| Sustainable Urban Infrastructure Planning | | | |
|---|---|---|---|
| *Course Code* | **1MCIM201/1MCEM201** | *Scheme* | *2026* |
| *Type of Course* | *Integrated Professional Core Courses (IPCC)* | *Semester* | *II* |
| *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. Understand the concepts, frameworks, and challenges of urban infrastructure planning and development.
2. Analyse urban infrastructure systems, demand, capacity, and service delivery requirements.
3. Develop planning strategies for transport, water, sanitation, solid waste, and utility infrastructure.
4. Apply governance, institutional, financial, and regulatory principles in urban infrastructure management.
5. Evaluate project implementation, monitoring, maintenance, and sustainability aspects of urban infrastructure.
6. Integrate inclusive planning, resilience, and smart city approaches into urban infrastructure development.

**Module-1**

**Introduction to Urban Infrastructure:**

- *Urbanisation trends, settlement patterns, and growth of cities.*
- *Definition, scope, and components of urban infrastructure.*
- *Infrastructure-service relationship, demand assessment, and service standards.*
- *Planning hierarchy, urban growth management, and land-use linkages.*
- *Basic principles of inclusive, sustainable, and resilient urban infrastructure planning.*

**Linked COs: CO1, CO2** **Number of Hours: 08**

**Module-2**

**Urban Transport Infrastructure:**

- *Role of transport infrastructure in urban development.*
- *Road hierarchy, arterial/sub-arterial streets, junction design, and right-of-way concepts.*
- *Public transport systems: bus-based systems, multimodal integration, terminals, and interchange planning.*
- *Non-motorized transport infrastructure: footpaths, cycle tracks, universal accessibility, and complete streets.*
- *Traffic management, parking planning, transit-oriented development, and intelligent transport systems.*

**Linked COs: CO2, CO3** **Number of Hours: 09**

**Module-3**

**Core Urban Services and Utilities:**

- *Water supply planning: source, treatment, distribution, storage, and demand estimation.*
- *Sewerage and sanitation systems, drainage planning, and stormwater management.*
- *Solid waste management systems and decentralized treatment options.*
- *Urban power, communication, and basic utility corridor planning.*
- *Performance indicators, service levels, and lifecycle considerations.*

**Linked COs: CO2, CO3** **Number of Hours: 09**

**Module-4**

**Governance and Institutional Framework:**

- *Urban local bodies, parastatal agencies, metropolitan governance, and institutional roles.*
- *Urban development laws, bylaws, planning regulations, and approval processes.*
- *Governance of infrastructure projects, public-private partnerships, and stakeholder engagement.*
- *Financial planning, user charges, grants, municipal finance, and capital budgeting.*
- *Project implementation, monitoring, accountability, and grievance redressal mechanisms.*

**Linked COs: CO4, CO5** **Number of Hours:08**

**Module-5**

**Smart, Sustainable, and Resilient Urban Development:**

- *Smart city concepts, GIS-based planning, digital twins, and urban data systems.*
- *Climate-resilient infrastructure, disaster risk reduction, and adaptation strategies.*
- *Green infrastructure, low-impact development, and sustainability metrics.*
- *Lifecycle maintenance, asset management, and performance monitoring.*
- *Integrated urban development proposals and case studies.*

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

**PRACTICAL COMPONENTS OF IPCC**

**LIST OF EXPERIMENTS (LI=28 Hrs)**

1. 2. *Prepare an urban infrastructure profile for a selected city or ward.*
   3. *Prepare land-use and transport linkage map using GIS or base maps.*
   4. *Develop a road hierarchy and junction improvement plan.*
   5. *Prepare a pedestrian and NMT improvement proposal.*
   6. *Estimate water demand and prepare a basic water supply layout.*
   7. *Design a sewerage/stormwater drainage concept plan.*
   8. *Analyse a solid waste management system for a local body.*
   9. *Prepare a governance and institutional mapping chart for an urban project.*
   10. *Conduct a service-level assessment and suggest improvements.*
   11. *Prepare a mini-project on integrated urban infrastructure planning for a selected locality.*

**Suggested Learning Resources:**

**Text Books:**

1. *Rao, M. V. S., and Rao, H. V. S., Urban Infrastructure Planning.*
2. *O'Flaherty, C. A., Transport Planning and Traffic Engineering.*
3. *Khanna, S. K., Justo, C. E. G., and Veeraraghavan, Urban Transportation Planning.*

**Reference Books / Manuals**

1. *CPHEEO manuals on water supply, sewerage, and solid waste management.*
2. *IRC guidelines on urban roads, pedestrian facilities, and traffic engineering.*
3. *Government manuals on urban governance and municipal finance.*

**Software Tools:**

1. AutoCAD / Civil 3D.
4. QGIS / ArcGIS.
5. MS Project / Primavera P6.
6. Spreadsheet tools for demand and cost analysis.

**Web links and Video Lectures (e-Resources) & Software tools**

1. *NPTEL / SWAYAM courses on construction management and scheduling.*
2. *Primavera P6 and MS Project official learning resources.*
3. *BIM and 4D planning tutorials for construction projects.*

**Software Tools:**

**Core software tools:**

- *Project Management & Scheduling: Oracle Primavera P6 Professional, Microsoft Project (MSP).*
- *BIM, 4D/5D Simulation, & Logistics: Autodesk Navisworks Manage, Bentley Synchro 4D, Bexel Manager.*

**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 (both CIE and SEE)*

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% o the maximum marks prescribed for SEE to be eligible for a pass in the course.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

*Continuous Internal Evaluation:*

*(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 of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.*

*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 the 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 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.*

*Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component*

| *Component* | *Description* | *Marks* |
|---|---|---|
| *Allotment of marks for regular classwork* | | |
| *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 /* | *Ability to set up apparatus, follow procedure, take* | *5* |

| | | | |
|---|---|---|---|
| | *Experiment Performance* | *observations, and obtain correct results in the test experiment.* | *marks* |
| | *Viva-Voce* | *Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.* | *5 marks* |
| | *Subtotal* | | *10* |
| | *Total* | | *25* |

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

*As per National credit framework (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 activities 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. The course coordinator can also design learning activities based on course outcomes.*

| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
|---|---|---|
| *1* | **TW1 – Urban infrastructure audit of a local ward / campus / micro-zone:** *Students shall do Inventory, service gaps, map, and recommendations* | *25* |
| *2* | **TW2 – Transport infrastructure case study:** *Road hierarchy, junction study, public transport integration, NMT observations* | *25* |
| *3* | **TW3- Governance and service delivery study:** *Institutional mapping, roles, funding, and bottleneck analysis* | *25* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **SL1 Study of transport infrastructure case / metro / BRT / walkability: Short** *note with key standards and applicability* | *25* |
| *2* | **SL2 Study of transport infrastructure case / metro / BRT / walkability:** *Comparative report with drawings or sketches* | *25* |
| *3* | **SL3 – Governance model review for city infrastructure delivery:** *Note on institutions, finance, and implementation issues* | *25* |

**Sample rubrics for TW activities:**

| *Criterion* | *4 – Excellent* | *3 – Good* | *2 – Satisfactory* | *1 – Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *The problem is clearly defined with strong justification, objectives, and scope.* | *The problem is mostly clear with minor gaps in framing or justification.* | *The problem is stated, but clarity or justification is limited.* | *The problem is poorly defined or unclear.* |
| *Data and method* | *Data collected/used is appropriate and sufficient; methods/tools are well chosen and logically applied.* | *Data and methods are generally appropriate with minor issues or omissions.* | *Data is limited or partially relevant; methods are basic or inconsistently applied.* | *Data is inadequate/irrelevant; methods are inappropriate or missing.* |

| *Criterion* | *4 – Excellent* | *3 – Good* | *2 – Satisfactory* | *1 – Needs Improvement* |
|---|---|---|---|---|
| *Analysis* | *Analysis is thorough; interpretations are logically argued and results are valid.* | *Analysis is generally sound with minor errors or missing details.* | *Analysis is partial; contains gaps or superficial interpretation.* | *Analysis is weak, incorrect, or largely missing.* |
| *Recommendations* | *Recommendations are feasible, context-specific, and clearly derived from analysis.* | *Recommendations are relevant but may have minor limitations or lack detail.* | *Recommendations are generic or only loosely connected to analysis.* | *Recommendations are incomplete, unrealistic, or absent.* |
| *Presentation* | *Work is very well organized, neat, and professionally presented, including structure, figures, and language.* | *Work is well organized with minor issues in formatting or clarity.* | *Presentation is acceptable but uneven; structure or formatting needs improvement.* | *Work is poorly organized, difficult to follow, or untidy.* |

**Suggested rubrics for Practical continuous assessment:**

| *Performance Indicators* | *Excellent* | *Very Good* | *Good* | *Satisfactory* |
|---|---|---|---|---|
| *Fundamental Knowledge (4) (PO1)* | *The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics. (4)* | *Student has good knowledge of some topics related to construction planning and BIM workflows. (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 planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)* | *Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)* | *Student is capable of discussing a single planning workflow with merits and demerits. (3)* | *Student can explain the planning/design approach only partly. (1-2)* |
| *Implementation (8) (PO3 & PO8)* | *Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)* | *Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)* | *Student is capable of implementing the workflow with partial explanation. (3-4)* | *Student can implement only limited parts of the workflow. (1-2)* |

| | | | | |
|---|---|---|---|---|
| *Result &Analysis (5) (PO4)* | *Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)* | *Student will be able to run the workflow for all the cases. (4)* | *Student will be able to run the workflow for a few cases and analyze the output. (3)* | *Student will be able to run the workflow but not able to analyze the output. (1-2)* |
| *Demonstration (8) (PO9)* | *The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)* | *The lab record/portfolio 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)* |

| PROJECT EVALUATION, FINANCE & ECONOMICS | | | |
|---|---|---|---|
| *Course Code* | **1MCIM202/1MCEM202** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *CO1 Explain the fundamentals of project evaluation, financial planning, and economic decision-making in engineering projects.*
2. *CO2 Estimate project costs, cash flows, and financial viability using standard techniques.*
3. *CO3 Apply discounted cash flow methods, break-even analysis, and project appraisal tools for decision-making.*
4. *CO4 Analyze economic feasibility using time value of money, inflation, depreciation, taxation, and cost-benefit principles.*
5. *CO5 Prepare project reports, evaluate funding options, and interpret financial and economic indicators for infrastructure and engineering projects..*

**Module-1**

**Introduction to Project Evaluation:**

- *Definition, objectives, scope, and need for project evaluation.*
- *Project life cycle: identification, formulation, appraisal, implementation, monitoring, and closure.*
- *Types of projects in engineering and infrastructure domains.*
- *Technical, financial, economic, social, and environmental appraisal.*
- *Basics of project planning, feasibility studies, and risk identification.*

**Linked COs: CO1** **Number of Hours: 8 hrs**

**Module-2**

**Project Costing and Financial Analysis:**

- *Project cost components: capital cost, operating cost, maintenance cost, and contingency.*
- *Preparation of project cash flow statements.*
- *Time value of money, present worth, future worth, and annual worth concepts.*
- *Interest rates, discounting, compounding, and equivalence relations.*
- *Capital budgeting, payback period, net present value, internal rate of return, and profitability index.*

**Linked COs: CO2** **Number of Hours: 9 hrs**

**Module-3**

**Economic Evaluation of Projects:**

- *Principles of engineering economics.*
- *Inflation, depreciation, taxes, insurance, and salvage value.*
- *Replacement analysis and economic life of projects.*
- *Break-even analysis and sensitivity analysis.*
- *Cost-benefit analysis for public and infrastructure projects.*

**Linked COs: CO3, CO4** **Number of Hours: 9 hrs**

**Module-4**

**Project Financing and Funding Methods:**

- *Sources of project finance: equity, debt, grants, loans, and public funding.*
- *Financial institutions, PPP models, and concession frameworks.*

- *Budgeting, financial planning, and fund allocation.*
- *Loan repayment, annuity, and amortization schedules.*
- *Basics of financial risk, credit appraisal, and financial sustainability.*

**Linked COs: CO4** **Number of Hours: 8 hrs**

**Module-5**

**Project Appraisal and Decision Support:**

- *Preparation of project evaluation reports.*
- *Multi-criteria decision-making in project selection.*
- *Social cost-benefit analysis and stakeholder considerations.*
- *Sustainability, lifecycle costing, and long-term value assessment.*
- *Case studies on infrastructure, civil works, and industrial projects.*

**Linked COs: CO5** **Number of Hours: 8 hrs**

**Suggested Learning Resources:**

**Textbooks**

1. *Prasanna Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review, McGraw-Hill.*
2. *B. C. Punmia, Project Planning and Control, Laxmi Publications.*
3. *N. P. Bhatia, Engineering Economics and Project Management, Oxford University Press.*
4. *Newnan, Eschenbach, and Lavelle, Engineering Economic Analysis, Oxford University Press.*
5. *R. Panneerselvam, Engineering Economics, PHI Learning.*
6. *Gray, Larson, and Desai, Project Management: The Managerial Process, McGraw-Hill.*

**Reference Books**

1. *J. R. Meredith and S. J. Mantel, Project Management: A Managerial Approach, Wiley.*
2. *Grant, Ireson, and Leavenworth, Principles of Engineering Economy, Wiley.*
3. *White, Sondhi, and Fried, The Analysis and Use of Financial Statements, Wiley.*
4. *IMF/World Bank/GoI public project appraisal manuals and budget documents.*
5. *Relevant standards and guidelines on project financing, appraisal, and economic analysis.*

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

1. *NPTEL courses on engineering economics, project management, and financial analysis.*
2. *Government of India project appraisal and infrastructure finance guidelines.*
3. *RBI and SEBI resources for financial concepts and market instruments.*
4. *Spreadsheet tools for cash flow analysis, NPV, IRR, and sensitivity analysis.*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a*

*subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **TW1**- *Prepare a feasibility report for a selected engineering or infrastructure project.* | *24* |
| *2* | **TW2 Prepare** *a detailed project cash flow and financial appraisal sheet using NPV, IRR, and payback period*. | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **SL1:** *Study a public infrastructure project and analyze its economic viability using cost-benefit principles.* | *24* |
| *2* | **SL2:** *Prepare an amortization schedule for a loan-based project financing model.* | *24* |
| *3* | **SL3:** *Compare PPP, EPC, and conventional funding models for a project case study.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear identification of the issue with strong relevance to lean/productivity concepts.* | *Issue identified clearly with minor gaps.* | *Basic identification with limited clarity.* | *Poorly defined or irrelevant problem.* |
| *Method / procedure* | *Appropriate method chosen and executed systematically.* | *Method mostly appropriate with minor omissions.* | *Partially appropriate method with several gaps.* | *Incorrect or incomplete method.* |

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Analysis / interpretation* | *Data or observations are analyzed logically and convincingly.* | *Analysis is sound with minor errors.* | *Limited analysis with some interpretation.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Recommendations are practical, specific, and aligned to findings.* | *Recommendations are relevant but somewhat general.* | *Recommendations are basic and partially relevant.* | *Recommendations are vague or unrealistic.* |
| *Presentation / documentation* | *Neat, well organized, and professionally presented.* | *Clear presentation with minor formatting issues.* | *Acceptable but uneven organization.* | *Poorly organized or incomplete.* |

| MODERN CONSTRUCTION EQUIPMENT, FORMWORK AND TECHNIQUES | | | |
|---|---|---|---|
| *Course Code* | **1MCIM203** | *Scheme* | *2026* |
| *Type of Course* | **Professional Core Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain the classification, selection, and economic considerations of construction equipment used in civil engineering works.*
2. *Apply appropriate earthmoving, hauling, lifting, and transportation equipment for different construction operations.*
3. *Select and describe suitable concreting, formwork, and scaffolding systems for safe and efficient construction.*
4. *Analyze specialized construction techniques such as piling, tunneling, precast construction, and modular construction.*
5. *Evaluate modern trends in construction automation, digital monitoring, sustainability, and productivity improvement.*
6. *Develop practical solutions for improving construction efficiency, safety, and project performance.*

**Module-1**

**Introduction to Construction Equipment:**

*Construction equipment classification, selection criteria, economic considerations, ownership and operating cost, depreciation, productivity estimation, and equipment management. Earthmoving equipment: excavators, backhoe loaders, bulldozers, graders, scrapers, and loaders. Factors affecting equipment choice in different project conditions.*

**Linked CO: CO1.** **Number of Hours: 08**

**Module-2**

**Earthwork and Transportation Equipment:**

*Equipment for excavation, hauling, compaction, and material handling. Trucks, dumpers, conveyors, cranes, hoists, winches, and lifting systems. Equipment planning for large-scale infrastructure works, highways, and building construction. Safety aspects and productivity enhancement in material movement.*

**Linked CO: CO2.** **Number of Hours: 08**

**Module-3**

**Concrete Production, Formwork and Scaffolding:**

*Batching plants, mixers, concrete pumps, transit mixers, vibrators, slip form equipment, and shotcrete equipment. Mechanized concreting techniques, curing systems, and quality control in concrete construction. Formwork systems: conventional formwork, modular formwork, aluminium formwork, tunnel form, climbing form, and slip form; design, erection, stripping, and safety considerations. Scaffolding systems: tubular scaffolding, frame scaffolding, mobile scaffolds, suspended scaffolds, access platforms, inspection, and safety practices. Use of equipment in mass concreting, tall structures, and special structures.*

**Linked CO: CO3.** **Number of Hours: 10**

**Module-4**

**Construction Techniques and Specialized Methods:**

*Techniques in pile foundation construction, tunnelling, dewatering, underpinning, precast construction, modular construction, and repair works. Mechanized construction methods for bridges, roads, and industrial structures. Introduction to advanced methods such as 3D printing in construction, robotics, and prefabrication*.

**Linked CO: CO4.** **Number of Hours: 08**

**Module-5**

**Emerging Trends and Project Applications:**

*Modernization in construction: automated equipment, digital monitoring, sensor-based construction, and equipment telematics. Lean construction, productivity improvement, sustainability, and environmental considerations. Case studies on equipment selection, formwork systems, scaffolding systems, and technique optimization for real projects.*

**Linked CO: CO5, CO6.** **Number of Hours: 08**

**Suggested Learning Resources:**

**Textbooks:**

1. *Peurifoy, R.L., Schexnayder, C.J., and Shapira, A., Construction Planning, Equipment, and Methods, 9th Edition, McGraw-Hill Education.*
2. *Sharma, S.C. and Kapoor, P.K., Construction Equipment and its Management, 2nd Edition, Khanna Publishers.*
3. *Deodhar, S.V., Construction Equipment and Job Planning, 3rd Edition, Khanna Publishers.*
4. *Varghese, P.C., Building Construction, 2nd Edition, PHI Learning.*

**Reference Books**

1. *Arora, S.P. and Bindra, S.P., Building Construction, 19th Edition, Dhanpat Rai Publications.*
2. *Punmia, B.C., Jain, A.K. and Jain, A.K., Building Construction, 12th Edition, Laxmi Publications.*
3. *Chudley, R. and Greeno, R., Building Construction Handbook, 11th Edition, Routledge.*
4. *Schaufelberger, J.E. and Migliaccio, G.C., Construction Equipment Management, 2nd Edition, Pearson..*

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

1. *NPTEL/SWAYAM courses on construction planning, equipment, and project management.*
2. *Manufacturer technical resources for excavators, cranes, batching plants, and machine control systems.*
3. *Industry white papers on BIM-enabled construction, telematics, autonomous equipment, and smart site management.*
4. *Project management and equipment planning tutorials using Primavera, MS Project, and BIM platforms.*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of*

*25 marks. The average of the two test marks shall be the marks secured by a student in IA.*
*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **TW1 – Equipment Identification and Selection Exercise:** *Identify major construction equipment used in an assigned project scenario and justify the selection based on site conditions, output, and safety. Linked COs: CO1, CO3..* | *24* |
| *2* | **TW2 – Productivity Analysis of Equipment Fleet:** *Calculate productivity of earthmoving, hauling, lifting, or concreting equipment for a given site and recommend balancing measures. Linked COs: CO2, CO3.* | *24* |
| *3* | **TW3 – Automation and Smart Site Case Study: Study a smart construction site or equipment with telematics, machine guidance, or digital monitoring and present findings with diagrams and observations. Linked COs: CO4, CO6** | |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **SL1 – Equipment Economics Review:** *Compare ownership, rental, and leasing options for a specific construction equipment set and submit lifecycle cost observations. Linked COs: CO3, CO5.* | *24* |
| *2* | **SL2 – Digital Construction Review:** *Prepare a review on BIM-linked equipment planning, GPS-guided machinery, telematics, or automation in construction. Linked COs: CO4, CO6.* | *24* |

**Sample rubrics for TW activities:**

| *Criterion* | *4 – Excellent* | *3 – Good* | *2 – Satisfactory* | *1 – Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Problem is clearly defined with strong justification and clear objectives.* | *Problem is mostly clear with minor gaps in framing or justification.* | *Problem is stated but lacks clarity or detailed justification.* | *Problem is poorly defined or unclear.* |
| *Data and method* | *Data collected/used is appropriate and sufficient; methods/tools are well chosen* | *Data and methods are generally appropriate with minor issues or omissions.* | *Limited or partially relevant data; methods are basic or inconsistently* | *Data is inadequate/irrelevant; methods are inappropriate or missing.* |

| *Criterion* | *4 – Excellent* | *3 – Good* | *2 – Satisfactory* | *1 – Needs Improvement* |
|---|---|---|---|---|
| | *and logically applied.* | | *applied.* | |
| *Analysis* | *Analysis is thorough; interpretations are logically argued and results are valid.* | *Analysis is generally sound with minor errors or missing details.* | *Analysis is partial; contains gaps or superficial interpretation.* | *Analysis is weak, incorrect, or largely missing.* |
| *Recommendations* | *Recommendations are feasible, context-specific, and clearly derived from analysis.* | *Recommendations are relevant but may have minor limitations or lack detail.* | *Recommendations are generic or only loosely connected to analysis.* | *Recommendations are incomplete, unrealistic, or absent.* |
| *Presentation* | *Work is very well organized, neat, and professionally presented.* | *Work is well organized with minor issues in formatting or clarity.* | *Presentation is acceptable but uneven.* | *Work is poorly organized, difficult to follow, or untidy.* |

| ADVANCED CONSTRUCTION CONTRACT ADMINISTRATION, CLAIMS AND PROCUREMENT | | | |
|---|---|---|---|
| *Course Code* | **1MCIM204/1MCEM204/1MCCT204** | *Scheme* | *2026* |
| *Type of Course* | *Professional Core Course* | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain the principles of construction contract administration, contract documents, roles, and responsibilities in project delivery.*
2. *Analyze common construction claims, their causes, entitlement, documentation, and procedural requirements.*
3. *Apply procurement strategies, tendering methods, and contract selection principles for different project contexts.*
4. *Evaluate time, cost, quality, and risk implications arising from variations, delays, disruptions, and contractual non-compliance.*
5. *Prepare claim support documents, contract administration records, and procurement-related reports using industry practices.*
6. *Assess dispute avoidance, negotiation, mediation, adjudication, and arbitration mechanisms in construction projects.*

**Module-1**

**Fundamentals of Contract Administration:**

*Introduction to construction contracts, contract documents, roles of employer, engineer/consultant, contractor, subcontractor, and key administrative functions. Formation of contracts, essentials of valid contracts, interpretation of clauses, contract hierarchy, notices, instructions, records, and correspondence. Types of construction contracts: item rate, lump sum, design-build, EPC, turnkey, cost-plus, and target-cost contracts.*

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

**Module-2**

**Procurement Systems and Tendering:**

*Procurement concepts, project delivery methods, selection of procurement strategy, and suitability for infrastructure and building projects. Prequalification, tendering procedures, bid evaluation, negotiation, award, and contract finalization. e-procurement, two-cover and two-stage bidding, quality and cost-based selection, and public procurement practices. Risk allocation in procurement and contract packaging for multidisciplinary projects.*

**Linked COs: CO3, CO5.** **Number of Hours: 09**

**Module-3**

**Claims in Construction Projects:**

- *Definition and classification of claims: variation claims, delay claims, acceleration claims, disruption claims, prolongation cost claims, and loss and expense claims. Causes of claims, entitlement, causation, concurrent delay, record keeping, and claim submission process. Notice requirements, supporting documentation, quantum analysis, and techniques for claim preparation and assessment. Introduction to claim prevention through proactive administration and contract controls.*

**Linked COs: CO2, CO4, CO5.** **Number of Hours: 09**

**Module-4**

**Time, Cost, and Risk Administration:**

- *Time impact of variations, extensions of time, critical path implications, interim certificates, price adjustment, and change management. Cost control in contract administration, measurement, valuation of variations, payment certification, retention, and final account preparation. Risk management in contracts, insurance, force majeure, liquidated damages, penalties, and performance security. Administrative responses to disputes, non-performance, and contractual breaches.*

**Linked COs: CO1, CO4, CO5.** **Number of Hours: 08**

**Module-5**

**Dispute Resolution and Contemporary Practice**

- *Dispute avoidance techniques, negotiation, conciliation, mediation, dispute boards, adjudication, arbitration, and litigation overview. Documentation standards, contemporaneous records, claim defence, and expert evidence basics. Contemporary procurement and administration trends: collaborative contracting, digital contract records, data-driven administration, and integration with BIM/ISO 19650 information practices. Case studies on claim-rich projects and industry best practices.*

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

**Suggested Learning Resources:**

**Textbooks:**

1. *Murdoch, J. and Hughes, W., Construction Contracts: Law and Management, 5th Edition, Routledge.*
2. *Hudson, I. N. Duncan, Hudson's Building and Engineering Contracts, 14th Edition, Sweet & Maxwell.*
3. *Bunni, N. G., The FIDIC Forms of Contract, 3rd Edition, Wiley-Blackwell.*
4. *Chitkara, K. K., Construction Project Management: Planning, Scheduling and Controlling, 2nd Edition, McGraw-Hill Education.*

**Reference Books:**

1. *FIDIC, Conditions of Contract for Construction, Latest Edition, FIDIC.*
2. *Society of Construction Law, Delay and Disruption Protocol, 2nd Edition, Society of Construction Law.*
3. *AACE International, Recommended Practice on Forensic Schedule Analysis, Latest Edition, AACE International.*
4. *Kale, V. S., Construction Management and Planning, 5th Edition, PHI Learning.*

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

1. *NPTEL/SWAYAM courses on construction contracts, procurement, and dispute resolution.*
2. *ISO 19650 framework for information management in construction projects.*
3. *Professional resources on construction claims and contract administration 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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be*

*50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*
*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **TW-1: Contract Clause Analysis** *Students shall analyze a given construction contract and identify clauses related to notices, variations, payment, delay, and claims. They shall prepare a clause extraction sheet and summarize contractual obligations in a tabular format.* | *24* |
| *2* | **TW-2: Claim Notice Drafting** *Students shall draft a notice for delay/variation/latent condition based on a project scenario. The submission shall include event description, contractual basis, reservation of rights, and supporting records.* | *24* |
| *3* | **TW-3: Variation and EOT Worksheet** *Students shall prepare a variation valuation sheet and an extension of time worksheet using a sample case. They shall show cause, effect, time impact, and commercial implications.* | *24* |
| *4* | **TW-4: Procurement Plan and Bid Evaluation** *Students shall develop a procurement strategy for a project and prepare a comparative bid evaluation matrix. The exercise shall include risk allocation, bid method selection, and award recommendation.* | *24* |

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

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **SL-1: Case Study on Construction Claims:** *Students shall study a project case involving delay, variation, or dispute and present the claim history, causes, entitlement issues, and likely outcomes.* | *24* |
| *2* | **SL-2: Mock Procurement Review** *Students shall role-play employer, consultant, and bidder teams to evaluate tender documents, discuss bid risks, and recommend a procurement route.* | *24* |
| *3* | **SL-3: Record-Keeping and Notice Simulation:** *Students shall maintain a daily site record set for a simulated project event and prepare notices, minutes, and claim support* | *24* |

| | | |
|---|---|---|
| | *documents.* | |
| *4* | **SL-4: BIM-Enabled Contract Administration Discussion:** *Students shall discuss how digital information management, common data environment, and structured records support contract administration and claims control.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *Excellent (4)* | *Good (3)* | *Satisfactory (2)* | *Needs Improvement (1)* |
|---|---|---|---|---|
| *Understanding of contract terms* | *Correctly identifies and explains relevant clauses with clear legal/contractual basis apastyle.apa+1.* | *Identifies most clauses with minor omissions.* | *Identifies basic clauses but explanation is partial.* | *Incomplete or incorrect identification.* |
| *Technical accuracy* | *Demonstrates strong understanding of claim/procurement concepts.* | *Minor errors in interpretation.* | *Several conceptual gaps.* | *Major errors in interpretation.* |
| *Documentation quality* | *Professional format, complete records, clear structure.* | *Mostly well formatted and complete.* | *Adequate but lacking clarity or consistency.* | *Poorly organized or incomplete.* |
| *Practical application* | *Strong linkage to real project practice and industry needs constructionfront+1.* | *Good linkage with limited depth.* | *Basic application only.* | *No meaningful practical linkage.* |

| ADVANCED PROJECT MANAGEMENT (AI, LEAN, AGILE, BIM INTEGRATED) | | | |
|---|---|---|---|
| *Course Code* | **1MCIM205A** | *Scheme* | *2026* |
| *Type of Course* | **Professional Core Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain advanced project management principles, lifecycle planning, and digital delivery approaches in engineering projects.*
2. *Apply AI-enabled tools, Lean principles, and Agile methods to improve project planning, execution, and control.*
3. *Integrate BIM-based information management with scheduling, cost control, coordination, and decision-making.*
4. *Analyze project risks, productivity losses, delays, and performance issues using data-driven and collaborative methods.*
5. *Develop project dashboards, workflow improvements, and control strategies using contemporary project management practices.*
6. *Evaluate project governance, communication, and stakeholder coordination mechanisms in complex project environments.*

**Module-1**

**Foundations of Advanced Project Management:**

*Project management concepts, project life cycle, scope, schedule, cost, quality, risk, procurement, and stakeholder management. Traditional versus advanced project management approaches. Project governance, integrated project controls, baseline management, and performance monitoring. Introduction to digital project delivery, data-driven management, and collaboration in complex engineering projects.*

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

**Module-2**

**Lean Project Management and Agile Delivery:**

*Principles of Lean thinking, value stream mapping, waste elimination, pull planning, Last Planner System, takt planning, and continuous improvement in projects. Agile principles, iterative planning, sprint reviews, adaptive management, backlog prioritization, and hybrid delivery models for engineering projects. Application of Lean and Agile methods in construction and infrastructure project management.*

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

**Module-3**

**AI Applications in Project Management:**

*Introduction to AI and machine learning in project management. AI-assisted scheduling, predictive analytics, resource forecasting, risk prediction, anomaly detection, and decision support systems. Natural language processing for project documentation, dashboards, and automated reporting. Use of AI tools for productivity improvement, issue tracking, and project monitoring. Ethical considerations, limitations, and responsible use of AI in project environments.*

**Linked COs: CO1, CO2, CO5.** **Number of Hours: 09**

**Module-4**

**BIM-Integrated Project Management:**

*BIM fundamentals, levels of information need, common data environment, and information management workflows. Integration of BIM with planning, scheduling, cost management, quantity take-off, coordination, and progress tracking. 4D, 5D, and 6D BIM applications in project execution and control. BIM-enabled collaboration, clash detection, change management, and digital handover in project delivery.*

| **Linked COs: CO3, CO4, CO5.** | **Number of Hours: 08** |
|---|---|

**Module-5**

**Project Performance, Risk, and Control:**

*Project performance measurement, earned value management, key performance indicators, dashboards, and visual control techniques. Risk identification, mitigation, contingency planning, and resilience in complex projects. Communication management, stakeholder coordination, decision-making, and escalation mechanisms. Contemporary trends in integrated project delivery, digital twins, sustainability-linked project management, and case studies on AI, Lean, Agile, and BIM integration.*

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

**Suggested Learning Resources:**

**Textbooks:**

1. *Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK Guide), 8th Edition, Project Management Institute, 2026.*
2. *Kerzner, H., Project Management: A Systems Approach to Planning, Scheduling, and Controlling, 14th Edition, John Wiley & Sons Inc., 2025.*
3. *Ballard, G., The Last Planner System of Production Control, latest/relevant edition, Lean Construction Institute or equivalent publisher, as applicable.*
4. *Eastman, C. et al., BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers,* **4th Edition***, Wiley & Sons Ltd., 2025.*

**Reference Books**

1. *Womack, J. P., and Jones, D. T., Lean Thinking, latest edition, Free Press / Simon & Schuster, as applicable.*
2. *Highsmith, J., Agile Project Management, latest edition, Addison-Wesley / Pearson, as applicable.*
3. *Smith, P. and Tardif, M., BIM and the Project Lifecycle, latest edition, Wiley or equivalent publisher, as applicable.*
4. *Browning, T. R., Design Structure Matrix Methods and Applications, latest edition, MIT Press / equivalent publisher, as applicable.*

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

1. *NPTEL/SWAYAM courses on project management, Lean construction, BIM, and digital project delivery.*
2. *ISO 19650 resources for information management in BIM-enabled projects.*
3. *Industry case studies on AI-based project planning and performance analytics..*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

| |
|---|
| *Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*<br>*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*<br>*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks* |

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **TW-1: Lean Process Mapping.** *Students shall map a project workflow, identify waste, and propose Lean improvements using value stream mapping.* | *24* |
| *2* | **TW-2: AI-Based Risk Forecasting Exercise**. *Students shall use a case dataset or scenario to identify risk patterns, trends, and mitigation actions***.** | *24* |
| *3* | **TW-3: BIM 4D Coordination Review**. *Students shall prepare a coordination note linking model elements with schedule activities and clashes.* | *24* |
| *4* | **TW-4: Agile Sprint Planning for Projects.** *Students shall create a sprint backlog and review board for a project management task.* | *24* |

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

| Sl. No. | Self-learning Activities | Number of Hours / Semester |
|---|---|---|
| *1* | **SL-1: Case Study on AI in Projects.** *Students shall study an AI-enabled project control case and present benefits, limitations, and lessons learned.* | *24* |
| *2* | **SL-2: Lean Construction Improvement Review.** *Students shall examine a project process and suggest waste reduction measures.* | *24* |
| *3* | **SL-3: BIM-Based Project Coordination Study.** *Students shall review how BIM supports planning, cost, and* **communication.** | *24* |
| *4* | **SL-4: Agile or Hybrid Delivery Reflection.** *Students shall analyze the suitability of Agile or hybrid methods for a selected engineering project.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *Excellent (4)* | *Good (3)* | *Satisfactory (2)* | *Needs Improvement (1)* |
|---|---|---|---|---|
| *Understanding of concepts* | *Correctly explains project management, Lean, Agile, AI, and BIM* | *Identifies most concepts with minor omissions.* | *Basic understanding with partial explanation.* | *Incomplete or incorrect understanding.* |

| *Criteria* | *Excellent (4)* | *Good (3)* | *Satisfactory (2)* | *Needs Improvement (1)* |
|---|---|---|---|---|
| | *concepts.* | | | |
| *Technical accuracy* | *Strong and correct application to the given project case.* | *Minor errors in interpretation.* | *Several conceptual gaps.* | *Major errors in interpretation.* |
| *Documentation quality* | *Professional format, complete records, clear structure.* | *Mostly well formatted and complete.* | *Adequate but lacking consistency.* | *Poorly organized or incomplete.* |
| *Practical application* | *Strong linkage to real project practice and industry needs.* | *Good linkage with limited depth.* | *Basic application only.* | *No meaningful practical linkage.* |

| WATER RESOURCES INFRASTRUCTURE SYSTEMS | | | |
|---|---|---|---|
| *Course Code* | **1MCIM205B/1MCEM205B** | *Scheme* | *2026* |
| *Type of Course* | **Professional Core Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain the planning, components, and functioning of water resources infrastructure systems.*
2. *Analyze irrigation, drainage, flood control, and river training systems for project suitability.*
3. *Apply hydraulic and planning principles to design and assess water conveyance and storage infrastructure.*
4. *Evaluate operation, maintenance, safety, and performance requirements of water resources projects.*
5. *Prepare technical reports and management plans for water resources infrastructure development.*
6. *Assess contemporary challenges in sustainable water infrastructure, climate resilience, and governance.*

**Module-1**

**Introduction to Water Resources Infrastructure:**

*Water resources and their development, importance of water infrastructure in agriculture, urban supply, industry, and ecosystem services. Planning principles of water resources projects, basin-level planning, multipurpose development, and infrastructure classification. Components of water resources systems: reservoirs, dams, canals, barrages, lift irrigation systems, headworks, tunnels, aqueducts, and distribution networks.*

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

**Module-2**

**Irrigation and Conveyance Systems:**

*Irrigation demand estimation, crop water requirement, duty and delta, command area development, and irrigation scheduling. Canal systems, canal alignment, canal lining, canal structures, cross drainage works, canal outlets, and distribution networks. Pressurized irrigation systems such as sprinkler and drip irrigation, suitability, advantages, limitations, and system components.*

**Linked COs: CO1, CO2, CO3.** **Number of Hours: 08**

**Module-3**

**Storage, Flood, and Drainage Infrastructure:**

*Reservoir planning, site selection, storage zones, yield analysis, spillways, outlet works, and dam safety basics. Flood control infrastructure including embankments, levees, detention basins, flood routing, and river training works. Drainage systems for agricultural and urban areas, surface and subsurface drainage, waterlogging control, and conjunctive use considerations.*

**Linked COs: CO2, CO3, CO4.** **Number of Hours: 09**

**Module-4**

**Operation, Maintenance, and Performance Management:**

*Operation and maintenance of water resources infrastructure, inspection schedules, performance monitoring, and asset management concepts. Common failures and service issues in canals, dams, gates, regulators, and drainage facilities. Rehabilitation, modernization, automation, instrumentation, safety management, emergency action*

*planning, and lifecycle considerations.*

**Linked COs: CO4, CO5, CO6.** **Number of Hours: 09**

**Module-5**

**Sustainable and Climate-Resilient Water Systems:**

*Integrated water resources management, watershed-based approaches, climate variability, drought management, and flood resilience. Environmental and social considerations in water infrastructure projects, sustainability assessment, stakeholder participation, and governance. Smart water systems, digital monitoring, data-driven operations, reuse, adaptation strategies, and case studies on modern water infrastructure projects.*

**Linked COs: CO2, CO4, CO6.** **Number of Hours: 08.**

**Suggested Learning Resources:**

**Textbooks:**

1. *Subramanya, K., Engineering Hydrology, McGraw-Hill.*
2. *Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers.*
3. *Michael, A. M., Irrigation Theory and Practice, Vikas Publishing.*
4. *R. B. Singh, Water Resources Systems Planning and Management — Tata McGraw-Hill Publishing, 1987, 1st Edition.*
5. *Chow, Maidment & Mays, Applied Hydrology — McGraw-Hill, 1988, 1st Edition*

**Reference Books**

1. *Ven Te Chow, Maidment, and Mays, Applied Hydrology, McGraw-Hill.*
2. *USBR, Design of Small Dams, United States Bureau of Reclamation.*
3. *FAO, Irrigation and Drainage Papers, Food and Agriculture Organization.*
4. *Asawa, G. L., Irrigation Engineering, New Age International*

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

1. *NPTEL/SWAYAM courses on irrigation engineering, hydrology, and water resources systems.*
2. *Central Water Commission and Ministry of Jal Shakti resources on water infrastructure planning and management.*
3. *Relevant standards and manuals on dam safety, canal design, and flood 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. 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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*<br>*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks* |

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **TW1***: Problem set on frequency analysis and design flood calculation (individual), including uncertainty range.* | *24* |
| *2* | **TW2:** *Design exercise: open channel section and lining selection (pair work), include drawings and cost estimate.* | *24* |
| *3* | **TW3:** *Case study analysis: reservoir sedimentation rate estimation and remediation options (team of 4).* | *24* |
| | **TW4:** *Operation rule curve preparation for a small reservoir using simplified mass-balance (individual).* | |

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

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **SL1:** *HEC-RAS steady & unsteady flow modelling of a canal reach, calibration with sample data. Output: report with model setup and interpretation.* | *24* |
| *2* | **SL2:** *SWMM modelling of urban drainage for a small catchment; storm-event simulation and evaluation of peak flow reduction measures.* | *24* |
| *3* | **SL3:** *Reservoir operation simulation using mass-balance (spreadsheet/HEC-ResSim basic) to evaluate different release policies.* | *24* |
| *4* | **SL4:** *Pumping station selection and performance curve matching; energy cost estimation.* | *24* |

**Sample rubrics for TW activities:**

| *Criterion* | *4 – Excellent* | *3 – Good* | *2 – Satisfactory* | *1 – Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Problem is clearly defined with strong justification and clear objectives.* | *Problem is mostly clear with minor gaps in framing or justification.* | *Problem is stated but lacks clarity or detailed justification.* | *Problem is poorly defined or unclear.* |
| *Data and method* | *Data collected/used is appropriate and sufficient; methods/tools are well chosen and logically* | *Data and methods are generally appropriate with minor issues or omissions.* | *Limited or partially relevant data; methods are basic or inconsistently applied.* | *Data is inadequate/irrelevant; methods are inappropriate or missing.* |

| *Criterion* | *4 – Excellent* | *3 – Good* | *2 – Satisfactory* | *1 – Needs Improvement* |
|---|---|---|---|---|
| | *applied.* | | | |
| *Analysis* | *Analysis is thorough; interpretations are logically argued and results are valid.* | *Analysis is generally sound with minor errors or missing details.* | *Analysis is partial; contains gaps or superficial interpretation.* | *Analysis is weak, incorrect, or largely missing.* |
| *Recommendations* | *Recommendations are feasible, context-specific, and clearly derived from analysis.* | *Recommendations are relevant but may have minor limitations or lack detail.* | *Recommendations are generic or only loosely connected to analysis.* | *Recommendations are incomplete, unrealistic, or absent.* |
| *Presentation* | *Work is very well organized, neat, and professionally presented.* | *Work is well organized with minor issues in formatting or clarity.* | *Presentation is acceptable but uneven.* | *Work is poorly organized, difficult to follow, or untidy.* |

| DISASTER RESILIENCE & RISK REDUCTION FOR INFRASTRUCTURE | | | |
|---|---|---|---|
| *Course Code* | **1MCIM205C/1MCEM205C** | *Scheme* | *2026* |
| *Type of Course* | **Professional Core Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain the concepts of disaster risk, resilience, vulnerability, and hazard in the context of infrastructure systems.*
2. *Analyze disaster impacts on buildings, transportation, water, energy, and lifeline infrastructure.*
3. *Apply risk assessment and mitigation techniques for resilient infrastructure planning and design.*
4. *Evaluate structural and non-structural measures for disaster preparedness, response, recovery, and retrofit.*
5. *Prepare disaster resilience plans, vulnerability assessment reports, and risk reduction recommendations for infrastructure projects.*
6. *Assess policy, codes, standards, and contemporary practices in disaster management and resilient infrastructure development.*

**Module-1**

**Fundamentals of Disaster Risk and Resilience:**

*Introduction to disaster, hazard, exposure, vulnerability, capacity, resilience, and disaster risk reduction. Types of disasters: natural, human-induced, and compound events. Disaster risk drivers in infrastructure systems. Concepts of safety, robustness, redundancy, resourcefulness, and rapidity in resilient systems. Overview of national and international frameworks for disaster risk reduction.*

**Linked COs: CO1, CO6** **Number of Hours: 8**

**Module-2**

**Infrastructure Vulnerability and Risk Assessment:**

*Vulnerability of civil infrastructure to earthquakes, floods, cyclones, landslides, fires, tsunamis, and climate-related extremes. Risk identification, hazard mapping, asset criticality assessment, and consequence analysis. Introduction to qualitative and quantitative risk assessment methods. GIS-based hazard assessment, vulnerability indices, and prioritization of critical infrastructure.*

**Linked COs: CO2, CO3, CO5** **Number of Hours: 9**

**Module-3**

**Resilient Design and Mitigation Measures:**

*Principles of resilient design for buildings, bridges, roads, water supply systems, drainage systems, and utilities. Structural and non-structural mitigation measures, ductile detailing, base isolation, retrofitting, protection systems, and safe construction practices. Planning for resilience through land-use control, system redundancy, emergency access, and protected lifeline corridors.*

**Linked COs: CO3, CO4** **Number of Hours: 8**

**Module-4**

**Disaster Preparedness, Response, and Recovery:**

*Emergency preparedness planning, contingency planning, evacuation planning, and incident command systems. Damage assessment, post-disaster inspection, temporary restoration, and recovery planning for infrastructure services. Business continuity, emergency resource planning, communication protocols, and stakeholder coordination during disasters. Role of local bodies, utilities, and infrastructure operators in response and recovery*

| **Linked COs: CO1, CO4, CO5** | **Number of Hours: 9** |
|---|---|

**Module-5**

**Policy, Codes, and Contemporary Practice:**

*National Disaster Management Act, NDMA guidelines, NBC provisions related to disaster safety, and relevant BIS/IRC standards. Climate adaptation, nature-based solutions, smart infrastructure, and resilient urban systems. Integration of resilience in project planning, design review, asset management, and lifecycle decision-making. Case studies on disaster-affected infrastructure and successful resilience interventions.*

**Linked COs: CO2, CO3, CO6** **Number of Hours: 8**

**Suggested Learning Resources:**

**Textbooks:**

1. *Delmonaco, V., and Kershaw, D., Disaster Resilience and Infrastructure Systems, 1st Edition, CRC Press.*
2. *UNEP, Building Resilience in Infrastructure Systems, 1st Edition, Elsevier.*
3. *Bosher, L., Disaster Risk Reduction and Built Environment, 2nd Edition, Wiley-Blackwell.*
4. *Sahni, P., Disaster Risk Reduction in South Asia, 2nd Edition, Springer.*

**Reference Books**

1. *Chandrasekaran, A. R., Disaster Management and Mitigation, 2nd Edition, PHI Learning.*
2. *Gupta, H. K., Disaster Management, 3rd Edition, Universities Press.*
3. *Smith, K., Environmental Hazards: Assessing Risk and Reducing Disaster, 7th Edition, Routledge.*
4. *FEMA, Guidelines for Design of Safe and Resilient Infrastructure, Latest Edition, FEMA.*

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

1. *NDMA and NIDM online resources on disaster risk reduction.*
2. *NPTEL/SWAYAM courses on disaster management, infrastructure resilience, and climate adaptation.*
3. *UNDRR resources on resilient infrastructure and risk reduction.*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include*

| *Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.* | | |
|---|---|---|
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| *1* | **TW1***: Hazard mapping of a selected campus or neighborhood infrastructure system.* | *24* |
| *2* | **TW2:** *Vulnerability assessment of a building, bridge, road, water supply, or drainage asset.* | *24* |
| *3* | **TW3:** *Preparation of a disaster resilience checklist for an infrastructure project.* | *24* |
| *4* | **TW4:** *Risk matrix development for a multi-hazard infrastructure environment.* | *24* |
| *5* | **TW5:** *Post-disaster damage observation and reporting exercise using a case study.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **SL1:** *Review of an NDMA guideline and presentation of key implications for infrastructure planning.* | *24* |
| *2* | **SL2:** *Case study analysis of a major infrastructure failure during a disaster event.* | *24* |
| *3* | **SL3:** *Comparative study of resilient design measures in two different infrastructure systems.* | *24* |
| *4* | **SL4:** *Seminar on climate adaptation strategies for urban infrastructure.* | *24* |
| *5* | **SL5:** *Discussion on policy and code provisions for disaster-safe construction.* | *24* |

**Sample rubrics for TW activities:**

| *Criterion* | *Excellent (4)* | *Good (3)* | *Satisfactory (2)* | *Needs Improvement (1)* |
|---|---|---|---|---|
| *Technical understanding* | *Correct, complete, and insightful application* | *Mostly correct with minor gaps* | *Basic understanding with limited depth* | *Inadequate or incorrect understanding* |
| *Analysis and problem solving* | *Strong identification of hazards and mitigation* | *Adequate analysis with minor omissions* | *Partial analysis with weak justification* | *Poor or no meaningful analysis* |
| *Report quality* | *Well-structured, clear, and professional* | *Generally clear with minor formatting issues* | *Acceptable but uneven organization* | *Disorganized and incomplete* |

| *Criterion* | *Excellent (4)* | *Good (3)* | *Satisfactory (2)* | *Needs Improvement (1)* |
|---|---|---|---|---|
| *Data use and interpretation* | *Accurate, relevant, well-interpreted data* | *Relevant data with minor interpretation issues* | *Limited data use* | *No meaningful data use* |
| *Timeliness and presentation* | *Submitted on time; excellent presentation* | *Minor delay or presentation issues* | *Acceptable but weak presentation* | *Late or poorly presented* |

| RESOURCES PLANNING AND MANAGEMENT IN INFRASTRUCTURE PROJECTS | | | |
|---|---|---|---|
| *Course Code* | **1MCIM205D/1MCEM205D** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain the principles of resource planning, resource allocation, and resource optimization in infrastructure projects.*
2. *Analyze labor, material, equipment, and financial resource requirements for different project stages.*
3. *Apply planning tools and methods for resource scheduling, levelling, smoothing, and productivity control.*
4. *Evaluate resource-related risks, constraints, and cost-time impacts in infrastructure project execution.*
5. *Prepare resource plans, manpower histograms, equipment deployment plans, and monitoring reports.*
6. *Assess contemporary practices such as digital resource management, BIM-enabled planning, and sustainability-focused resource utilization.*

**Module-1**

**Fundamentals of Resource Planning:**

*Introduction to resources in infrastructure projects, classification of resources, resource life cycle, role of resource planning in project success, resource demand identification, and linkage with scope, schedule, and cost baselines. Concepts of resource productivity, utilization, and wastage control.*

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

**Module-2**

**Labor and Workforce Management:**

*Workforce planning, skill classification, labor deployment, crew formation, manpower estimation, productivity analysis, labor calendars, shift planning, and site labor control. Motivation, supervision, welfare, safety, and performance monitoring in construction labor management.*

**Linked COs: CO2, CO3, CO5.** **Number of Hours: 08**

**Module-3**

**Material and Equipment Resource Management:**

*Material requirement planning, procurement linkage, inventory control, storage, handling, issue and reconciliation, material wastage reduction, and tracking systems. Equipment selection, fleet planning, equipment output, utilization, maintenance scheduling, and deployment optimization for infrastructure works.*

**Linked COs: CO2, CO3, CO4.** **Number of Hours: 08**

**Module-4**

**Resource Scheduling and Optimization:**

*Resource-constrained scheduling, resource loading, resource levelling, resource smoothing, time-cost trade-off, and critical path implications of resource constraints. Use of bar charts, histograms, network methods, and digital tools for planning and control.*

**Linked COs: CO3, CO4, CO5.** **Number of Hours: 08**

**Module-5**

**Integrated Resource Control and Contemporary Practice:**

*Cash flow and financial resource planning, earned value considerations, resource monitoring and reporting, variance analysis, corrective actions, and project control dashboards. Sustainable resource use, lean*

*construction principles, BIM-enabled resource coordination, digital dashboards, and case studies from infrastructure projects.*

**Linked COs: CO1, CO4, CO6.** **Number of Hours: 08**

**Suggested Learning Resources**

**Textbooks**

1. *Chitkara, K. K., Construction Project Management: Planning, Scheduling and Controlling, 2nd Edition, McGraw-Hill Education.*
2. *Harris, F. and McCaffer, R., Modern Construction Management, latest edition, Wiley-Blackwell.*
3. *Halpin, D. W. and Woodhead, R. W., Construction Management, latest edition, Wiley.*
4. *Koushki, P. and others, Resource Planning and Control in Construction, latest edition, relevant publisher.*

**Reference Books**

1. *Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK Guide), latest edition.*
2. *Koskela, L., Lean Construction Principles and Practices, latest edition.*
3. *Halpin, D. and Martinez, L., The Resource Management Handbook for Construction, latest edition.*
4. *AACE International resources on planning, scheduling, and productivity control, latest editions.*

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

1. *NPTEL/SWAYAM courses on construction planning, project management, and resource optimization.*
2. *BIM and digital construction management resources.*
3. *Project control dashboards and resource tracking tutorials.*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE.*

| *The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.* | | |
|---|---|---|
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| *1* | **TW-1: Resource Breakdown Structure preparation.** *Students identify all major resources for a sample infrastructure project and classify them into labor, materials, equipment, money, and information.* | *24* |
| *2* | **TW-2: Manpower planning sheet.** *Students estimate crew strength, skill mix, and daily/weekly labor demand for a selected construction activity.* | *24* |
| *3* | **TW-3: Material requirement and inventory sheet.** *Students prepare a simple material demand plan with procurement lead time, storage needs, and wastage allowance.* | *24* |
| *4* | **TW-4: Equipment deployment plan.** *Students select construction equipment for a project stage and prepare a utilization and maintenance schedule.* | *24* |
| | **TW-5: Mini case study report.** *Students analyze a real or simulated project where resource shortage caused delay or cost overrun and propose corrective actions.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **SL-1: MOOC or video module on construction planning.** *Students complete a short online module on resource management, project control, or construction productivity.* | *24* |
| *2* | **SL-2: Reading assignment on lean construction.** *Students prepare a report note on waste reduction and resource efficiency in infrastructure projects.* | *24* |
| *3* | **SL-3: BIM-based resource planning exploration.** *Students study how BIM supports resource coordination, scheduling, and site logistics.* | *24* |
| *4* | **SL-4; Equipment productivity comparison.** *Students compare output, cost, and suitability of two equipment options for the same task.* | *24* |
| *5* | **SL-5: Digital tool practice.** *Students use spreadsheet software to prepare a simple resource plan, histogram, or cash-flow resource table.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| SUSTAINABLE MATERIALS AND TECHNIQUES IN REPAIR AND REHABILITATION OF INFRASTRUCTURE | | | |
|---|---|---|---|
| *Course Code* | **1MCIM205E/1MCEM205E** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain deterioration mechanisms in infrastructure and the need for repair and rehabilitation.*
2. *Select sustainable repair materials based on performance, durability, and environmental impact.*
3. *Plan appropriate repair and rehabilitation techniques for concrete, masonry, steel, and infrastructure systems.*
4. *Evaluate the effectiveness of non-destructive testing, condition assessment, and diagnostic methods.*
5. *Prepare repair strategies, retrofitting proposals, and maintenance plans using sustainable practices.*
6. *Assess lifecycle performance, cost, carbon impact, and long-term resilience of rehabilitation solutions.*

**Module-1**

**Deterioration and Assessment:**

- *Causes of distress in infrastructure: corrosion, carbonation, chloride ingress, fatigue, overload, settlement, leakage, and environmental effects.*
- *Types of damage in RC, masonry, steel, and composite structures.*
- *Visual inspection, condition survey, distress mapping, and documentation.*
- *Introduction to repair philosophy, durability, sustainability, and lifecycle thinking.*

**Linked COs: CO1, CO4.** **Number of Hours: 08**

**Module-2**

**Sustainable Repair Materials:**

- *Principles of material selection for repair and rehabilitation.*
- *Sustainable cementitious materials, geopolymers, supplementary cementitious materials, polymer-modified mortars, micro-concrete, fiber-reinforced repair materials, and corrosion inhibitors.*
- *Epoxy, PU, shotcrete, bonding agents, grouts, and protective coatings.*
- *Green materials, recycled materials, low-carbon products, and eco-friendly repair systems.*

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

**Module-3**

**Repair and Rehabilitation Techniques:**

- *Crack repair methods: routing and sealing, injection grouting, stitching, external bonding.*
- *Repair of spalled concrete, patch repair, jacketing, section enlargement, and overlay systems.*
- *Rehabilitation of beams, slabs, columns, foundations, retaining walls, tanks, bridges, pavements, and water-retaining structures.*
- *Protective treatment, surface preparation, strengthening, and retrofit methods.*

**Linked COs: CO3, CO5.** **Number of Hours: 09**

**Module-4**

**Diagnosis, NDT, and Monitoring:**

- *Non-destructive testing methods: rebound hammer, UPV, half-cell potential, cover meter, GPR, infrared thermography, and corrosion assessment.*
- *Destructive and semi-destructive tests for in-situ evaluation.*

- *Structural health monitoring, sensors, data interpretation, and digital condition assessment.*
- *Role of diagnostics in selecting repair methods and verifying performance*

**Linked COs: CO1, CO4, CO6.** **Number of Hours: 08**

**Module-5**

**Retrofitting, Sustainability, and Case Studies:**

- *Seismic retrofitting, strengthening of deficient structures, and resilience enhancement.*
- *Lifecycle assessment, embodied carbon, maintenance planning, service-life extension, and circular economy in rehabilitation.*
- *Quality control, safety, execution planning, and post-repair monitoring.*
- *Case studies on bridges, buildings, tanks, marine structures, and heritage infrastructure.*

**Linked COs: CO2, CO3, CO6.** **Number of Hours: 09**

**Suggested Learning Resources:**

**Textbooks:**

1. *S. C. Paul, P. Kumar Mehta, and A. K. Jain, Repair and Rehabilitation of Concrete Structures, 2nd Edition, New Age International Publishers.*
2. *R. Dodge Woodson, Concrete Structures: Protection, Repair and Rehabilitation, 2nd Edition, Butterworth-Heinemann.*
3. *Dr. B. Vidivelli, Repair and Rehabilitation of Concrete Structures, 1st Edition, Standard Publishers Distributors.*

**Reference Books:**

1. *A. K. Sinha and P. Kumar, Durability of Concrete and Repair Materials, 1st Edition, Oxford University Press.*
2. *M. F. Kapala, Rehabilitation and Strengthening of Concrete Structures, 2nd Edition, CRC Press.*
3. *A. M. Neville, Properties of Concrete, 5th Edition, Pearson.*
4. *R. N. Raikar, Diagnosis and Treatment of Structures, 1st Edition, Dhanpat Rai Publications.*

**Standards and Codes**

1. *IS 456:2000, Plain and Reinforced Concrete - Code of Practice.*
2. *IS 13311 (Part 1 and Part 2), Non-Destructive Testing of Concrete.*
3. *IS 13935, Repair and Seismic Strengthening of Buildings.*
4. *IRC and relevant bridge rehabilitation guidelines, latest edition.*

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

1. *Online Repositories: SANS Industrial Control Systems (ICS) Security resources, Indian Computer Emergency Response Team (CERT-In) bulletins, NPTEL course on "Cyber Security".*
2. *Software Tools: Wireshark (network packet capture and analysis), Shodan (search engine for internet-connected OT devices for vulnerability scanning), Threat Dragon / Microsoft Threat Modeling Tool.*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum*

*of 40% of the maximum marks prescribed for SEE to be eligible for passing.*
*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*
*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **TW1-Distress Diagnosis Report:** *Students shall inspect a chosen structure or case study, identify distress symptoms, prepare a damage map, and recommend probable causes.* | *24* |
| *2* | **TW-2-Repair Material Selection Matrix:** *Students shall compare sustainable repair materials for a given repair scenario and justify the selection based on durability, cost, carbon impact, and application suitability.* | *24* |
| *3* | **TW3-Rehabilitation Method Proposal:** *Students shall propose a repair and rehabilitation strategy for a damaged structural element with sketches, sequence of execution, and quality checks.* | *24* |
| | **TW4-Lifecycle Repair Plan:** *Students shall prepare a lifecycle-oriented maintenance and repair plan for an infrastructure asset considering sustainability and service-life extension.* | *24* |

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

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **SL-1: Case Study on Infrastructure Failure:** *Students shall study a real case of deterioration or rehabilitation and summarize the causes, diagnosis, repair decisions, and lessons learned.* | *24* |
| *2* | **SL2-NDT Method Review***: Students shall review one NDT technique, explain its working principle, limitations, and relevance to repair decision-making.* | *24* |
| *3* | **SL3-Green Repair Materials Review:** *Students shall prepare a comparative note on low-carbon or recycled repair materials and their suitability for sustainable rehabilitation.* | *24* |

**Sample rubrics for TW activities:**

| *Criterion* | *Excellent 4* | *Good 3* | *Satisfactory 2* | *Needs Improvement 1* |
|---|---|---|---|---|
| *Understanding of distress/repair concept* | *Correctly identifies and explains the issue with strong technical clarity.* | *Identifies the issue well with minor gaps.* | *Basic identification with limited explanation.* | *Incorrect or incomplete understanding.* |
| *Technical accuracy* | *Methods and observations are technically sound.* | *Minor technical errors.* | *Several conceptual gaps.* | *Major technical errors.* |
| *Sustainability consideration* | *Clearly integrates sustainability and lifecycle thinking.* | *Adequate sustainability linkage.* | *Limited sustainability reference.* | *No sustainability linkage.* |
| *Presentation and organization* | *Professional format, clear diagrams/tables, logical flow.* | *Well organized with minor formatting issues.* | *Acceptable but uneven presentation.* | *Poorly organized or incomplete.* |
| *Practical relevance* | *Strong real-world applicability and justified recommendations.* | *Good practical relevance.* | *Limited application.* | *No meaningful practical connection.* |

**Rubrics for SL Activities:**

| *Criterion* | *Excellent 4* | *Good 3* | *Satisfactory 2* | *Needs Improvement 1* |
|---|---|---|---|---|
| *Quality of literature/case review* | *Uses relevant and credible sources with strong synthesis.* | *Good sources with adequate synthesis.* | *Limited sources, basic summary.* | *Weak or missing sources.* |
| *Technical content* | *Accurate, complete, and conceptually strong.* | *Mostly accurate with minor omissions.* | *Partial coverage of content.* | *Inaccurate or incomplete content.* |
| *Independent learning* | *Shows clear self-learning and critical thinking.* | *Some evidence of independent effort.* | *Limited independent analysis.* | *Minimal effort or copied content.* |
| *Sustainability focus* | *Strong emphasis on sustainable materials/practices.* | *Moderate sustainability linkage.* | *Weak sustainability linkage.* | *No sustainability focus.* |
| *Communication quality* | *Clear, concise, and professionally presented.* | *Mostly clear with minor issues.* | *Understandable but inconsistent.* | *Poorly written or disorganized.* |

| QUALITY & SAFETY MANAGEMENT | | | |
|---|---|---|---|
| *Course Code* | **1MCIM205F/1MCEM205F/1MCCT205F** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *CO1: Evaluate quality control systems, inspection checklists, and total quality frameworks for structural engineering components.*
2. *CO2: Formulate statistical quality control (SQC) models and continuous improvement tools to minimize defects in construction operations.*
3. *CO3: Analyze site hazard profiles, calculate risk ratings, and implement rigorous safety inspection protocols.*
4. *CO4: Design robust construction safety management systems (SMS) aligned with statutory regulations and global safety frameworks.*
5. *CO5: Synthesize accident investigation models, root-cause methodologies, and safety-assist digital technologies for hazard mitigation.*

**Module-1**

**Construction Quality Frameworks & TQM Principles**

- *Definition of quality in construction: Quality characteristics, parameters, and owner-contractor expectations.*
- *Quality Assurance (QA) versus Quality Control (QC) systems.*
- *Principles of Total Quality Management (TQM) applied to construction organizations.*
- *Structural quality document controls: Project Quality Plans (PQP), standard operating procedures (SOP), and inspection checklists for site operations (concreting, reinforcement, brickwork).*
- *Introduction to the ISO 9001:2015 Quality Management Systems standard.*

**Linked COs: CO1** **Number of Hours: 8 hrs**

**Module-2**

**Statistical Quality Control & Defects Management**

- *Statistical Quality Control (SQC) fundamentals: Variable and attribute data sampling frameworks.*
- *Formulation of control charts (X-bar, R-charts, and p-charts) for concrete compressive strength and material properties.*
- *Cost of Quality (CoQ): Prevention, appraisal, internal failure, and external failure costs.*
- *Seven Basic Quality Control Tools (Ishikawa fishbone diagrams, Pareto analysis, histograms, scatter plots, control charts, check sheets, stratification).*
- *Six Sigma methodologies and Root Cause Analysis (RCA) loops for structural defects mitigation.*

**Linked COs: CO2** **Number of Hours: 9 hrs**

**Module-3**

**Construction Safety Engineering & Hazard Identification**

- *Overview of safety challenges in civil engineering: Fall protection, structural collapses, excavation cave-ins, and electrical hazards.*
- *Hazard Identification and Risk Assessment (HIRA) methodologies.*
- *Developing Risk Matrices: Calculating Probability, Severity, and overall Risk Priority Numbers (RPN).*
- *Design and deployment of Job Safety Analysis (JSA) protocols for high-risk operations.*
- *Selection, procurement, and enforcement of Personal Protective Equipment (PPE) standards on sites.*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Safety Management Systems & Statutory Frameworks**

- *Structure of an enterprise-level Safety Management System (SMS): Policy formulation, safety committees, and safety training matrices.*
- *Safety culture and behavioral safety programs for field workers.*
- *Statutory regulations in India: The Building and Other Construction Workers (BOCW) Act, 1996; Factory Act provisions; and National Building Code (NBC) safety guidelines.*
- *International Safety Standards: Structural overview of ISO 45001:2018 (Occupational Health and Safety Management Systems).*

**Linked COs: CO4** **Number of Hours: 8 hrs**

**Module-5**

**Accident Investigations & Digital Safety Systems**

- *Economics of safety: Direct vs. indirect costs of accidents (Iceberg theory of accident costs).*
- *Accident reporting and recording frameworks: Calculation of Frequency Rates, Severity Rates, and Incident Rates.*
- *Accident investigation techniques: Fault Tree Analysis (FTA) and the "5 Whys" methodology.*
- *Digital innovations in safety management: Smart PPE, AI-driven computer vision for real-time hazar d detection, drone-based site safety inspection, and VR/AR safety training simulations.*

**Linked COs: CO5** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Juran, J. M., & Gryna, F. M. Quality Planning and Analysis, McGraw-Hill.*
2. *Davies, V. J., & Tomasin, K. Construction Safety Handbook, Thomas Telford, London.*
3. *Bhattacharjee, S. K. Quality Management in Construction, Khanna Publishers.*

**Reference Books**

1. *Holt, A. S. J. Principles of Construction Safety, Blackwell Science.*
2. *Bureau of Indian Standards (BIS). National Building Code of India (Part 7: Construction Management, Rules and Regulations).*
3. *Government of India. The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996.*

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

1. *Online Repositories: National Safety Council of India guidelines, OSHA (Occupational Safety and Health Administration) training modules, NPTEL course on "Construction Engineering & Management".*
2. *Software Tools: MS Excel / Minitab (for SQC charts and data analysis), Procore / Novade (digital site safety inspection and checklist tools), Lumion / Unity (for virtual safety walk-through concepts).*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken*

*together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Statistical Quality Control & Concrete Strength Audit:** *Collect concrete cube compressive strength test logs from an active batching plant or construction site. Construct X-bar and R-charts to evaluate structural process control compliance, diagnose out-of-control signals using Ishikawa diagrams, and draft a quality audit report.* | *24* |
| *2* | **Comprehensive Site HIRA & JSA Portfolio:** *Select a highly complex, active construction phase (e.g., deep basement excavation, structural steel erection, or tower crane dismantling). Perform a comprehensive Hazard Identification and Risk Assessment (HIRA) study, compile the risk matrix registry, and formulate a detailed Job Safety Analysis (JSA) execution sheet.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **ISO 9001/45001 Integrated System Manual Blueprint:** *Conduct independent academic research outlining a framework to merge an organization's standalone Quality (ISO 9001) and Safety (ISO 45001) documentation into a unified, integrated site execution manual.* | *24* |
| *2* | **AI-Computer Vision Safety Application Case Study:** *Perform an independent technology assessment reviewing the operational efficiency and deployment challenges of utilizing automated AI-linked CCTV cameras to track safety mask/harness compliance breaches on urban high-rise projects.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| URBAN MULTIMODAL TRANSPORTATION INFRASTRUCTURE SYSTEMS | | | |
|---|---|---|---|
| *Course Code* | **1MCIM205G/1MCEM205G** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain the principles, components, and planning framework of multimodal urban transportation infrastructure systems.*
2. *Analyze multimodal corridors, intersections, and terminals for mobility, safety, and capacity performance.*
3. *Apply planning and design principles for roads, public transport facilities, pedestrian, and cycling infrastructure.*
4. *Evaluate pavement, drainage, accessibility, and asset management needs in urban transport systems.*
5. *Prepare improvement plans and technical reports for integrated multimodal urban infrastructure projects.*
6. *Assess ITS, data-driven planning, and policy options for sustainable multimodal mobility.*

**Module-1**

**Introduction to Urban Multimodal Transportation Systems:**

*Urban transport system components, land-use and transport interaction, mobility patterns, modal split, hierarchy of road and transit networks, concept of multimodal integration, first-mile and last-mile connectivity, role of urban transport in sustainable city development, mobility planning process, survey data requirements, and introduction to transport demand analysis.*

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

**Module-2**

**Urban Road and Corridor Planning:**

*Urban road classification, functional hierarchy, right-of-way planning, cross-section elements, access management, parking management, median and verge design, corridor planning for multimodal streets, and provision for buses, pedestrians, cyclists, and emergency vehicles in urban street design*.

**Linked COs: CO1, CO3, CO4.** **Number of Hours: 08**

**Module-3**

**Intersection and Multimodal Traffic Control:**

*At-grade and grade-separated intersections, junction channelization, roundabouts, signalized intersections, pedestrian crossing treatments, signal phasing, coordination, public transport priority, safety improvement measures, capacity concepts, level of service, and traffic performance indicators for multimodal corridors.*

**Linked COs: CO2, CO3, CO5.** **Number of Hours: 08**

**Module-4**

**Public Transport, NMT, and Interchange Infrastructure:**

*Bus stop planning, bus bays, terminals, depots, BRT corridor elements, passenger facilities, interchange design, multimodal terminal planning, metro and rail transit station interfaces, feeder integration, universal accessibility, wayfinding, last-mile transfer facilities, footpath design, pedestrian crossings, curb ramps, tactile guidance, cycle tracks, bicycle parking, shared street concepts, and integration of non-motorized transport with public transport.*

**Linked COs: CO3, CO5, CO6.** **Number of Hours: 09**

**Module-5**

**Pavement, Drainage, Asset Management, and ITS:**

*Pavement types for urban streets, utility coordination, reinstatement after utility cuts, street drainage, inlets,*

*stormwater integration, maintenance planning, life-cycle cost concepts, asset management for transport infrastructure, intelligent transport systems, traffic monitoring, adaptive signal control, passenger information systems, shared mobility, parking management systems, GIS-based planning, digital twins, data-driven multimodal planning, sustainable mobility, resilience, and emerging trends in smart urban transport systems.*

**Linked COs: CO4, CO5, CO6.** **Number of Hours: 09**

**Suggested Learning Resources**

**Textbooks**

1. *Vuchic, V. R., Urban Transit Systems and Technology, Wiley.*
2. *Khisty, C. J. and Lall, B. K., Transportation Engineering: An Introduction, Pearson.*
3. *Papacostas, C. S. and Prevedouros, P. D., Transportation Engineering and Planning, Pearson.*
4. *Meyer, M. D. and Miller, E. J., Urban Transportation Planning, McGraw-Hill.*

**Reference Books**

1. *IRC guidelines on urban roads, geometric design, and traffic control.*
2. *MoHUA guidelines on urban transport, NMT, and smart mobility.*
3. *Cervero, R., The Transit Metropolis, Island Press.*
4. *TRB/TCRP reports on bus, rail, and station planning..*

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

1. *NPTEL/SWAYAM courses on urban transport planning and traffic engineering.*
2. *MoHUA and Smart Cities Mission resources on urban mobility.*
3. *IRC and TRB practice notes on multimodal transport 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. 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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities*

| *as per the course outcomes.* | | |
|---|---|---|
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| *1* | **TW-1: Multimodal corridor analysis:** *Students study a 1–2 km urban corridor and document road geometry, bus stops, pedestrian facilities, cycle provisions, junctions, parking pressure, and transfer points. They prepare a short report with annotated sketches, photos, and a list of improvement needs. This activity strongly supports* | *24* |
| *2* | **TW-2: Intersection and pedestrian safety audit:** *Students conduct a field-based audit of one signalized or unsignalized junction, recording pedestrian crossings, signal operation, conflict points, crossing time, accessibility gaps, and safety deficiencies. The output should include an audit checklist, problem diagram, and suggested engineering measures.* | *24* |
| *3* | **TW-3: Public transport terminal study:** *Students examine a bus terminal, BRT stop, or metro interchange and document passenger movement, wayfinding, queuing, platform arrangement, feeder access, and universal design features. They submit a layout sketch and a critique of the terminal's multimodal effectiveness.* | *24* |
| *4* | **TW-4: Complete street improvement proposal:** *Students prepare a conceptual design for a street section showing carriageway, sidewalk, cycle track, bus stop, drainage, utilities, and street furniture. The deliverable should include a before-and-after layout, rationale, and simple cost/prioritization note.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **SL-1: Case Study on a Metro Project:** *Students shall study a metro project in India or abroad and present planning features, ridership strategy, station design, and operational lessons.* | *24* |
| *2* | **SL-1: Case study on bus/metro integration** *Students independently study a city case where bus, metro, or rail systems are connected through feeders or interchanges. They prepare a report on integration strategy, passenger transfer quality, and lessons for local application* | *24* |
| *3* | **SL-3: Smart Mobility Technology Review:** *Students shall study digital mobility tools such as AFC, real-time passenger information, predictive maintenance, or mobility-as-a-service.* | *24* |
| *4* | **SL-4: Safety and Emergency Management Note:** *Students shall prepare a note on metro safety systems, evacuation, fire protection, and emergency communication.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *Excellent (4)* | *Good (3)* | *Satisfactory (2)* | *Needs Improvement (1)* |
|---|---|---|---|---|
| *Understanding of concept* | *Demonstrates clear and accurate understanding of metro planning and urban mobility concepts.* | *Mostly clear understanding with minor gaps.* | *Basic understanding, but some important ideas are missing.* | *Limited or incorrect understanding.* |
| *Technical application* | *Applies concepts correctly to the given case or task.* | *Applies most concepts correctly.* | *Partial application with limited depth.* | *Weak or incorrect application.* |
| *Analysis and reasoning* | *Strong logic, comparison, and justification of recommendations.* | *Reasonable analysis with minor weaknesses.* | *Simple analysis with limited justification.* | *Little or no meaningful analysis.* |
| *Presentation and documentation* | *Well structured, neat, complete, and professional.* | *Good presentation with minor issues.* | *Acceptable, but inconsistent or incomplete in places.* | *Poorly organized or incomplete.* |

| NON-DESTRUCTIVE TESTING FOR CIVIL ENGINEERING | | | |
|---|---|---|---|
| Course Code | **1MCIM206A/1MCEM206A** | Scheme | 2026 |
| Type of Course | **Professional Elective Course** | Semester | II |
| Teaching Hours/Week (L:T:P) | 42(3:0:0 ) | CIE Marks | 50 |
| Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL | 90 (42:0:0:48) | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Type of Examination (IPCC): | Theory | Exam Hours | 03 |

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

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

1. CO1: Understand the role, nature, purpose, and management of NDT activities in material science and civil engineering.
2. CO2: Apply surface NDT methods including Visual Testing, Penetrant Testing, Magnetic Testing, and Eddy Current Testing for defect detection.
3. CO3: Analyze internal inspection methods such as Radiography, Ultrasonic Testing, Thermography, and Acoustic Emission techniques.
4. CO4: Evaluate NDT applications for inspection of bridges and dams including failure causes and preventive measures.
5. CO5: Apply disaster risk reduction concepts, mitigation, adaptation, and resilience strategies in real-world contexts.
6. CO6: Assess concrete structures using NDT methods and interpret results for residual life assessment.

**Module-1**

**Introduction and Management of NDT Activities:**

- Role of NDT in material science, Nature, Definition, Purpose and Importance Advantages and limitations of NDT.
- Various NDT Methods - Principles and applications and limitations of Management of NDT Processes.

**Self-study:** Students shall prepare a report on the role of NDT in quality control and quality assurance in construction projects.

**Linked COs: CO1** **Number of Hours: 9 hrs**

**Module-2**

**Surface NDT Methods :**

- **Visual Testing:** Requirements, Equipment, for lab in situ and Remote Visual Testing, Visual inspection of welds, and visual acceptance standards.
- **Penetrant Testing:** types, procedures, test equipment, sensitivity indicators, flaw evaluation, ASME Acceptance standards, Advantages and limitation. Studying the working principles of Rebound Hammer.
- **Magnetic Testing:** Types, procedures test equipment ASME Acceptance Standards. Advantages and limitations of applications.
- **Eddy current Testing:** Principles Types equipment advantages and limitations.

**Self-study:** Students shall prepare a comparative analysis of surface NDT methods and their suitability for different applications.

**Linked COs: CO2** **Number of Hours: 9 hrs**

**Module-3**

**NDT Methods for Internal Inspection;**

- **Radiography Testing:** Principles Techniques Sensitivity analysis, Equipment Radiation sources- X rays Gamma rays and neutrons, Detectors X ray films Imaging plates, Image processing Interpretation and defect evaluation. Computed Tomography its advantages and disadvantages.
- **Ultrasonic Testing:** Principles its advantages and disadvantages. Equipment Techniques Probes, A B & C Scan methods, Phased array Ultrasonic testing Advantages and Limitations. Studying the working principles of Ultrasonic Pulse Velocity Meter, Profometer.
- **Thermography:** Principles equipment applications advantages, limitations and applications.

- **Acoustic Emission:** Principles, Types equipment Advantages limitations and applications.

**Self-study:** Students shall prepare a report on the principles and applications of advanced NDT techniques in civil engineering

**Linked COs: CO3** **Number of Hours: 8 hrs**

**Module-4**

**NDT of Bridges and Dams** :

- Types of Bridges and their main issues & failure causes and preventive measures. Different NDT methods and applications concerning the Inspection of important bridge elements.
- Types of Dams and their main issues & failure causes and preventive measures. Different NDT methods and applications concerning the Inspection of important dam elements.

**Self-study:** Students shall prepare a case study on NDT inspection of a major bridge or dam structure in India.

**Linked COs: CO4** **Number of Hours: 8 hrs**

**Module-5**

**NDT of Concrete Structures** :

- Important Case studies like Case study of Dhruva Reactor building. Residual life assessment methods in civil engineering. Study of NDT of Concrete Structures in India.
- Studying the working principles of Scanning Electron Microscopy (SEM) and XRD testing methods.

**Self-study:** Students shall prepare a report on residual life assessment methodologies for concrete structures.

**Linked COs: CO5** **Number of Hours: 8 hrs**

**Suggested Learning Resources:**

**Textbooks**

1. J Prasad, CG Krishnadas Nair and T Rangachari "Non destructive Testing of materials" Vol 1, 2 and 3.
2. Non destructive Testing handbook Vol 10 Non destructive Testing Overview American society for non-destructive testing.
3. NDT of Bridges by Indian Railway Institute of Civil Engineering

**Reference Books**

1. Non Destructive Evaluation of Concrete structures Case study Dhruva Rai, Sateesh and Dr Verde BARC.
2. Methods for Predicting Remaining Life of Concrete in Structures NISTIR4954 J Clifton and Pommersheim Building and Fire Research Laboratory Gaithersburg, Maryland 20899.
3. Residual Life Assessment of Concrete Structures-A Review Neethu Urs, Manthesh B S, Harish Jayaram, Dr. M N Hegde.

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

1. NPTEL courses on Non-Destructive Testing of Materials.
2. IS 13311 (Part 1 & 2): Methods of Non-destructive testing of concrete.
3. ASTM standards for NDT methods.
4. ASNT (American Society for Nondestructive Testing) 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 (both CIE and SEE)**

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a

subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

**Continuous Internal Evaluation:**

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | Identifying material properties like compressive strength, corrosion, and microstructural defects using NDT methods. | 24 |
| 2 | Documentation of the findings from NDT techniques in detailed reports, including data analysis and recommendations for further actions. | 24 |
| 3 | Data Interpretation and Diagnosis: Develop skills in interpreting NDT results, such as reading ultrasonic wave signals, analyzing thermal images, and detecting voids or cracks. | 24 |
| 4 | Conduct a case study on NDT inspection of a bridge or dam structure and prepare a comprehensive report. | 24 |
| 5 | Perform residual life assessment of a concrete structure using NDT data and prepare a detailed analysis report. | 24 |

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

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| 1 | Prepare a report on the role of NDT in quality control and quality assurance in construction projects (as per Module-1 self-study). | 16 |
| 2 | Prepare a comparative analysis of surface NDT methods and their suitability for different applications (as per Module-2 self-study). | 16 |
| 3 | Prepare a report on the principles and applications of advanced NDT techniques in civil engineering (as per Module-3 self-study). | 16 |
| 4 | Prepare a case study on NDT inspection of a major bridge or dam structure in India (as per Module-4 self-study). | 16 |
| 5 | Prepare a report on residual life assessment methodologies for concrete structures (as per Module-5 self-study). | 16 |

**Sample rubrics for TW activities:**

| Criteria | 4 - Excellent | 3 - Good | 2 - Satisfactory | 1 - Needs Improvement |
|---|---|---|---|---|
| Problem understanding | Clear problem framing with strong justification. | Mostly clear with minor gaps. | Basic attempt with limited clarity. | Poorly defined problem. |
| Data and method | Appropriate data and sound methodology. | Mostly appropriate with minor issues. | Limited data or partial method. | Inadequate or incorrect method. |
| Analysis | Robust interpretation and valid results. | Generally sound with minor errors. | Partial analysis with gaps. | Weak or incorrect analysis. |
| Recommendations | Strong, feasible, and context-specific. | Relevant with minor limitations. | Generic recommendations. | Incomplete or unrealistic. |
| Presentation | Well organized and professional. | Good organization with minor issues. | Acceptable but uneven. | Poorly presented. |

| CONSTRUCTION SITE MANAGEMENT | | | |
|---|---|---|---|
| *Course Code* | **1MCIM206B/1MCEM206B** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42 (3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain construction site organization, functions, and operational procedures for effective project execution.*
2. *Apply planning, scheduling, and resource management techniques to site operations.*
3. *Analyze site safety, quality control, and productivity requirements in construction projects.*
4. *Integrate equipment, materials, labor, and logistics planning for smooth site management.*
5. *Evaluate site records, progress reporting, and control measures for construction monitoring.*
6. *Develop practical solutions for common site operation issues using engineering and managerial principles*

**Module-1**

**Foundations of Construction Site Operation:**

*Construction project organization, site objectives, site hierarchy, responsibilities of project manager, site engineer, supervisor, storekeeper, quality engineer, and safety officer. Site mobilization, site layout planning, access routes, temporary facilities, utilities, and documentation. Introduction to site operations and coordination among stakeholders.*

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

**Module-2**

**Site Planning and Resource Management:**

*Site planning principles, work sequencing, bar chart planning, construction workflow, labour planning, material planning, equipment deployment, and subcontractor coordination. Daily work planning, procurement interface, inventory control, material handling, and site logistics*.

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

**Module-3**

**Construction Methods and Equipment Operations:**

*Site-based construction methods for earthwork, foundations, concreting, masonry, formwork, reinforcement, finishing, and basic structural works. Selection and operation of construction equipment, productivity of machinery, maintenance aspects, and safe equipment use. Monitoring work output and resolving operational bottlenecks.*

**Linked COs: CO2, CO3, CO4.** **Number of Hours: 09**

**Module-4**

**Site Safety, Quality, and Environmental Control:**

*Safety management at construction sites, hazard identification, risk control, PPE, permit systems, housekeeping, emergency procedures, and accident reporting. Quality assurance and quality control in site activities, inspection checklists, material testing, nonconformance handling, and documentation. Environmental considerations, waste management, dust/noise control, and sustainability practices at sites.*

**Linked COs: CO3, CO5, CO6.** **Number of Hours: 08**

**Module-5**

**Site Monitoring, Measurement, and Reporting:**

*Measurement of work, progress monitoring, daily and weekly site reports, labor and material statements, contractor billing, records management, and delay analysis. Site communication, coordination meetings, issue tracking, escalation, and corrective action planning. Introduction to digital site monitoring, mobile reporting, and*

*contemporary tools for construction control.*

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

**Suggested Learning Resources:**

**Textbooks**

1. *Chudley, R. and Greeno, R., Building Construction Handbook, latest edition, Routledge.*
2. *Punmia, B.C., Jain, A.K. and Jain, A.K., Building Construction, latest edition, Laxmi Publications.*
3. *Arora, S.P. and Bindra, S.P., Building Construction, latest edition, Dhanpat Rai.*
4. *Arora, K.R., Construction Planning and Management, latest edition, Standard Publishers.*

**Reference Books**

1. *Peurifoy, R.L. et al., Construction Planning, Equipment, and Methods, latest edition.*
2. *Harris, F. and McCaffer, R., Modern Construction Management, latest edition.*
3. *O'Brien, J.J. and Plotnick, F.L., Construction Planning and Scheduling, latest edition.*
4. *Relevant BIS codes, NBC provisions, and standard construction safety manuals*

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

1. *NPTEL/SWAYAM courses on construction management and site engineering.*
2. *Standard safety guidelines from construction and labour authorities.*
3. *Digital site management and quality control case studies.*
4. *Advanced-Project-Management-AI-Lean-Agile-BIM-Integrated.*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / |
|---|---|---|

| | | Semester |
|---|---|---|
| *1* | **TW-1: Site Layout Study.** *Students shall prepare a site layout plan showing access, storage, utilities, and temporary facilities*. | *24* |
| *2* | **TW-2: Daily Work Planning Exercise**. *Students shall prepare a day-wise resource and activity plan for a construction site.* | *24* |
| *3* | **TW-3: Safety Audit Observation.** *Students shall identify site hazards and suggest control measures using a checklist* | *24* |
| *4* | **TW-4: Progress Monitoring Report**. *Students shall prepare a weekly site progress report with photographs, measurements, and issues.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **SL-1:** *Study of a construction site accident case and prepare a brief report.* | *24* |
| *2* | **SL-2:** *Review of construction equipment productivity and maintenance practices* | *24* |
| *3* | **SL-3:** *Study of quality control procedures for concrete and masonry work.* | *24* |
| *4* | **SL-4:** *Digital tools used in site monitoring and reporting.* | *24* |

**Sample rubrics for TW activities:**

| *Criterion* | *Excellent 4* | *Good 3* | *Satisfactory 2* | *Needs Improvement 1* |
|---|---|---|---|---|
| *Problem identification* | *Clearly identifies transport problem, causes, and scope.* | *Identifies problem with minor gaps.* | *Basic identification with limited depth.* | *Unclear or incorrect problem framing.* |
| *Technical relevance* | *ITS solution is highly relevant and industry-aligned.* | *Mostly relevant with minor omissions.* | *Partially relevant.* | *Poor match between problem and solution.* |
| *Analysis and design* | *Strong logic, system flow, and implementation detail.* | *Adequate analysis with small gaps.* | *Limited analysis and weak design detail.* | *No meaningful analysis or design.* |
| *Data and evidence* | *Uses valid data, standards, or references effectively.* | *Uses relevant data with minor issues.* | *Limited evidence or weak interpretation.* | *No usable data or evidence.* |
| *Presentation quality* | *Clear, professional, and well-structured.* | *Minor formatting or communication issues.* | *Acceptable but inconsistent.* | *Poorly structured and difficult to follow.* |

| INFRASTRUCTURE ASSET MANAGEMENT | | | |
|---|---|---|---|
| *Course Code* | **1MCIM206C/1MCEM206C/1MCCT206C** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *CO1 Explain the concepts, life cycle stages, and strategic role of infrastructure asset management in civil infrastructure systems.*
2. *CO2 Assess asset condition, performance, and risk using suitable inspection, rating, and prioritization methods.*
3. *CO3 Develop maintenance, rehabilitation, and renewal strategies for infrastructure assets using life-cycle principles.*
4. *CO4 Prepare asset management plans, budget forecasts, and service-level frameworks for infrastructure agencies.*
5. *CO5 Apply digital tools, GIS/BIM-based data systems, and decision-support methods for infrastructure asset management.*

**Module-1**

**Introduction to Infrastructure Asset Management**

- *Definition, objectives, scope, and need for infrastructure asset management.*
- *Types of infrastructure assets: roads, bridges, buildings, water supply, sewerage, drainage, and utilities.*
- *Asset life cycle: planning, acquisition, operation, maintenance, rehabilitation, and disposal.*
- *Principles of sustainable infrastructure stewardship.*
- *Asset management policy, governance, and institutional framework***.**

**Linked COs: CO1** **Number of Hours: 8 hrs**

**Module-2**

**Asset Inventory, Condition and Performance Assessment:**

- *Asset inventory and asset register preparation.*
- *Data requirements for infrastructure asset management.*
- *Condition assessment methods, visual inspection, rating systems, and defect identification.*
- *Performance indicators, serviceability, and functional adequacy.*
- *Prioritization of assets based on criticality, usage, and consequence of failure.*

**Linked COs: CO2** **Number of Hours: 09 hrs**

**Module-3**

**Life-Cycle Planning and Maintenance Strategies**

- *Preventive, corrective, predictive, and reactive maintenance.*
- *Routine, periodic, and special maintenance activities.*
- *Rehabilitation, strengthening, restoration, and replacement planning.*
- *Life-cycle cost analysis and whole-life costing.*
- *Optimization of maintenance intervals and intervention timing.*

**Linked COs: CO3** **Number of Hours: 08 hrs**

**Module-4**

**Asset Management Planning and Financial Framework**

- *Asset management plan structure and contents.*
- *Service level benchmarks and performance targets.*
- *Budgeting for asset operations, maintenance, and renewal.*
- *Funding models and financial prioritization.*
- *Risk-based planning, trade-off analysis, and decision matrices.*

**Linked COs: CO4** **Number of Hours: 09 hrs**

**Module-5**

**Digital Tools and Decision Support Systems:**

- *Use of GIS, BIM, IoT, and digital twins in infrastructure asset management.*
- *Asset databases and computer-based maintenance management systems.*
- *Decision support systems for prioritization and scenario analysis.*
- *Remote monitoring, sensor-based asset health tracking, and dashboards.*
- *Case studies on road, bridge, water, and public facility asset management.*

**Linked COs: CO5** **Number of Hours: 09 hrs**

**Suggested Learning Resources:**

**Textbooks**

1. *John Woodhouse, Asset Management Excellence, Woodhouse Partners.*
2. *Abdelhalim Boussabaine and Richard Kirkham, Whole Life-Cycle Costing, Wiley-Blackwell.*
3. *Keith Hobbs, Infrastructure Asset Management, ICE Publishing.*
4. *Hudson, W. R., Haas, R., & Uddin, W. Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation, and Renovation, McGraw-Hill Education.*
5. *Amadi-Echendu, J. E., et al. Definitions, Concepts and Scope of Engineering Asset Management, Springer.*
6. *Lloyd, C. Asset Management: Whole-life Management of Physical Assets, Thomas Telford.*

**Reference Books**

1. *A. Hudson, R. Haas, W. Uddin, Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation and Renovation, McGraw-Hill.*
2. *Wai-Fah Chen and Lian Duan, Bridge Engineering Handbook, CRC Press.*
3. *John E. R. Bellinger, Asset Management in Practice, relevant professional publication. IPWEA. International Infrastructure Management Manual (IIMM) (Latest Edition).*
4. *ISO 55000 Suite Documents: Asset management — Overview, principles and terminology.*
5. *Grigg, N. S. Infrastructure Planning, Engineering, and Economics, McGraw-Hill.*

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

1. *Online Repositories: Institute of Asset Management (IAM) technical guides, US Federal Highway Administration (FHWA) asset planning manuals, NPTEL course on "Construction Engineering & Management".*
2. *Software Tools: QGIS / ArcGIS (spatial data analysis), MS Excel Solver (optimization modeling), open-source asset management configurations (e.g., Maximo/SAP Asset Manager concept models).*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | *Prepare an asset register and condition-rating sheet for a selected campus or municipal infrastructure system.* | *24* |
| *2* | *Develop a life-cycle maintenance and renewal plan for a bridge, road, or building asset.* | *24* |

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

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **ISO 55001 Strategic Compliance Analysis:** *Conduct independent academic research providing a systematic review mapping how a legacy state utility entity can align its operational data storage logs to fulfill the compliance requirements of the ISO 55001 Asset Management standard.* | *24* |
| *2* | **GIS Spatial Network Asset Visualization:** *Build a localized open-source GIS repository (using QGIS) mapping a mock linear distribution network. Tag components with attributes such as installation dates, age parameters, structural material compositions, and current performance tracking scores.* | *24* |
| *3* | *Prepare a digital asset dashboard using Excel, GIS, or BIM-linked data for an infrastructure asset case.* | *24* |
| *4* | *Study an international or national asset management standard and prepare a brief report on its application.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear asset problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally, sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| STRUCTURAL HEALTH MONITORING OF CIVIL ENGINEERING STRUCTURES | | | |
|---|---|---|---|
| *Course Code* | **1MCIM206D/1MCEM206D** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42 (3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain the principles, terminology, and need for structural health monitoring in civil engineering systems.*
2. *Identify damage indicators, monitoring strategies, and sensing technologies used in civil infrastructure.*
3. *Apply vibration-based, model-based, and data-driven SHM methods for condition assessment.*
4. *Interpret SHM data using signal processing, statistical methods, and basic AI-based approaches.*
5. *Develop monitoring plans, inspection protocols, and decision frameworks for real infrastructure assets.*
6. *Evaluate SHM practices, standards, and emerging industry applications for bridges, buildings, and lifeline structures.*

**Module-1**

**Fundamentals of Structural Health Monitoring:**

*Introduction to SHM, objectives, scope, and evolution of SHM for civil engineering structures. Need for monitoring bridges, buildings, dams, towers, tunnels, and industrial structures. Concepts of damage, deterioration, performance, safety, reliability, and serviceability. SHM lifecycle: planning, sensing, acquisition, processing, diagnosis, prognosis, and decision support. Static, dynamic, continuous, periodic, and event-triggered monitoring. SHM in the context of asset management and resilience.*

**Linked COs: CO1, CO6** **Number of Hours: 8**

**Module-2**

**Damage Mechanisms, Indicators, and Monitoring Strategies:**

*Sources of deterioration in civil structures, including cracking, corrosion, fatigue, settlement, overloading, seismic effects, and environmental degradation. Damage states, damage indices, and performance measures. Structural response features such as displacement, acceleration, strain, frequency, damping, modal shapes, and curvature. Introduction to local and global damage detection approaches. Monitoring strategies for concrete, steel, composite, prestressed, and masonry systems.*

**Linked COs: CO1, CO2, CO3** **Number of Hours: 9**

**Module-3**

**Sensor Systems and Data Acquisition:**

*Sensors used in SHM: strain gauges, accelerometers, displacement sensors, inclinometers, fiber optic sensors, acoustic emission sensors, temperature and humidity sensors, corrosion sensors, and wireless sensor nodes. Sensor placement, calibration, sampling, synchronization, power supply, communication, and durability considerations. Data acquisition systems, edge devices, real-time transmission, cloud platforms, and digital data logging. Practical issues in field deployment, environmental noise, and long-term monitoring.*

**Linked COs: CO2, CO3, CO5** **Number of Hours: 9**

**Module-4**

**Signal Processing and Data Interpretation:**

*Pre-processing of SHM data, filtering, normalization, noise reduction, outlier treatment, and feature extraction. Time-domain, frequency-domain, and time-frequency methods. Modal analysis fundamentals, natural frequency, mode shape, modal curvature, and damping estimation. Statistical pattern recognition, baseline comparison, anomaly detection, and trend interpretation. Introduction to machine learning concepts for SHM, including classification, clustering, and regression-based diagnosis.*

| **Linked COs: CO3, CO4** | **Number of Hours: 8** |
|---|---|

**Module-5**

**SHM Applications, Case Studies, and Industry Practice:**

*SHM applications in bridges, buildings, flyovers, stadium roofs, dams, retaining structures, and marine/offshore civil systems. Case studies on real-time monitoring, post-event assessment, retrofit verification, and life extension studies. Integration of SHM with digital twins, BIM/GIS, asset management systems, and maintenance planning. Industry workflow for condition assessment reports, intervention recommendations, and monitoring dashboards. Emerging trends: AI-enabled SHM, low-cost sensors, smart materials, edge analytics, and sustainability-driven monitoring.*

**Linked COs: CO4, CO5, CO6** **Number of Hours: 8**

**Suggested Learning Resources:**

**Textbooks**

1. *Daniel Balageas, Claus-Peter Fritzen, and Alfredo Güemes, Structural Health Monitoring, 1st Edition, ISTE / Wiley.doe.iitm.ac*
2. *Srinivasan Chandrasekaran, Structural Health Monitoring, 1st Edition, NPTEL / IIT Madras as a course reference for SHM fundamentals and applications.archive.nptel.ac*
3. *Waleed Abdullah et al. (eds.), Civil Structural Health Monitoring: Proceedings of CSHM-9 Workshop, 1st Edition, Springer Nature, 2024.books. google*
4. *Alexandre Cury et al. (eds.), Structural Health Monitoring Based on Data Science Techniques, 1st Edition, Springer Cham, 2021.link. springer*
5. *Chen Hua-Peng and Ni Yi-Qing, Structural Health Monitoring of Large Civil Engineering Structures, 1st Edition, Wiley, 2018.onlinelibrary.wiley*

**Reference Books**

1. *Vistasp M. Karbhari and Farhad Ansari (eds.), Condition Monitoring and Structural Health Monitoring of Infrastructure Systems, 1st Edition, Elsevier, 2025.*
2. *Wiesław Ostachowicz and Alfredo Güemes, New Trends in Structural Health Monitoring, 1st Edition, Springer, 2013.*
3. *A. E. Aktan, F. N. Catbas, and related authors on structural identification and SHM methods, as cited in NPTEL SHM resources.*
4. *Recent journal and conference papers on civil SHM, digital twins, and AI-enabled monitoring.*

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

1. *NPTEL: Structural Health Monitoring — conceptual lectures, syllabus, and course details.nptel*
2. *NPTEL syllabus PDF — detailed SHM module outline and applications.archive.nptel.ac*
3. *NPTEL study materials — supplementary learning support.nptelprep*
4. *Tufts SHM Case Studies — real-world structural health monitoring examples.sites.tufts*
5. *UNDRR and related resilience resources — useful for resilience-linked monitoring context.*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **TW-1:** *SHM case study of a bridge or building, including identification of likely damage mechanisms and monitoring needs.* | *24* |
| *2* | **TW-2:** *Prepare a sensor layout and monitoring plan for a selected civil structure.* | *24* |
| *3* | **TW-3:** *Analyze sample SHM data and extract key response features.* | *24* |
| *4* | **TW-4:** *Develop a condition assessment note and intervention recommendation for an existing structure.* | *24* |
| *5* | **TW-5:** *Prepare a mini project on digital-twin-enabled SHM or AI-assisted damage detection.* | *24* |

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

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **SL-1:** *NPTEL/SWAYAM module review on SHM fundamentals and sensor technologies.* | *24* |
| *2* | **SL-2:** *Literature review on SHM of bridges/buildings and prepare a one-page technical note.* | *24* |
| *3* | **SL-3:** *Online study of one SHM case study and submit a critical review.* | *24* |
| *4* | **SL-4:** *Short module on signal processing or Python-based data visualization for SHM data.* | *24* |

**Sample rubrics for TW activities:**

| *Criterion* | *Excellent (5)* | *Good (4)* | *Satisfactory (3)* | *Needs Improvement (2)* | *Weight* |
|---|---|---|---|---|---|
| *Problem understanding* | *Clear, accurate, and complete understanding of SHM problem and context.* | *Minor gaps in context or framing.* | *Basic understanding with limited depth.* | *Incomplete or weak understanding .* | *20%* |
| *Technical relevance* | *Strong linkage to sensors, data, damage, and monitoring strategy.* | *Mostly relevant with minor omissions.* | *Some technical relevance, but generic.* | *Limited technical depth.* | *25%* |
| *Analysis and interpretation* | *Sound analysis with correct interpretation of SHM outputs.* | *Mostly correct with minor errors.* | *Partial analysis and interpretation.* | *Weak or incorrect analysis.* | *25%* |
| *Industry applicability* | *Solution is realistic, implementable, and industry-oriented.* | *Good applicability with small gaps.* | *Moderate practicality.* | *Poor practical relevance.* | *20%* |
| *Presentation and documentation* | *Well-structured, concise, and professional.* | *Clear but slightly uneven.* | *Acceptable but basic.* | *Poorly organized or incomplete.* | *10%* |

| GEOSPATIAL ANALYTICS & AI APPLICATIONS IN INFRASTRUCTURE SYSTEM | | | |
|---|---|---|---|
| *Course Code* | **1MCIM206E/1MCEM206E** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain fundamental concepts of geospatial data, remote sensing, GIS, and AI-driven analytics for infrastructure systems.*
2. *Apply spatial analysis and geospatial workflows for infrastructure planning, mapping, and asset monitoring.*
3. *Use AI and machine learning methods to interpret geospatial datasets for prediction, classification, and decision support.*
4. *Evaluate infrastructure performance, risk, and resilience using spatial-temporal analytics.*
5. *Develop geospatial and AI-based solutions for sustainable infrastructure management and reporting.*

**Module-1**

**Introduction to Geospatial Analytics and Infrastructure Systems:**

*Geospatial data, coordinate systems, projections, map types, and spatial referencing. GIS concepts, layers, attributes, topology, and spatial databases. Remote sensing fundamentals, satellite imagery, digital elevation models, and geospatial data sources for infrastructure applications. Overview of infrastructure domains such as transportation, water resources, urban systems, energy, and environmental monitoring.*

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

**Module-2**

**Spatial Data Acquisition and Analysis:**

*Data collection using GPS, GNSS, UAVs, satellite imagery, LiDAR, and ground surveys. Data preprocessing, georeferencing, digitization, raster and vector analysis, buffering, overlay, and network analysis. Terrain analysis, slope, aspect, watershed delineation, and corridor planning for infrastructure projects.*

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

**Module-3**

**AI and Machine Learning for Geospatial Data:**

*Introduction to AI, machine learning, deep learning, and data-driven infrastructure analytics. Feature extraction from spatial data, supervised and unsupervised learning, classification, clustering, and regression. Applications in land-use classification, object detection, change detection, anomaly detection, and predictive mapping.*

**Linked COs: CO2, CO3.** **Number of Hours: 09**

**Module-4**

**Geospatial Intelligence for Infrastructure Monitoring:**

*Asset inventory and condition assessment using GIS and AI-based tools. Spatial-temporal monitoring of roads, buildings, drainage systems, utilities, and urban growth. Risk mapping for flood, landslide, heat island, erosion, and service disruption. Dashboarding, spatial decision support systems, and integration of geospatial analytics with digital infrastructure management.*

**Linked COs: CO3, CO4.** **Number of Hours: 09**

**Module-5**

**Applications, Sustainability, and Smart Infrastructure:**

*AI-enabled planning for resilient infrastructure, smart cities, and climate adaptation. Geospatial support for sustainability assessment, life-cycle planning, maintenance prioritization, and emergency response. Case studies on*

*transportation networks, water systems, urban drainage, renewable energy siting, and infrastructure planning using GIS and AI tools.*

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

**Suggested Learning Resources:**

**Textbooks**

1. *Burrough, P. A., McDonnell, R. A., and Lloyd, C. D., Principles of Geographical Information Systems, Oxford University Press.*
2. *Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W., Geographic Information Systems and Science, Wiley.*
3. *Jensen, J. R., Introductory Digital Image Processing: A Remote Sensing Perspective, Pearson.*
4. *Hastie, T., Tibshirani, R., and Friedman, J., The Elements of Statistical Learning, Springer.*
5. *Bishop, C. M., Pattern Recognition and Machine Learning, Springer.*

**Reference Books**

1. *DeMers, M. N., Fundamentals of Geographic Information Systems, Wiley.*
2. *Lillesand, T., Kiefer, R. W., and Chipman, J., Remote Sensing and Image Interpretation, Wiley.*
3. *Goodfellow, I., Bengio, Y., and Courville, A., Deep Learning, MIT Press.*
4. *Obe, R. and Hsu, L., PostGIS in Action, Manning.*

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

1. *NPTEL and SWAYAM courses on GIS, remote sensing, AI, and spatial analytics.*
2. *ISRO/NRSC geospatial data portals and resources.*
3. *QGIS, Google Earth Engine, and open geospatial data repositories.*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete*

| | | |
|---|---|---|
| *minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.* | | |
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| *1* | **TW-1:** *GIS-based corridor mapping and suitability analysis for an infrastructure project.* | *24* |
| *2* | **TW-2:** *Remote sensing-based land-use change detection for an urban or watershed area.* | *24* |
| *3* | **TW-3:** *AI-based classification or prediction task using spatial data.* | *24* |
| *4* | **TW-4:** *Spatial risk mapping and decision support report for a selected infrastructure case.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **SL-1:** *QGIS workflow for base map preparation and layer analysis.* | *24* |
| *2* | **SL-2:** *Google Earth Engine exercise for image classification or time-series analysis.* | *24* |
| *3* | **SL-3:** *Machine learning model development using geospatial feature data.* | *24* |
| *4* | **SL-4:** *Dashboard preparation for infrastructure monitoring and reporting.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *Excellent (4)* | *Good (3)* | *Satisfactory (2)* | *Needs Improvement (1)* |
|---|---|---|---|---|
| *Understanding of concept* | *Demonstrates clear and accurate understanding of metro planning and urban mobility concepts.* | *Mostly clear understanding with minor gaps.* | *Basic understanding, but some important ideas are missing.* | *Limited or incorrect understanding.* |
| *Technical application* | *Applies concepts correctly to the given case or task.* | *Applies most concepts correctly.* | *Partial application with limited depth.* | *Weak or incorrect application.* |
| *Analysis and reasoning* | *Strong logic, comparison, and justification of recommendations.* | *Reasonable analysis with minor weaknesses.* | *Simple analysis with limited justification.* | *Little or no meaningful analysis.* |
| *Presentation and documentation* | *Well structured, neat, complete, and professional.* | *Good presentation with minor issues.* | *Acceptable, but inconsistent or incomplete in places.* | *Poorly organized or incomplete.* |

| CYBER SECURITY AND URBAN INFRASTRUCTURE MANAGEMENT | | | |
|---|---|---|---|
| *Course Code* | **1MCIM206F** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain foundational concepts of cyber security, threat landscapes, and security controls in urban infrastructure systems.*
2. *Analyze cyber risks in smart cities, utility networks, transport systems, and digital governance platforms.*
3. *Apply security principles to urban infrastructure planning, operation, and maintenance.*
4. *Evaluate vulnerabilities, incident response strategies, and resilience measures for critical urban systems.*
5. *Develop security-aware management strategies for data, networks, IoT systems, and infrastructure assets.*
6. *Assess governance, compliance, and policy issues related to cyber security in urban infrastructure management.*

**Module-1**

**Cyber Security Foundations:**

*Introduction to cyber security, confidentiality, integrity, availability, authenticity, and non-repudiation. Threats, vulnerabilities, attacks, malware, phishing, social engineering, and insider risks. Security controls, risk treatment, authentication, authorization, encryption basics, and access management. Overview of cyber security in public infrastructure and smart urban systems*

**Linked COs: CO1, CO2** **Number of Hours: 08**

**Module-2**

**Urban Infrastructure Digital Systems:**

*Urban infrastructure as cyber-physical systems: water supply, sewage, transport, power, traffic control, smart lighting, surveillance, and e-governance platforms. Digital assets, operational technology, information technology, sensor networks, and communication layers. Data flows, interoperability, GIS, IoT, SCADA, and building management systems. Security challenges in integrated urban infrastructure environments.*

**Linked COs: CO1, CO2, CO3** **Number of Hours: 09**

**Module-3**

**Threats and Risk Assessment:**

*Cyber threat modeling for urban infrastructure, attack surfaces, exposure points, and critical dependencies. Risk identification, likelihood-impact analysis, vulnerability assessment, and prioritization. Common attacks on smart city systems, ransomware, denial-of-service, data breaches, device compromise, and supply-chain risks. Security audit methods, penetration testing overview, and asset classification.*

**Linked COs: CO2, CO4** **Number of Hours: 09**

**Module-4**

**Security Design and Resilience:**

- *Security-by-design principles for urban infrastructure projects. Network segmentation, secure configuration, backup strategies, redundancy, disaster recovery, business continuity, and fail-safe*

*design. Protection of IoT devices, sensors, controllers, and communication systems. Incident detection, monitoring, logging, alerting, and response coordination. Resilience planning for essential public services and critical infrastructure continuity.*

**Linked COs: CO3, CO4, CO5** **Number of Hours: 08**

**Module-5**

**Governance, Policy, and Management:**

*Cyber security governance for urban infrastructure authorities, municipalities, utilities, and special purpose vehicles. Standards, policies, compliance, audits, asset ownership, vendor management, and data protection practices. Security procurement, contract clauses, service-level expectations, and third-party risk management. Case studies on smart city incidents, lessons learned, and best practices for secure urban infrastructure management.*

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

**Suggested Learning Resources:**

**Textbooks:**

1. *Stallings, W., and Brown, L., Computer Security: Principles and Practice, latest edition, Pearson.*
2. *Peltier, T. R., Information Security Risk Analysis, latest edition, Auerbach.*
3. *Townsend, A. M., Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia, latest edition, W.W. Norton. Radvanovsky, R., & Brodsky, L. Critical Infrastructure: Homeland Security and Resilience, CRC Press.*
4. *Knapp, E. D., & Langill, J. T. Industrial Network Security: Securing Critical Infrastructure Networks for Smart Grid, SCADA, and Other Industrial Control Systems, Syngress.*
5. *Sabillon, R. Cybersecurity and Infrastructure Protection: Frameworks, Methodologies, and Cyber Risks, Wiley.*

**Reference Books:**

1. *Tipton, H. F., and Krause, M., Information Security Management Handbook, latest edition, CRC Press.*
2. *Chawla, G., Cyber Security for Smart Cities and Critical Infrastructure, latest edition, Springer.*
3. *ISO/IEC 27001 and ISO/IEC 27002, latest editions.*
4. *National Critical Information Infrastructure Protection Centre and CERT-In advisories, latest available publications. NIST Special Publication 800-82: Guide to Industrial Control Systems (ICS) Security.*
5. *Vacca, J. R. Managing Information Security Risks: The 2018 Vulnerability Landscape, Syngress.*
6. *ISO/IEC 27032: Information Technology — Security Techniques — Guidelines for Cybersecurity.*

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

1. *Online Repositories: SANS Industrial Control Systems (ICS) Security resources, Indian Computer Emergency Response Team (CERT-In) bulletins, NPTEL course on "Cyber Security".*
2. *Software Tools: Wireshark (network packet capture and analysis), Shodan (search engine for internet-connected OT devices for vulnerability scanning), Threat Dragon / Microsoft Threat Modeling Tool.*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be*

*50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*
*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*
*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Smart Utility Vulnerability Assessment & Blueprint:** *Choose a critical city utility sub-system (e.g., an automated water distribution grid or an interconnected traffic management node). Map out its entire IT-OT network topology, execute a complete threat-modeling analysis, and design a hardened infrastructure protection plan leveraging the Purdue network model.* | *24* |
| *2* | **Incident Response & Playbook Design:** *Formulate a highly detailed emergency cyber-incident playbook for a municipal council under a simulated high-impact attack (e.g., a ransomware outbreak taking down a metro rail network). Detail communication protocols, operational containment actions, backup activations, and regulatory reporting steps.* | *24* |

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

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **ISA/IEC 62443 Compliance Mapping:** *Conduct independent academic research providing a structured assessment of the practical requirements to transition a legacy municipal pump station to meet the compliance benchmarks of the ISA/IEC 62443 industrial cybersecurity standard.* | *24* |
| *2* | **Smart City Citizen Privacy Impact Analysis:** *Analyze the data collection flows of an active smart-city monitoring initiative (such as automated AI facial recognition or automated license plate scanners). Draft a Privacy Impact Assessment (PIA) document checking alignment with the Digital Personal Data Protection (DPDP) framework.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| SMART CONSTRUCTION MATERIALS & NANOTECHNOLOGY | | | |
|---|---|---|---|
| *Course Code* | **1MCIM206G/1MCCT206F** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (PCC):* | *Theory- CIE +SEE* | *Exam Hours* | *03* |

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

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

1. *Explain the fundamentals, classification, and performance requirements of smart construction materials and nanomaterials used in civil engineering.*
2. *Identify the role of nanotechnology in modifying material properties for strength, durability, sustainability, and functionality.*
3. *Apply smart materials and nano-enabled materials in concrete, coatings, sensors, self-healing systems, and energy-efficient building components.*
4. *Analyze the long-term performance, serviceability, and durability of advanced materials in construction applications.*
5. *Evaluate environmental, economic, and safety aspects associated with the use of smart materials and nanotechnology in construction.*
6. *Develop suitable material selection strategies for infrastructure projects using smart and nano-enhanced construction materials.*

**Module-1**

**Fundamentals of Smart Construction Materials:**

- *Introduction to smart materials: definition, characteristics, classification, and need in construction.*
- *Traditional materials versus smart materials, limitations of conventional construction materials.*
- *Functions of smart materials in sensing, actuation, adaptation, self-monitoring, and response.*
- *Performance requirements for modern infrastructure: strength, durability, resilience, sustainability, and functionality.*
- *Overview of advanced material systems used in civil engineering.*
- *Introduction to intelligent and multifunctional building materials.*

**Linked COs: CO1, CO6** **Number of Hours:0 8**

**Module-2**

**Nanotechnology in Construction Materials:**

- *Introduction to nanotechnology, nanoscale phenomena, and nano-engineering of materials.*
- *Nano-modification of cement, concrete, steel, glass, ceramics, and polymers.*
- *Nano-silica, nano-alumina, nano-titania, carbon nanotubes, graphene, and nanoclays in civil engineering materials.*
- *Influence of nanoparticles on hydration, microstructure, porosity, and interfacial transition zone.*
- *Property enhancement through nanotechnology: mechanical, thermal, chemical, and durability improvements.*
- *Health, safety, and environmental concerns related to nanomaterials.*

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

**Module-3**

**Smart and Functional Concrete Systems:**

- *High-performance concrete, self-compacting concrete, and fiber-reinforced concrete.*
- *Self-healing concrete: mechanisms, bacterial healing, encapsulated agents, and mineral precipitation.*
- *Self-sensing concrete and piezoresistive behavior for structural health monitoring.*

- *Concrete with phase change materials for thermal regulation.*
- *Photocatalytic and air-purifying concrete.*
- *Applications of nano-enabled concrete in pavements, bridges, buildings, and precast elements.*

**Linked COs: CO3, CO4** **Number of Hours: 08**

**Module-4**

**Smart Materials for Buildings and Infrastructure:**

- *Smart coatings, corrosion-resistant systems, and anti-microbial surface materials.*
- *Shape memory alloys, magnetostrictive materials, and electroactive polymers in civil applications.*
- *Smart glass, electrochromic materials, and adaptive façade systems.*
- *Embedded sensors, fiber optic sensors, and wireless sensor networks for material and structural monitoring.*
- *Applications in smart buildings, transport infrastructure, and sustainable urban systems.*
- *Integration of smart materials with digital monitoring and maintenance practices***.**

**Linked COs: CO3, CO4, CO6** **Number of Hours: 09**

**Module-5**

**Sustainability, Life-Cycle Performance, and Applications:**

- *Life-cycle assessment of smart and nano-enabled construction materials.*
- *Durability enhancement, service life prediction, and maintenance reduction.*
- *Energy-efficient construction through advanced materials.*
- *Recyclability, embodied carbon reduction, and circular economy considerations.*
- *Standards, codes, testing methods, and practical implementation issues.*
- *Case studies on smart materials and nanotechnology in contemporary construction projects.*

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

**Suggested Learning Resources:**

**Textbooks**

1. *Sanjay Kumar Sharma, Nanotechnology in Construction Materials, Springer, latest edition.*
2. *M.S. Shetty, Concrete Technology, S. Chand, latest edition.*
3. *Ashok K. Bhatia, Advanced Construction Materials, McGraw Hill, latest edition.*
4. *James K. Wight and James G. MacGregor, Reinforced Concrete: Mechanics and Design, Pearson, latest edition*
5. *Shah, S. P., Gopalakrishnan, K., & Birgisson, B. Nanotechnology in Construction, Springer.*
6. *Cao, G. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press.*
7. *Addington, D., & Schodek, D. L. Smart Materials and New Technologies: For the Architecture and Design Professions, Harvard University / Architectural Press.*

**Reference Books**

1. *P. Kumar Mehta and Paulo J.M. Monteiro, Concrete: Microstructure, Properties, and Materials, McGraw Hill, latest edition.*
2. *C. Hall and W.D. Hoff, Water Transport in Brick, Stone and Concrete, CRC Press, latest edition.*
3. *B. Vidivelli, Advanced Concrete Technology, Technical Publications, latest edition.*
4. *C.M. Calafiore, Smart Materials in Civil Engineering Applications, Elsevier, latest edition.*
5. *Relevant IS codes, ASTM standards, and research papers on smart and nano-enabled construction materials.Pacheco-Torgal, F., Jalali, S., & Labrincha, J. Eco-efficient Construction and Building Materials: Life Cycle Assessment (LCA), Eco-labelling and Case Studies, Woodhead Publishing.*
6. *Ouellette, L. A., & Srinivasan, A. V. Smart Structures: Analysis and Design, Cambridge University Press.*
7. *RILEM State-of-the-Art Reports: Technical Committee reports on Nanotechnology in Cement-Based Materials.*

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

1. *Online Repositories: Nanotechnology in Construction (NICOM) international proceedings, NPTEL course on "Textured Materials and Nanotechnology".*
2. *Software Tools: ANSYS / ABAQUS (for modeling multi-scale material stresses), MATLAB (for thermal transient evaluations of PCM layers), ImageJ (for analyzing SEM porosity particle sizes).*

**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 (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

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

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

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Material selection case study:** *Students select a smart or nano-enabled material for a given civil engineering application and justify the choice based on performance, durability, sustainability, and cost.* | *24* |
| *2* | **Comparative property chart:** *Students prepare a comparison of conventional materials versus smart/nano materials for strength, toughness, permeability, self-healing, or thermal performance.* | *24* |
| *3* | **Mini project / group task:** *Students work in groups to design a concept for a smart building component or nano-modified concrete mix for a chosen use.* | *24* |

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

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Seminar presentation:** *Each student presents on one topic such as nano-silica in concrete, self-healing concrete, smart glass, or self-sensing materials., charting the density growth of Calcium Silicate Hydrate (C-S-H) gels.* | *24* |
| *2* | **Poster presentation:** *Students create a poster on a smart material system, highlighting mechanism, application, and advantages.* | *24* |

**Sample rubrics for TW activities:**

| *Criterion* | *5* | *4* | *3* | *2* | *1* |
|---|---|---|---|---|---|
| *Technical understanding* | *Explains concepts accurately and in depth* | *Minor gaps* | *Basic understanding* | *Partial understanding* | *Weak or incorrect* |
| *Relevance of application* | *Choice is highly appropriate and well justified* | *Mostly appropriate* | *Moderately relevant* | *Limited relevance* | *Not relevant* |
| *Analysis and comparison* | *Gives strong comparison with evidence* | *Good comparison* | *Some comparison* | *Minimal comparison* | *No meaningful analysis* |
| *Clarity of presentation* | *Very clear and well organized* | *Clear* | *Acceptable* | *Poorly organized* | *Unclear* |
| *References and data use* | *Uses reliable sources correctly* | *Uses adequate sources* | *Some sources used* | *Few sources* | *No proper sources* |

| SMART CONSTRUCTION & INFRASTRUCTURE APPLICATIONS LABORATORY | | | |
|---|---|---|---|
| *Course Code* | **1MCIML207** | *Scheme* | *2026* |
| *Type of course* | *Professional Core Course Lab* | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *2(0: 0: 2)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy L:T:P:SL:TW* | *30(0: 0:28:2)* | *SEE Marks* | *50* |
| *Credits* | *1* | *Total Marks* | *100* |
| *Type of Examination* | **Practical** | *Exam Hours* | *3* |

**Course outcome (Course Skill Set)**

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

1. *CO1 -- L3: Configure smart construction and infrastructure software tools for project planning, data capture, and digital workflow preparation.*
2. *CO2 -- L4: Interpret sensor data, digital models, schedules, and infrastructure performance indicators for construction applications.*
3. *CO3 -- L4: Analyze project logic, productivity, monitoring, and resource-related information using digital tools.*
4. *CO4 -- L5: Design and evaluate smart construction solutions for planning, monitoring, safety, quality, and asset management.*
5. *CO5 -- L6: Apply BIM, GIS, IoT, dashboard, and reporting tools to prepare professional outputs and practical recommendations.*

**Note:**

1. *The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 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* **80 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* **20 marks.**

*For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from* **Part-B**, *along with other similar questions designed to enhance the students' skills.*

**PART – A**
**FIXED EXPERIMENTS**

2. *Introduction to smart construction software tools: creating a project, setting calendars, defining work breakdown structure, and entering basic project information. CO1*
3. *Preparation of activity list, precedence relationships, and network diagram for a building or infrastructure project using digital tools. CO1, CO2*
4. *Project scheduling using software tools: bar chart, CPM schedule, milestones, and critical path identification. CO2, CO3*
5. *Resource allocation and levelling for labour, materials, and equipment in a construction project. CO3, CO4*
6. *Cost estimation and cash flow preparation using quantities, unit rates, and activity-wise cost distribution. CO2, CO3*
7. *Productivity analysis for selected construction operations such as excavation, concreting, masonry, or formwork using digital data analysis tools. CO2, CO4*
8. *Site layout planning, safety zoning, and utility coordination for a building project using BIM/GIS-based*

*tools. CO3, CO4*

9. *Construction progress monitoring and reporting using planned vs actual comparison, S-curve, dashboard outputs, and variance analysis. CO4, CO5Site layout planning and safety zoning for a building project using digital drawing or BIM-based tools. CO3, CO4*
10. *Construction progress monitoring and reporting using planned vs actual comparison, S-curve, and variance analysis. CO4, CO5*

**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.*

2. *Prepare a complete smart construction management plan for a small building project including scope, WBS, schedule, resource plan, and digital tracking strategy. CO2, CO4, CO5*
3. *Develop a time-cost trade-off analysis for a selected project and recommend the optimum crashing strategy. CO3, CO4, CO5*
4. *Prepare a material procurement and inventory control plan for a construction site using digital planning tools. CO2, CO4, CO5*
5. *Analyze the effect of labour productivity variation on project duration and cost, and suggest corrective measures. CO3, CO4, CO5*
6. *Develop a BIM-based construction coordination model for clash detection, sequencing, or site logistics planning. CO4, CO5*
7. *Prepare a comprehensive project report for a real or simulated project including schedule, budget, safety, quality, and execution recommendations. CO4, CO5*

**Textbooks:**

1. *Punima, B. C., Jain, A., and Jain, A., Construction Planning and Management, Laxmi Publications.*
2. *Chitkara, K. K., Construction Project Management: Planning, Scheduling and Control, McGraw-Hill Education.*
3. *Halpin, D. W. and Woodhead, R. W., Construction Management, Wiley.*
4. *Harris, F. and McCaffer, R., Modern Construction Management, Wiley-Blackwel.*

**Reference books / Manuals:**

1. *O'Brien, J. J., Construction Management Principles and Practice, McGraw-Hill.*
2. *Oberlender, G. D., Project Management for Engineering and Construction, McGraw-Hill.*
3. *Reddy, B. V. and others, Building Planning and Drawing / Construction Practices as applicable.*
4. *Relevant BIS codes, CPWD manuals, and standard construction management handbooks.*

**Software tools:**

1. *Microsoft Project or equivalent for planning and scheduling.*
2. *Primavera P6 or equivalent for project control and resource management.*
3. *AutoCAD, Revit, Navisworks, ArcGIS, or equivalent for drawing, BIM, GIS, and coordination.*
4. *Excel, MATLAB, or Python for estimation, tabulation, graphs, analysis, and dashboards.*
5. *Any equivalent project management, BIM, or GIS software approved by the department.*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be*

*50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.*
*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation (CIE):**

*For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks." Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)*
*Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.*
*The remaining 15 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 the practical test as indicated in the Table 1.*
*The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.*

**Table – 1 Distribution of marks corresponding to laboratory component**

| Component | Description | Marks |
|---|---|---|
| **Allotment of marks for regular classwork** | | |
| *Ability in Conducting Experiments* | *Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.* | *10 marks* |
| *Laboratory Record / Journal* | *Regular and neat maintenance of lab record, accuracy of results, and timely submission.* | *15 marks* |
| | **Subtotal** | **25** |
| **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.* | *10marks* |
| | **Subtotal** | **15** |
| | **Total** | **40** |

**Table 2 Distribution of marks corresponding to PART -B of the laboratory component**

**Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10**

| Criteria and Guiding factors | Students' Level and Rubrics<br>Excellent: E, Good: G, Fair: F<br>Needs Improvements: NI | | | |
|---|---|---|---|---|
| | **E** | **G** | **F** | **NI** |
| **(1)** *Problem Understanding*<br>**Criteria:** *Is the problem understood correctly and framed appropriately?*<br>*(i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints.*<br>*(iii) Ability to rephrase or model the problem logically.* | *2.0* | *1.5* | *1.0* | *0.5* |
| **(2)** *Conceptual Knowledge* | | | | |

| | | | | |
|---|---|---|---|---|
| **Criteria**: *Are the chosen methods or concepts valid for this type of problem?*<br>*(i) Application of appropriate theories, principles, or laws.*<br>*(ii) Integration of multiple concepts where necessary.*<br>*(iii) Accuracy in stating relevant equations or models.* | *2.0* | *1.5* | *1.0* | *0.5* |
| **(3)** *Approach and Strategy*<br>**Criteria**: *Is the approach well thought out and methodical?*<br>*(i) Logical structure and progression.*<br>*(ii) Use of diagrams, sketches, or flowcharts if applicable.*<br>*(iii) Identification of assumptions and boundary conditions.* | *2.0* | *1.5* | *1.0* | *0.5* |
| **(4)** *Execution and Accuracy*<br>**Criteria**: *Are the calculations correct? Is the final solution reasonable?*<br>*(i) Correct application of formulas/methods.*<br>*(ii) Accuracy of calculations or simulations (if any).*<br>*(iii) Unit consistency and result verification.* | *2.0* | *1.5* | *1.0* | *0.5* |
| **(5)** *Innovation or Depth*<br>**Criteria**: *Has the student shown original thinking or alternative methods?*<br>*(i)Novel or efficient solutions. (ii)Consideration of alternate approaches.*<br>*(iii)Interdisciplinary integration or practical extensions.* | *1* | *0.75* | *0.5* | *0.25* |
| **(6)** *Presentation and Clarity*<br>**Criteria**: *Is the answer easy to follow and professionally written?*<br>*(i) Organization and neatness.*<br>*(ii) Clarity of explanation, labelling, and steps.*<br>*(iii) Use of proper technical terminology.* | *1* | *0.75* | *0.5* | *0.25* |
| *Total* | *10* | *7.5* | *5.0* | *2.5* |

**Note:**

*(i) The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.*

*(ii) If the total score results in a fraction, it should be rounded off to the next higher integer.*

*(iii) The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.*

*(iv) To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.*