, some omissions. | Incomplete/untidy. | Not submitted/illegible |
| P5: Viva Voce & Presentation | CO5/PO12<br>(Lifelong learning) | Confident, deep insights, relates to application s. | Answers most questions correctly. | Basic responses, some hesitation. | Few correct answers. | Unable to respond. |

**Rubrics for SEE / CIE Test:**

| **Performance Indicator (CO/PO Mapping)** | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| PI-1:<br>Experimental Skill / Technique (CO-1 / PO-5) | Executes procedure flawlessly, handles equipment with confidence, completes work within time, and shows initiative in trouble shooting. | Performs procedure correctly; equipment handling is safe but with minor hesitation; completes most steps on time. | Follows procedure but withintermittent errors; needs frequent guidance; time management is poor. | Makes repeated procedural errors; unsafe handling; requires continuous supervision; incomplete work. | Fails to follow basic steps; unsafe practices; work not attempted or abandoned. |
| PI-2:<br>Observation & Data Recording (CO-2 / PO-2) | Records all required observations systematically; data is accurate, Well-labeled, and presented in prescribed format. scribd+1 | Records most observation s correctly; dat is Readable but with minor omissions or formatting issues. | Records incomplete or inconsistent data; units/labels missing; entries are disorganized. | Data recording is haphazard; major omissions; units/labels largely absent. | No meaningful data recorded; or copied/incorrect entries without any understanding. |

| | | | | | |
|---|---|---|---|---|---|
| PI-3: Computation / Analysis (CO-3 / PO-4) | Applies correct formulas, computes results accurately, interprets graphs/tables meaningfully, and identifies sources of error | Computes results correctly with minor arithmetic errors; graph/plot is acceptable; interpretation is partial | Uses correct method but makes significant calculation errors; graph/plot is poorly drawn; interpretation is weak. | Incorrect method or formula; computations are mostly wrong; no clear interpretation | No attempt at computation/analysis; blank or nonsensical entries. |
| PI-4: Safety, Discipline & Professionalism (CO-4 / PO-12) | Maintains strict adherence to lab safety, SOPs, and instructions; respects peers and equipment; works independently. | Generally follows safety rules and instructions ; acceptable conduct; needs minimal supervision. | Occasionally ignores minor safety precautions; requires reminders on discipline. | Repeated lapses in safety/behavior; disturbs others; needs constant monitoring. | Gross violation of safety norms; disruptive or negligent behavior; unsafe for self/others. |
| PI-5: Viva-Voce / Conceptual Understanding (CO-5 / PO-1) | Demonstrates deep understanding g of concepts, objectives, and methodology; answers questions confidently and precisely. nsec+1 | Shows clear understanding ng of key concepts; answers most questions satisfactorily. | Understands basics but struggles with detailed or application-bas ed questions. | Limited understanding ;answers are vague or incorrect on fundamental points. | Unable to answer basic questions; shows no Understanding of the experiment. |

**Rubrics suggested for Practical continuous assessment**

| Performance Indicators | Excellent | Very Good | Good | Satisfactory |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output. (3) | Student will be able to run the program but not able to analyze the output. (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

# Ability Enhancement Course (Laboratory) Syllabus

| FIELD SURVEY AND MAPPING PROJECT (SURVEY CAMP FOR INFRASTRUCTURE) | | | |
|---|---|---|---|
| Course Code | 1BIFL607A | Scheme | 2025 |
| Type of Course | Ability Enhancement Course (Laboratory) | Semester | VI |
| Teaching Hours/Week (L :T : P) | 28 (0:0:2) | CIE Marks | 50 |
| Total Hours of Pedagogy CI( L :T):LI(P):SL:TW | 30 (0:0:2:2) | SEE Marks | 50 |
| Credits | 01 | Total Marks | 100 |
| Type of Examination | Practical | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L3)** Apply traversing, leveling, and contouring for topographic mapping.
2. **CO2 (L4)** Analyze alignment surveys for infrastructure (roads, canals, bridges).
3. **CO3 (L3)** Generate detailed site plans using total station/GPS data.
4. **CO4 (L4)** Integrate survey data into CAD/GIS for project reports.
5. **CO5 (L5)** Evaluate errors, adjustments for accurate infrastructure layouts.

**SET OF EXPERIMENTS**

1. NEW TANK PROJECTS: The work shall consist of;
a. Reconnaissance survey for selection of site and conceptualization of project.
b. Alignment of center line of the proposed bund, Longitudinal and cross sections of the center line.
c. Detailed survey required for project execution like Capacity surveys, Details at Waste weir and sluice points, Canal alignment etc. as per requirement
d. Design and preparation of drawing with report

2. WATER SUPPLY AND SANITARY PROJECT: The work shall consist of;
a. Reconnaissance survey for selection of site and conceptualization of project.
b. Examination of sources of water supply, Calculation of quantity of water required based on existing and projected population.
c. Preparation of village map by using total station.
d. Survey work required for laying of water supply and UGD
e. Location of sites for water tank. Selection of type of water tank to be provided. (ground level, overhead and underground)
f. Design of all elements and preparation of drawing with report.

3. HIGHWAY PROJECT: The work shall consist of;
a. Reconnaissance survey for selection of site and conceptualization of project.
b. Preliminary and detailed investigations to align a new road (min. 1 to 1.5 km stretch) between two obligatory points. The investigations shall consist of topographic surveying of strip of land for considering alternate routes and for final alignment. Surveying by using total station.
c. Report should justify the selected alignment with details of all geometric designs for traffic and design speed assumed.
d. Drawing shall include key plan initial alignment, final alignment, longitudinal section along final alignment, typical cross sections of road.

4. RESTORATION OF AN EXISTING TANK: The work shall consist of;
a. Reconnaissance survey for selection of site and conceptualization of project.
b. Alignment of center line of the existing bund, Longitudinal and cross sections of the center line.
c. Detailed survey required for project execution like Capacity surveys, Details at Waste weir and sluice points, Canal alignment etc. as per requirement
d. Design of all elements and preparation of drawing with report.

5. TOWN/HOUSING / LAYOUT PLANNING: The work shall consist of;
a. Reconnaissance survey for selection of site and conceptualization of project.
b. Detailed survey required for project execution like contour surveys
c. Preparation of layout plans as per regulations
e. Center-line marking-transfer of centre lines from plan to ground
f. Design of all elements and preparation of drawing with report as per regulations

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Surveying Vol II/III – B.C. Punmia (traverse, curves, infra surveys).
2. Surveying & Levelling – R. Subramanian.

**Reference Books:**

1. Fundamentals of Surveying – S.K. Roy.
2. Total Station/GPS manuals (Trimble/Leica).

| **Web links and Video Lectures (e-Resources):**<br>• NPTEL: Surveying/Geomatics (IIT Roorkee) |
|---|
| **NCrF – TWSL Activities for Lab** |
| • Self-practice: Additional traverses/topo using apps (e.g., GIS mapper).<br>• Reflection: Camp report on infra-applications/SDG 9 |
| **Teaching-Learning Process (Innovative Delivery Methods):**<br>The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.<br>1. Field camp (10-14 days) with faculty supervision; daily viva/data checks.<br>2. Post-camp: Plotting/CAD in lab (2 weeks).<br>3. Tools: Total station, GPS, auto-level, theodolite, DGPS awareness |

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

**Eligibility for SEE:**

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**

**Rubrics for CIE – Continuous assessment:**

| Performance Indicator | Superior(5) | Good(4) | Fair(3) | Needs Improvement(2) | Unacceptable(1) |
|---|---|---|---|---|---|
| **1.Regularity & Participation CO1/PO5** | Always punctual, fully engaged, and takes initiative in field/lab work. | Regular and actively participates in all tasks. | Moderately regular with limited participation. | Irregular and shows minimal effort. | Absent or causes frequent disruptions. |
| **2.Understanding Objectives & Setup CO2/PO2** | Fully understands the project objective and independently sets up the survey/design plan accurately. | Good grasp of objective and setup with minor help. | Partial understanding; requires guidance for basic setup. | Struggles to identify objective or required setup. | No understanding; setup is incorrect. |
| **3. Survey / Investigation / Execution CO3/PO4** | Executes survey/investigation flawlessly, records precise field data, and completes work systematically. | Executes correctly with minor errors; data is mostly accurate. | Partially successful; some errors in field procedure or measurements. | Major errors in procedure or results; needs frequent support. | Fails to conduct the work properly. |
| **4. Record Writing / Drawings CO4/PO10** | Record is neat, complete, analytical, and drawings are accurate beyond requirements. | Complete and neat record with calculations and drawings. | Basic record with some omissions or weak presentation. | Incomplete, untidy, or poorly organized record. | Not submitted or illegible. |
| **5. Viva Voce / Presentation CO5/PO12** | Confident, precise, and gives strong technical justification with application-based answers. | Answers most questions correctly and clearly. | Basic responses with some hesitation. | Few correct answers; weak conceptual clarity. | Unable to respond meaningfully. |

Rubrics for SEE / CIE Test:

| Performance Indicator | Superior(6) | Good(5) | Fair(4) | Needs Improvement(2-3) | Unacceptable-(1) |
|---|---|---|---|---|---|
| **Experimental Skill / Technique COx/POy** | Executes procedure flawlessly, handles equipment confidently, and troubleshoots independently. | Performs procedure correctly with minor hesitation. | Follows procedure with intermittent errors and needs guidance. | Repeated procedural errors and unsafe handling. | Fails to follow basic steps. |
| **Observation & Data Recording COx/POy** | Records all observations systematically with correct units, labels, and format. | Records most observations correctly with minor omissions. | Incomplete or inconsistent data with some missing labels. | Major omissions and disorganized data. | No meaningful data recorded. |
| **Computation / Analysis COx/POy** | Uses correct formulas, computes accurately, and interprets results meaningfully. | Minor arithmetic errors; interpretation is partial. | Correct method but significant calculation errors. | Mostly wrong method or incorrect computations. | No computation or analysis attempt. |
| **Safety, Discipline & Professionalism. COx/POy** | Strictly follows safety norms, SOPs, and works independently. | Generally follows rules with minimal supervision. | Needs occasional reminders on safety and discipline. | Repeated lapses in safety and behavior. | Gross violation of safety norms. |
| **Viva Voce / Conceptual Understanding. COx/POy** | Deep understanding of concepts, methodology, and application. | Clear understanding and satisfactory answers. | Understands basics but struggles with application questions. | Limited understanding and vague answers. | Unable to answer basic questions. |

| **Rubrics suggested for Practical continuous assessment** | | | | |
|---|---|---|---|---|
| **Performance Indicators** | **Excellent** | **Very Good** | **Good** | **Satisfactory** |
| Fundamental Knowledge (4) (PO1) | Student shows deep knowledge of all relevant concepts, codes (IS/ASTM), survey techniques, and hydraulic/geometric design principles across all five project types. (5) | Student has good knowledge of core concepts for 3-4 project types and can explain survey-design linkages. (4) | Student can narrate basic concepts for 1-2 project types but lacks depth in standards or analysis. (3) | Student shows unclear understanding of fundamental civil engineering survey and design concepts. (1-2) |
| Design Of Project (5) (PO2 & PO3) | Student proposes 2+ design alternatives for the project (tank capacity, highway alignment, layout config) and proves best solution with technical justification. (5) | Student proposes 2 feasible designs but struggles to clearly select optimal one. (4) | Student proposes single design with merits/demerits analysis for site conditions. (3) | Student explains basic design concept without alternatives or justification. (1-2) |
| Field Implementation/Survey Execution (8) (PO3 & PO8) | Student executes complete survey chain flawlessly - reconnaissance → alignment → detailed surveys (tank capacity, waste weir, highway T.S., layout contours) | Student completes all survey stages correctly using total station and can explain methodology. (5-6) | Student implements required surveys with proper field procedure explanation. (3-4) | Student conducts basic survey work with guidance. (1-2) |

| | | | | |
|---|---|---|---|---|
| | with total station precision. (7-8) | | | |
| Result &Analysis (5) (PO4) | Student analyzes complete data set (tank capacity curves, highway geometric design, water demand projections) with error analysis and code verification. (5) | Student computes all required parameters (tank volume, water demand, highway curves) accurately. (4) | Student computes key parameters for some project components with basic analysis. (3) | Student provides raw data without meaningful computation or analysis. (1-2) |
| Demonstration & Report (8) (PO9) | Complete professional package: Key plans, L-sections, cross-sections, capacity curves, layout plans per regulations, centerline marking on ground, executive summary. (7-8) | Well-organized drawings/report with all required elements (longitudinal sections, typical X-sections, tank details) clearly presented. (5-6) | Basic drawings/report with essential components but lacks polish or some elements missing. (3-4) | Poorly organized work with missing drawings/sections or unclear presentation. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

| NON-DESTRUCTIVE TESTING LAB FOR CIVIL AND INFRASTRUCTURE ENGINEERING | | | |
|---|---|---|---|
| **Course Code:** | **1BIFL607B** | Scheme | 2025 |
| Type of Course | Ability Enhancement Course (Laboratory) | Semester | VI |
| Teaching Hours/Week (L: T:P) | 28 (0:0:2) | CIE Marks | 50 |
| Total Hours of Pedagogy CI (L: T):LI(P): SLTW | 30 (0:0:2:2) | SEE Marks | 50 |
| Credits | 01 | Total Marks | 100 |
| Examination type (SEE) | Practical | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. CO1 (L2 – Understand): Describe principles, equipment, procedures, and applications of common NDT methods for civil materials and structures.
2. CO2 (L3 – Apply): Conduct NDT tests on concrete, steel, masonry, and infrastructure elements following standard protocols.
3. CO3 (L3 – Apply): Interpret test data, generate reports, and identify defects (cracks, voids, corrosion) from NDT results.
4. CO4 (L4 – Analyze): Organize NDT results using plots/tables and correlate with structural condition assessment.
5. CO5 (L3 – Apply): Export NDT findings for maintenance planning, quality control, and forensic investigations.

**SET OF EXPERIMENTS (L1 = 28 hours)**

1. Introduction to NDT: rebound hammer (Schmidt hammer) on concrete cubes/cores – surface hardness to compressive strength correlation (IS 13311 Part 2).
2. Ultrasonic pulse velocity (UPV) test on concrete beams/elements – quality grading (IS 13311 Part 1).
3. Half-cell potentiometry for rebar corrosion assessment on RCC specimens.
4. Cover meter test for rebar location/depth/cover measurement.
5. Rebound hammer + UPV combined index for in-situ concrete assessment.
6. Penetration resistance test (Windsor probe) on concrete – simulated field test.
7. Ground penetrating radar (GPR) basics for detection of embedded reinforcement, voids, and hidden defects.
8. Electrical resistivity method for assessing moisture ingress and durability of concrete.

**Suggested Learning Resources**

Text books:

1. Malhotra & Carino, "Handbook on Nondestructive Testing of Concrete." CRC Press.
2. ACI 228.2R, "NDT Guide for Concrete Evaluation."

Reference Books:

1. Malhotra & Carino, "Handbook on Nondestructive Testing of Concrete." CRC Press.
2. ACI 228.2R, "NDT Guide for Concrete Evaluation.

**Web links and Video Lectures (e-Resources):**

- NPTEL: Non-Destructive Evaluation (IIT Madras).
- NPTEL: Advanced Concrete Technology (IIT Kanpur – NDT section).

**NCrF – TWSL Activities for Lab (2 hours) -Any one Activity**

- Watching NDT demo videos (UPV calibration, thermography).
- Self-paced practice: data analysis sheets for rebound/UPV correlation.
- Reflection: role of NDT in sustainable maintenance/forensics.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average marks for report and test shall be out of 50 marks.

**Eligibility for SEE:**

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks.**
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

**Rubrics for CIE- Continuous Assessment for practical courses**

| **Performance Indicator** | **CO–PO Mapping** | **Superior (5)** | **Good (4)** | **Fair (3)** | **Needs Improvement (2)** | **Unacceptable (1)** |
|---|---|---|---|---|---|---|
| **P1 Regularity & Lab Safety** | CO1, CO2 – PO8, PO9 | Always punctual; consistently follows PPE and NDT safety norms; careful with equipment and specimens; supports orderly lab conduct. | Generally punctual; follows safety most of the time; equipment handled correctly with minor reminders. | Attendance acceptable but occasional late/unsafe practices; needs reminders on handling equipment. | Irregular or often late; frequently ignores safety instructions; rough or careless handling of equipment. | Chronic absenteeism or unsafe behaviour; misuses/neglects NDT equipment; disrupts lab. |
| **P2 Understanding of Test Objective & Setup** | CO1, CO2 – PO1, PO2 | Clearly explains test principle, standard (e.g., IS 13311), and purpose; independently sets up equipment | States aim and basic principle; sets up test apparatus | Knows only aim statement; needs step-by-step help for connections | Confused about objective; struggles to follow setup instructions even with | Cannot state objective; unable to set up or use the NDT equipment meaningfully. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | (rebound hammer, UPV, half-cell, cover meter, etc.) correctly. | with minor guidance. | , calibration and positioning. | repeated guidance. | |
| **P3 Execution & Data Acquisition** | CO2 – PO2, PO3 | Follows full procedure as per standard; takes adequate, reliable readings at correct locations; notes environmental/field conditions; repeats/validates suspect data. | Procedure mostly correct; takes required readings; few minor procedural lapses that do not affect overall data quality. | Partial procedure followed; some readings missing, inconsistent or poorly recorded. | Major deviations from procedure; insufficient or clearly unreliable readings. | Fails to carry out test; no usable readings. |
| **P4 Data Processing, Interpretation & Reporting** | CO3, CO4, CO5 – PO4, PO10 | Correctly processes data (e.g., converts rebound index to strength, UPV to quality class, half-cell to corrosion risk); uses clear tables/plots; identifies defects/condition realistically and comments on implications for maintenance/forensics. | Calculations mostly correct; tables/plots present; gives broadly correct condition rating and basic implications. | Some correct calculations but noticeable errors; presentation cluttered; interpretation vague or partly incorrect. | Major calculation/presentation errors; little or no attempt to relate results to actual condition. | No meaningful processing or interpretation; report largely blank/copied. |
| **P5 Record / Mini-Project Documentation** | CO3, CO4, CO5 – PO9, PO12 | Lab record/mini-project is complete, well-structured (objective, method, data, analysis, conclusion); photos/figures labelled; clear engineering conclusions and SDG/sustainability link where relevant. | Record mostly complete and neat; structure visible; conclusions present but brief. | Record has several gaps or unclear sections; figures/tables lack labels; conclusions weak. | Record poorly organized or largely incomplete; hard to follow work done. | Record not submitted or almost entirely copied; no evidence of student's own work. |
| **P6 Viva-Voce (Concepts &** | CO1–CO5 – | Explains NDT principles, test limitations and choice of methods for given | Answers most conceptual and application | Answers basic "what was done" questions; struggles | Limited understanding; many incorrect or incomplete | Unable to answer basic questions on NDT principles or own experiment. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Professional Insight)** | PO1, PO12 | scenarios; answers application questions (e.g., when to combine UPV + RH) confidently; can suggest follow-up/maintenance actions. | questions correctly; shows sound grasp of key ideas. | with "why this test / what next" questions. | answers even on fundamentals. | |

**Rubrics for SEE / CIE Test:**

| Performance Indicator | CO–PO Mapping | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|---|
| **PI-1 Experimental Skill & Technique (Part-A)** | CO1, CO2 – PO2, PO3 | Executes Part-A NDT procedure (e.g., UPV, rebound hammer, half-cell) flawlessly: correct calibration, probe/hammer positioning, reading sequence and standard compliance; completes within time. | Generally correct execution with minor lapses; completes experiment with usable data. | Understands basic steps but makes several procedural errors; needs frequent prompting. | Many incorrect steps; incomplete or inconsistent execution; major guidance required. | Cannot perform the experiment; unsafe or incorrect use of equipment. |
| **PI-2 Data Recording & Calculation Accuracy (Part-A)** | CO3, CO4 – PO1, PO4 | Records all readings systematically with locations; units and formats correct; calculations (strength/quality/corrosion risk) accurate; any assumptions stated. | Most readings and calculations correct; minor omissions or arithmetic slips. | Some data missing or disorganised; noticeable calculation errors. | Data largely incomplete or poorly recorded; most calculations wrong. | No meaningful data or calculations. |
| **PI-3 Open-Ended Task Approach & Problem-Solving (Part-B)** | CO2–CO5 – PO2, PO3, PO11 | Chooses appropriate combination of NDT methods for the given open-ended scenario (condition assessment/forensic mini-case); plan is logical, covers key locations and constraints. | Reasonable method choice and plan; some minor gaps in coverage or justification. | Method partially appropriate; misses key locations/tests or over-relies on one tool. | Weak or ad-hoc plan; poor match between scenario and chosen tests. | No coherent plan; methods chosen arbitrarily or not attempted. |
| **PI-4 Synthesis, Condition Assessment &** | CO3, CO4, CO5 – PO4, PO10 | Integrates readings from different tests into a consistent condition rating; identifies likely defects; proposes realistic | Provides a plausible condition statement and basic recommenda | Offers qualitative judgement but with limited justification; | Very limited or incorrect assessment; recommendations not | No attempt at assessment or recommendations. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Recommendations** | | maintenance/repair/monitoring actions and notes limitations of NDT results. | tions; some recognition of limitations. | recommendations vague or generic. | linked to data. | |
| **PI-5 Communication (Report Sheet + Viva)** | CO1–CO5 – PO9, PO12 | SEE answer book / sheets are clear, structured and legible; sketches/tables/plots support arguments; viva answers show solid understanding of both tests and their applications. | Presentation generally clear; minor issues with layout; viva adequate on most points. | Disorganised writing or missing labels; viva reveals shallow understanding. | Poorly presented work; serious gaps in explanation during viva. | Work and viva indicate no real understanding of NDT or the tasks performed. |

**Rubrics suggested for Practical continuous assessment**

| Performance Indicator | PO | Excellent | Very Good | Good | Satisfactory |
|---|---|---|---|---|---|
| **Fundamental Knowledge (4)** | PO1 | The student has well-depth knowledge of NDT principles, equipment and test standards relevant to the course (e.g., rebound hammer, UPV, half-cell, cover meter, Windsor probe) (4). | Student has good knowledge of some NDT methods and their applications to concrete/steel/masonry (3). | Student is capable of narrating basic definitions or procedures but not capable of showing in-depth understanding of NDT concepts (2). | Student has not understood the NDT concepts clearly; unable to relate tests to materials/structures (1). |
| **Design of Experiment (5)** | PO2 & PO3 | Student is capable of discussing more than one suitable NDT method and test layout for the given problem (member type, distress, access) and capable of justifying the best combination with proper reason (5). | Student is capable of discussing a few appropriate NDT options or layouts for the problem but not capable of clearly selecting and justifying the best (4). | Student is capable of proposing a single NDT test arrangement with some mention of merits and de-merits (3). | Student is capable only of explaining the given test procedure in general, without adapting it to the specific problem/element (1–2). |
| **Implementation (8)** | PO3 & PO8 | Student is capable of implementing the planned NDT scheme correctly: proper equipment calibration, positioning, reading sequence and safety; collects sufficient, good-quality data | Student is capable of performing the required NDT test(s) correctly with minor mistakes; data set is mostly complete and reliable (5–6). | Student is capable of carrying out the test with guidance; some steps or readings are missing or inconsistent (3–4). | Student is capable of attempting the test but with frequent procedural errors or unsafe/incorrect handling of equipment; data is very limited or poor (1–2). |

| | | | | | |
|---|---|---|---|---|---|
| | | on the element under study (7–8). | | | |
| **Result & Analysis (5)** | PO4 | Student is able to process NDT readings correctly (e.g., convert rebound index/UPV/half-cell values), apply relevant charts/criteria, and compare results across locations with proper condition assessment and comments (5). | Student is able to compute results and assign basic quality/condition grades for all test locations (4). | Student is able to process results for a few locations and provides limited interpretation of defects/condition (3). | Student is able to write raw readings or basic outputs but not able to analyze or interpret the condition of the structure (1–2). |
| **Demonstration / Record (8)** | PO9 | The lab record is well-organized, with clear sections (e.g., Objective, Theory & Standard, Equipment, Procedure, Observations, Calculations, Results, Condition Assessment, Conclusions). Transitions between sections are smooth; photographs/plots are properly labelled (7–8). | The lab record is organized, with clear sections, but some sections are not well-defined or lack detail (5–6). | The lab record lacks clear organization or structure. Some sections (data, calculations, or conclusions) are unclear or incomplete (3–4). | The lab record is poorly organized, with missing or unclear sections; photos/figures and tables are not properly labelled (1–2). |

| AI-POWERED SMART BUILDING AND INFRASTRUCTURE DESIGN LAB | | | |
|---|---|---|---|
| **Course Code** | **1BIFL607C** | Scheme | 2025 |
| Type of Course | Ability Enhancement Course (Laboratory) | Semester | VI |
| Teaching Hours/Week (L :T : P) | 28 (0:0:2) | CIE Marks | 50 |
| Total Hours of Pedagogy CI( L :T):LI(P):SL:TW | 30 (0:0:2:2) | SEE Marks | 50 |
| Credits | 1 | Total Marks | 100 |
| Type of Examination | Practical | Exam Hours | 03 |

**Course outcome (Course Skill Set)**
**At the end of the course, the student will be able to:**

1. CO1 (L2 – Understand): Describe AI fundamentals, machine learning models, for civil engineering applications in building design.
2. CO2 (L3 – Apply): Apply AI algorithms to generate and optimize 3D models of smart buildings using generative design software
3. CO3 (L3 – Apply): Develop predictive models for structural health monitoring and infrastructure maintenance using AI-driven data analysis.
4. CO4 (L4 – Analyze): Analyze AI simulations for energy-efficient smart buildings and sustainable infrastructure under various loads.
5. CO5 (L3 – Apply): Integrate AI outputs with BIM workflows for collaborative design review and reporting in civil project.

**SET OF EXPERIMENTS (LI =28 hours)**

1. Introduction to AI tools: Setup AI tools and train basic ML model for material strength prediction from dataset.
2. AI-based 3D building modeling: Use generative AI (e.g., Autodesk Generative Design) to create optimized residential building layouts.
3. Smart structural analysis: Apply neural networks to predict beam deflections under loads using simulated data.
4. Infrastructure health monitoring: Develop CNN model for crack detection in images of bridges/roads.
5. Energy optimization in buildings: Simulate AI-controlled HVAC/lighting for energy savings in a virtual smart building.
6. AI-optimized sustainable roof tiles: Design solar-integrated tiles with cost-benefit analysis using ML regression.

**Suggested Learning Resources**

**Text books:**

1. "Artificial Intelligence in Civil Engineering" by Nishant Shrivastava - AI applications in structural design and smart infrastructure.
2. "Machine Learning for Civil Engineers" by Maryam Markom - Python-based models for building optimization.

**Reference Books:**

1. "AI and Machine Learning for Civil Engineers" by Saeed Esmaili - Case studies on smart buildings.
2. "Deep Learning for Civil Infrastructure" by various - Image analysis for health monitoring.

**Web links and Video Lectures (e-Resources):**

1. NPTEL: AI Applications in Civil Engineering - Lectures on ML for design.
2. Coursera: AI for Construction - Hands-on with generative tools.
3. YouTube: Autodesk AI in Civil Design - BIM integration demos

**NCrF – TW/SL Activities ( 2 hours) -Any one activity**

- Summarize AI tutorials on sustainable buildings (e.g., generative design for green infrastructure).
- Practice additional AI models for geotechnical predictions.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average marks for report and test shall be out of 50 marks.

**Eligibility for SEE:**

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks.**
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

**Rubrics for CIE- Continuous Assessment for practical courses**

| Performance Indicator | CO/PO Mapping | Superior (5) | Good (4) | Fair (3) | Needs Improvement (2) | Unacceptable (1) |
|---|---|---|---|---|---|---|
| P1: Regularity & Participation | CO1/PO5 (Lab discipline) | Always punctual, fully engaged, leads peers. | Regular, actively participates . | Moderately regular, some participation . | Irregular, minimal effort. | Absent/frequent disruptions. |
| P2: Understanding Objectives & Setup | CO2/PO2 (Problem analysis) | Fully comprehend s, independently sets up accurately. | Good grasp, sets up with minor help. | Partial understanding, basic setup. | Struggles with setup/aims. | No understanding , incorrect setup. scribd+1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| P3: Execution & Results | CO3/PO4 (Investigation) | Flawless conduction, precise results with error analysis. | Correct execution, accurate results. | Partial success, some errors. | Major errors in procedur e/results. | Fails to conduct properly. |
| P4: Record Writing | CO4/PO10 (Communicat ion) | Neat, complete, analytical beyond requirement s. | Complete, neat, includes calculations . | Basic record, some omissions. | Incomplete/ untidy. | Not submitted/ille gible |
| P5: Viva Voce & Presentation | CO5/PO12 (Lifelong learning) | Confident, deep insights, relates to applications. | Answers most questions correctly. | Basic responses, some hesitation. | Few correct answers. | Unable to respond. |

**Rubrics for SEE / CIE Test:**

| **Performance Indicator (CO/PO Mapping)** | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| PI-1: Experimental Skill / Technique (CO-1 / PO-5) | Executes procedure flawlessly, handles equipment with confidence, completes work within time, and shows initiative in troubleshooti ng. | Performs procedure correctly; equipment handling is safe but with minor hesitation; completes most steps on time. | Follows procedure but with intermittent errors; needs frequent guidance; time management is poor. | Makes repeated procedural errors; unsafe handling; requires continuous supervision; incomplete work. | Fails to follow basic steps; unsafe practices; work not attempted or abandoned. |
| PI-2: Observation & Data Recording (CO-2 / PO-2) | Records all required observations systematicall y; data is accurate, well-labeled, and presented in prescribed format. | Records most observation s correctly; data is readable but with minor omissions or formatting issues. | Records incomplete or inconsistent data; units/labels missing; entries are disorganized. | Data recording is haphazard; major omissions; units/labels largely absent. | No meaningful data recorded; or copied/incorrect entries without any understanding. |

| | | | | | |
|---|---|---|---|---|---|
| PI-3: Computation / Analysis (CO-3 / PO-4) | Applies correct formulas, computes results accurately, interprets graphs/tables meaningfully, and identifies sources of error. | Computes results correctly with minor arithmetic errors; graph/plot is acceptable; interpretation on is partial. | Uses correct method but makes significant calculation errors; graph/plot is poorly drawn; interpretation is weak. i | Incorrect method or formula; computations are mostly wrong; no clear interpretatio n. | No attempt at computation/analysis; blank or nonsensical entries. |
| PI-4: Safety, Discipline & Professionalis m (CO-4 / PO-12) | Maintains strict adherence to lab safety, SOPs, and instructions; respects peers and equipment; works independentl y. | Generally follows safety rules and instructions ; acceptable conduct; needs minimal supervision. | Occasionally ignores minor safety precautions; requires reminders on discipline. | Repeated lapses in safety/behavior; disturbs others; needs constant monitoring. | Gross violation of safety norms; disruptive or negligent behavior; unsafe for self/others. |
| PI-5: Viva-Voce / Conceptual Understanding (CO-5 / PO-1) | Demonstrates deep understandin g of concepts, objectives, and methodology; answers questions confidently and precisely. nsec+1 | Shows clear understandi ng of key concepts; answers most questions satisfactoril y. | Understands basics but struggles with detailed or application-bas ed questions. | Limited understandin g; answers are vague or incorrect on fundamental points. | Unable to answer basic questions; shows no understanding of the experiment. |

**Rubrics suggested for Practical continuous assessment**

| **Performance Indicators** | **Excellent** | **Very Good** | **Good** | **Satisfactory** |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |

| | | | | |
|---|---|---|---|---|
| | design with proper reason (5) | | | |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output. (3) | Student will be able to run the program but not able to analyze the output. (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

| DESIGN OF BUILDING SERVICES (MEP) LAB | | | |
|---|---|---|---|
| Course Code | 1BIFL607D | Scheme | 2025 |
| Type of Course | Ability Enhancement Course (Laboratory) | Semester | VI |
| Teaching Hours/Week (L :T : P) | 28(0:2:2) | CIE Marks | 50 |
| Total Hours of Pedagogy L :T:P:SL:TW | 30(0:0:2:2) | SEE Marks | 50 |
| Credits | 01 | Total Marks | 100 |
| Type of Examination | Practical | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

At the end of the course, the student will be able to:

1. **CO1 (L2 – Understand):** Describe basic MEP components (HVAC ducts, electrical panels, plumbing fixtures), codes (NBC 2016), coordination with civil/structural for building services integration.
2. **CO2 (L3 – Apply):** Create 2D layouts for plumbing/water supply systems using AutoCAD: fixtures, pipes, risers, sanitary drainage per IS codes
3. **CO3 (L3 – Apply):** Develop electrical layouts: lighting, power distribution, DB schedules, and load calculations for residential/commercial buildings.
4. **CO4 (L4 – Analyze):** Design HVAC systems (duct sizing, AHU placement); analyse energy efficiency, fire safety integration using Revit MEP basics.
5. **CO5 (L3 – Apply):** Integrate MEP services in BIM model; export for BOQ, clash detection; apply to infrastructure like hospitals/malls

**SET OF EXPERIMENTS**

1. Introduction to MEP CAD interface: Units, layers, symbols; preparation of simple plumbing riser diagram with fixtures and vents.
2. Residential plumbing layout: Hot and cold-water supply, sanitary lines, traps, and dimensioning as per NBC guidelines.
3. Electrical layout for residential building: Lighting plan, socket layout, panel board schedule, and basic cable sizing.
4. HVAC duct design for a room: Duct layout with diffusers and grilles; sizing using equal friction method; preparation of sectional/elevation views.
5. Fire-fighting system layout Sprinklers, hydrants, pumps, and zoning of piping systems.
6. MEP coordination drawing combined drawing showing plumbing and electrical systems; basic clash identification.

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Building Services Engineering – Integrated approach to MEP systems.
2. CAD for Engineers – Basics of drafting and modelling.

**Reference books / Manuals:**

1. National Building Code (NBC) – India (relevant sections).
2. Autodesk Revit MEP User Guide.
3. IS Codes for plumbing, electrical, and fire safety systems.

**Web links and Video Lectures (e-Resources):**

1. Autodesk official tutorials (AutoCAD & Revit MEP)
2. NPTEL courses on Building Services Engineering
3. YouTube channels for HVAC, plumbing, and BIM tutorials

**NCrF – TW/SL Activities (2 hours) -Any one activity**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Watching and summarizing selected video tutorials on MEP CAD interface, including layers, symbols, and unit settings such as preparation of a **simple plumbing riser diagram** with fixtures and vents.
2. Preparation of Digital Portfolio- Plumbing layout drawings (riser diagrams, water supply, drainage), Electrical layouts (lighting, socket plans, panel board schedules), HVAC duct layouts and fire-fighting system drawings.

3. A brief reflection note on the role of MEP systems in sustainable building design, covering: Water conservation through efficient plumbing design, Fire safety and resilience in buildings
4. Case Study Analysis. Review of a real-life building services failure due to poor MEP design/coordination, such as: Plumbing leakage or drainage failure, Electrical overloading or fire hazard, HVAC inefficiency or poor ventilation, Fire-fighting system malfunction

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

**Eligibility for SEE:**

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks.**

A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

Rubrics for CIE – Continuous assessment:

| **Performance Indicators** | **Superior (5)** | **Good(4)** | **Fair(3)** | **Needs Improvement (2)** | **Unacceptable (1)** |
|---|---|---|---|---|---|
| 1. Problem Understanding (PO1) | Clearly interprets given problem and requirements | Minor clarification needed | Basic understanding | Misinterpretation | No understanding |
| 2.Drawing/Model Development (PO3) | Complete and accurate drawing/model within time | Minor errors | Partially complete | Major errors | Incomplete |
| 3. Tool Efficiency (PO5) | Efficient and quick use of CAD/BIM tools | Minor delays | Moderate efficiency | Slow execution | Unable to proceed |
| 4. Output Quality (PO2) | Professional quality drawing with standards | Minor issues | Acceptable output | Poor quality | Incorrect output |

Rubrics for SEE / CIE Test:

| Performance Indicators | Superior (6) | Good (5) | Fair (4) | Needs Improvement (2-3) | Unacceptable-(1) |
|---|---|---|---|---|---|
| Problem Interpretation (PO1) | Fully understands and plans approach | Minor clarification needed | Basic understanding | Misinterpretation | No clarity |
| MEP Design Accuracy (PO2, PO3) | Fully accurate design with standards | Minor errors | Acceptable design | Major issues | Incorrect |
| Tool Application (PO5) | Advanced and efficient usage | Minor inefficiencies | Basic usage | Limited usage | Unable to use |
| Coordination (PO4) | Excellent integration of systems | Minor clashes | Some coordination | Poor coordination | No integration |
| Drawing Quality (PO9) | Professional output with proper layers, annotations | Minor issues | Average | Poor | Incomplete |

**Rubrics suggested for Practical continuous assessment**

| Performance Indicators | Excellent | Very Good | Good | Satisfactory |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |

| | | | | |
|---|---|---|---|---|
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output. (3) | Student will be able to run the program but not able to analyze the output. (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, and Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course