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

URBAN INFRASTRUCTURE DESIGN AND CONSTRUCTION			
Course Code	**1MCEM203**	*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. *CO1: Explain urban infrastructure systems, planning principles, and service networks.*
2. *CO2: Apply design principles for urban roads, water supply, sewerage, and drainage.*
3. *CO3: Develop basic layouts and component-level solutions for urban infrastructure services.*
4. *CO4: Analyze construction methods, execution issues, quality, and safety requirements.*
5. *CO5: Evaluate sustainability, resilience, and management strategies for urban systems.*
6. *CO6: Integrate maintenance, asset management, and smart-city practices in urban infrastructure.*

Module-1

Urban Infrastructure Systems and Planning Fundamentals:

Urban infrastructure concepts, types of urban infrastructure, role of infrastructure in city development, urban growth patterns, and infrastructure needs. Basic principles of urban planning, hierarchy of urban services, service levels, interdependence of infrastructure systems, and introduction to sustainability, resilience, and smart-city context. Overview of urban governance, municipal responsibilities, and infrastructure delivery frameworks.

Linked COs: CO1, CO5. **Number of Hours: 8.**

Module-2

Urban Roads, Streets, and Public Space Design:

Urban road network hierarchy, street cross-sections, junctions and intersections, sidewalks, cycle tracks, parking, traffic movement, and streetscape planning. Design considerations for public space, accessibility, universal design, pedestrian safety, and integration of underground utilities with road corridors. Basic geometric design aspects for urban streets and space-efficient circulation planning.

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

Module-3

Water Supply, Sewerage, and Storm Drainage:

Urban water supply systems, source planning, storage, transmission, distribution, service connections, and demand estimation. Sewerage systems, wastewater collection, network layout, pumping, treatment interface, and sanitation planning. Stormwater drainage principles, catchment understanding, runoff estimation, drainage layout, flood considerations, and integration with urban road systems.

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

Module-4

Construction of Urban Infrastructure Works:

Construction planning for urban infrastructure projects, site investigation, setting out, utility shifting, excavation, earthwork, pavement construction, drainage construction, water supply and sewer line laying. Construction equipment, quality control, materials, safety, sequencing of work, and temporary traffic management during execution. Methods for constructability, service continuity, and minimizing disruption in dense urban areas.

Linked COs: CO2, CO4, CO5. **Number of Hours: 8**

Module-5

Urban Infrastructure Management, Sustainability, and Maintenance:

Inspection, operation, maintenance, rehabilitation, and asset management of urban infrastructure. Life-cycle thinking, service performance monitoring, risk management, resilience, sustainability, green infrastructure, and nature-based solutions. Smart-city technologies, digital monitoring, GIS/BIM-enabled asset tracking, and contemporary challenges in urban infrastructure delivery and upkeep.

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

Suggested Learning Resources:

Textbooks:

1. *Urban Infrastructure: Design and Management by J.W. Hall and J. De Rouck, Taylor & Francis, latest edition.*
2. *Urban Engineering: Planning and Design of Urban Services by J. Parkin, Wiley, latest edition.*
3. *Urban Water Resources and Water Supply by L.W. Mays, McGraw-Hill, latest edition.*
4. *Sustainable Urban Drainage Systems by D. Butler, CRC Press, latest edition.*
5. *Urban Infrastructure Systems: Planning and Management by G. Heravi, Springer, latest edition.*
6. *Infrastructure Planning and Management by Rajesh B. A., McGraw-Hill Education, latest edition.*

Reference Books

1. *Urban Planning and Infrastructure Development by Bimal Kumar and V.K. Jain, Khanna Publishers, latest edition.*
2. *Building Services Engineering by D.V. Chadderton, Routledge, latest edition.*
3. *Environmental Engineering by H.S. Peavy, D.R. Rowe, and G. Tchobanoglous, McGraw-Hill, latest edition.*
4. *Planning and Design of Airports, Roads, and Urban Transport Infrastructure by R. Horonjeff, F.X. McKelvey, and others, McGraw-Hill, latest edition.*
5. *A Course in Highway Engineering by S.P. Bindra, Dhanpat Rai, latest edition.*
6. *Guidelines for Urban Roads, Drainage and Street Design published by Indian Roads Congress, latest edition.*
7. *Water Supply and Sewerage Manual published by CPHEEO, Ministry of Housing and Urban Affairs, latest edition.*

Web links and Video Lectures (e-Resources)

1. *NPTEL courses on urban planning, transportation engineering, water supply, drainage, and infrastructure management.*
2. *SWAYAM MOOCs on smart cities, urban planning, and sustainable infrastructure.*
3. *Indian Roads Congress resources for road design, street planning, and drainage guidelines.*
4. *CPHEEO manuals for water supply, sewerage, and urban sanitation systems.*
5. *MoHUA Smart Cities Mission portal for case studies and urban infrastructure implementation practices.*
6. *Google Scholar for recent research papers on urban infrastructure design, construction, resilience, and sustainability.*

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: Case-based discussion on urban infrastructure systems** *Students analyze selected city infrastructure cases and identify the planning, design, construction, and maintenance issues involved.*	*24*
2	**TW-2: Problem-based exercise on urban road and corridor design.** *Students work on a typical urban road section, junction arrangement, pedestrian movement, and utility corridor planning.*	*24*
3	**TW-3: Design studio activity on water supply and drainage layout** *Students prepare basic layouts for water supply, sewerage, and stormwater systems for a residential or institutional area.*	*24*
4	**TW-4: Construction sequencing exercise** *Students plan the order of construction activities for urban infrastructure works such as road improvement, pipe laying, and drainage construction.*	*24*
5	**Field visit or virtual site observation** *Students observe an ongoing or completed urban infrastructure project and note the construction methods, quality issues, safety practices, and service integration.*	*24*

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

Sl. No.	Self-learning Activities	Number of Hours / Semester
1	**SL-1: Urban road network study.** *Study a selected city area and classify the road hierarchy, junctions, pedestrian movement, and service corridors.*	*24*
2	**SL-2: Utility mapping exercise.** *Prepare a schematic map showing water supply, sewerage, and stormwater networks for a neighborhood or campus area.*	*24*
3	**SL-3: Drainage problem analysis** *Identify a local drainage or flooding issue and suggest technical*	*24*

	improvements for better stormwater management.	
4	**SL-4: Agile or Hybrid Delivery Reflection.** *Students shall analyze the suitability of Agile or hybrid methods for a selected engineering project.*	*24*
5	**SL_5: Construction method comparison.** *Compare open-cut construction, trenchless construction, and staged construction methods for urban utility works.*	*24*
6	**SL-6: Urban infrastructure component review** *Select one road, water supply, sewerage, or drainage project and write a short technical note on its design and construction features.*	*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 concepts.*	*Identifies most concepts with minor omissions.*	*Basic understanding with partial explanation.*	*Incomplete or incorrect understanding.*
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.*

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.*

PROJECT MANAGEMENT IN INFRASTRUCTURE PROJECTS			
Course Code	**1MCEM205A**	*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. *CO1: Explain the principles, processes, and governance framework of infrastructure project management.*
2. *CO2: Apply planning, scheduling, cost, quality, and risk management tools to infrastructure projects.*
3. *CO3: Analyse project delays, resource constraints, stakeholder issues, and contractual challenges in infrastructure delivery.*
4. *CO4: Use digital and contemporary methods such as lean planning, BIM-enabled coordination, and data-driven monitoring for project control.*
5. *CO5: Develop project control strategies, dashboards, and mitigation plans for infrastructure execution.*
6. *CO6: Evaluate project performance, communication, and sustainability considerations in complex infrastructure environments.*

Module-1

Foundations of Infrastructure Project Management:

Project concept and classification, infrastructure sectors, project life cycle, feasibility studies, scope definition, scheduling, budgeting, quality, risk, procurement, stakeholder management, and project governance. Traditional and contemporary project management approaches, baseline management, and performance monitoring

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

Module-2

Planning and Scheduling:

Work breakdown structure, network techniques, CPM/PERT, resource planning, time–cost trade-off, project crashing, procurement scheduling, and construction sequence planning. Introduction to milestone tracking and progress reporting in infrastructure projects.

Linked COs: CO2, CO35 **Number of Hours: 09**

Module-3

Module 3: Cost, Contracts, and Risk Management:

Cost estimation, cash flow planning, earned value basics, contract types, tendering, claims, variations, and dispute resolution. Risk identification, qualitative and quantitative risk analysis, mitigation planning, contingency reserves, and resilience in infrastructure projects.

Linked COs: CO2, CO3, CO5. **Number of Hours: 09**

Module-4

Lean, Digital, and BIM-Enabled Project Delivery:

Lean construction principles, value stream mapping, waste elimination, pull planning, Last Planner System, and continuous improvement. BIM-based coordination, 4D/5D integration, information management workflows, and collaboration using digital project delivery systems.

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

Module-5

Project Performance and Control:

Key performance indicators, dashboards, project reviews, productivity analysis, delay analysis, change management, communication management, and stakeholder coordination. Case studies on infrastructure project failures and success strategies, integrated control, and contemporary trends including digital twins and sustainability-linked project management.

Linked COs: CO3, 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), latest edition, PMI.*
2. *Kerzner, H., Project Management: A Systems Approach to Planning, Scheduling, and Controlling, latest edition, Wiley.*
3. *Chitkara, K. K., Construction Project Management: Planning, Scheduling and Control, latest edition, Tata McGraw Hill.*
4. *Lock, D., Project Management, latest edition, Gower/Routledge.*

Reference Books

1. *Womack, J. P. and Jones, D. T., Lean Thinking, latest edition, Free Press.*
2. *Highsmith, J., Agile Project Management, latest edition, Addison-Wesley.*
3. *Eastman, C. et al., BIM Handbook, latest edition, Wiley.*
4. *Smith, P. and Tardif, M., BIM and the Project Lifecycle, latest edition, Wiley.*

Web links and Video Lectures (e-Resources)

1. *NPTEL, Infrastructure Planning and Management by IIT Madras.*
2. *ISO 19650-1:2018, Information management using building information modelling.*
3. *Swayam/NPTEL courses on Project Management, Lean Construction, and BIM.*
4. *Project Management Institute resources and standards.*
5. *Industry case studies on infrastructure delivery, digital project controls, and BIM workflows.*

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 work breakdown structure and CPM network for a selected infrastructure project.*	*24*
2	**TW2:** *Develop a simple cost and cash-flow plan for a road/bridge/water-supply project.*	*24*
3	**TW3:** *Conduct a risk register exercise with mitigation measures for a case project.*	*24*
	TW4: *Prepare a stakeholder map and communication plan for an infrastructure project.*	*24*
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**SL1:** *Case study presentation on a delayed infrastructure project and its corrective actions.*	*24*
2	**SL2:** *Group assignment on BIM-enabled planning and coordination workflow.*	*24*
3	**SL3:** *Seminar on contract management, claims, and dispute resolution in infrastructure projects.*	*24*
4	**SL4:** *Review of an NPTEL/industry case study and reflective report.*	*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 applied.*	*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.*
Analysis	*Analysis is thorough; interpretations are logically*	*Analysis is generally sound with minor errors or missing*	*Analysis is partial; contains gaps or superficial*	*Analysis is weak, incorrect, or largely missing.*

Criterion	*4 – Excellent*	*3 – Good*	*2 – Satisfactory*	*1 – Needs Improvement*
	argued and results are valid.	*details.*	*interpretation.*	
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.*

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. *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)*
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- *ICT-Enabled Teaching*
- *Role Play*

Assessment Structure (both CIE and SEE)

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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):

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- Role Play

Assessment Structure (both CIE and SEE)

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

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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):

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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.*

ENVIRONMENTAL IMPACT ASSESSMENT FOR INFRASTRUCTURE PROJECTS			
Course Code	**1MCEM206F**	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, scope, and regulatory framework of Environmental Impact Assessment for infrastructure projects.
2. Apply screening, scoping, baseline studies, and impact identification techniques to infrastructure proposals.
3. Assess environmental, social, and economic impacts of infrastructure projects using appropriate tools and indicators.
4. Develop mitigation measures, Environmental Management Plans, and monitoring strategies.
5. Evaluate EIA reports and case studies with reference to infrastructure project categories and approval processes.

Module-1

Foundations of EIA:

Introduction to environment and development; concept, objectives, scope, and need for EIA; historical evolution of EIA; EIA in the project cycle; types of EIA; stakeholders and their roles; EIA notification and legal framework in India; screening and scoping; terms of reference; selection and registration criteria for EIA consultants; relevance of EIA for infrastructure projects such as roads, buildings, water supply, drainage, and transport systems.

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

Module-2

Baseline Studies and Impact Identification:

Baseline environmental monitoring; physical, biological, and socio-economic baseline data; indicators for air, water, soil, noise, ecology, and land use; prediction and assessment of impacts; impact identification tools such as checklist, matrix, network, overlay mapping, and cause–effect methods; analysis of alternatives; significance ranking of impacts; application to infrastructure project planning and design.

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

Module-3

Infrastructure Project Impacts:

Environmental impacts of infrastructure projects including highways, bridges, tunnels, airports, ports, metros, buildings, water resource projects, and solid waste facilities; construction-phase and operation-phase impacts; impacts on air quality, water resources, biodiversity, community health, traffic, land acquisition, and cultural properties; cumulative and induced impacts; environmental and social risk issues; climate sensitivity and disaster vulnerability in infrastructure planning.

Linked COs: CO2, CO4. Hours: 9. **Number of Hours: 09**

Module-4

Mitigation, EMP, and Monitoring:

Mitigation hierarchy; impact avoidance, minimization, restoration, and compensation; preparation of Environmental Management Plan (EMP); environmental monitoring plan; post-project monitoring; public

consultation and public hearing; environmental clearance process; reporting and documentation; compliance monitoring; sustainability integration in infrastructure projects; green infrastructure and nature-based solutions.

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

Module-5

EIA Reports and Case Studies:

Structure and review of EIA reports; quality of impact prediction and mitigation plans; appraisal criteria and decision-making; case studies of infrastructure projects such as highways, dams, airports, metro rail, industrial corridors, and urban development projects; lessons learned from failed and successful EIAs; emerging tools including GIS, remote sensing, digital dashboards, and public disclosure portals; contemporary trends in cumulative EIA and strategic environmental assessment.

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

Suggested Learning Resources:

Textbooks:

1. Canter, L. W., Environmental Impact Assessment, McGraw-Hill.
2. Jain, R. K., Environmental Impact Analysis: A Decision Making Tool, Wiley / relevant edition.
3. Glasson, J., Therivel, R., and Chadwick, A., Introduction to Environmental Impact Assessment, Routledge / equivalent latest edition.
4. Rau, J. G., and Wooten, D. C., Environmental Impact Analysis Handbook, McGraw-Hil

Reference Books:

1. Petts, J., Handbook of Environmental Impact Assessment, Wiley / equivalent latest edition.
2. Marshall, R., and Baxter, A., EIA and Sustainable Development, relevant publisher.
3. Therivel, R., and Partidario, M. R., The Practice of Strategic Environmental Assessment, Earthscan.
4. Larry Canter and related advanced EIA texts for project appraisal and mitigation studies.

Web links and Video Lectures (e-Resources)

1. NPTEL/SWAYAM courses on Environmental Impact Assessment and Environmental Management
2. MoEFCC environmental clearance and EIA notification resources
3. Central Pollution Control Board guidelines and manuals
4. United Nations Environment Programme resources on EIA and sustainability
5. World Bank environmental and social framework 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	**TW-1: EIA Screening and Scoping Exercise** Students shall identify the likely environmental issues for a selected infrastructure project and prepare a screening/scoping note.	24
2	**TW-2: Baseline Data Compilation** Students shall collect and organize baseline environmental data for air, water, noise, land use, flora-fauna, and socio-economic conditions for a project area.	24
3	**TW-3: Impact Identification Matrix** Students shall prepare a checklist/matrix for impact identification of a road, building, metro, or water project.	24
4	**TW-4: EMP Preparation** Students shall develop a basic Environmental Management Plan with mitigation measures, monitoring indicators, and responsibilities.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**SL-1: EIA Case Study Review** Students shall study one approved or rejected EIA report of an infrastructure project and present key observations.	24
2	**SL-2: Public Hearing and Clearance Study** Students shall review the public consultation and environmental clearance procedure for a chosen infrastructure project.	24
3	**SL-3: GIS/Remote Sensing in EIA** Students shall explore how spatial tools support baseline mapping and impact analysis in EIA.	24
4	**SL-4: Sustainable Infrastructure Reflection** Students shall analyze how EIA supports sustainable, climate-resilient infrastructure planning.	24

Sample rubrics for TW activities:

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Understanding of concepts	Correctly explains EIA principles, tools, and procedures.	Identifies most concepts with minor gaps.	Basic understanding with partial explanation.	Incomplete or incorrect understanding.
Technical accuracy	Strong and correct application to the 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 inconsistent.	Poorly organized or incomplete.
Practical application	Strong linkage to infrastructure project practice.	Good linkage with limited depth.	Basic application only.	No meaningful practical linkage.

PUBLIC–PRIVATE PARTNERSHIPS FOR INFRASTRUCTURE			
Course Code	**1MCEM206G**	*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 concept, need, and evolution of PPPs in infrastructure development.*
2. *Apply project identification, structuring, procurement, and financial planning principles to PPP projects.*
3. *Analyse legal, contractual, risk allocation, and dispute management aspects of PPPs.*
4. *Evaluate PPP models, performance indicators, and public sector governance mechanisms.*
5. *Develop a basic PPP project framework including feasibility, risk matrix, and implementation strategy.*

Module-1

Fundamentals of PPPs:

Concept, definition, evolution, and rationale of Public–Private Partnerships; infrastructure sectors suitable for PPP; public sector and private sector roles; life cycle of PPP projects; overview of policy environment and institutional framework; advantages, limitations, and critical success factors; comparison with traditional public procurement.

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

Module-2

PPP Project Identification and Structuring:

Project screening and identification; demand assessment; project feasibility studies; value for money concept; financial viability; project preparation activities; structuring of PPP projects; key project documents; concession period; output specifications; service standards; performance monitoring framework. **Linked COs: CO2, CO5** **Number of Hours: 09**

Module-3

Procurement, Contracts, and Risk Allocation

PPP procurement process; bid documents; RFQ and RFP; competitive bidding; evaluation of proposals; concession agreements; contract administration; risk identification, risk allocation, and risk mitigation; force majeure; termination and compensation clauses; dispute resolution mechanisms.

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

Module-4

PPP Financing and Financial Analysis

Sources of project finance; equity, debt, and blended finance; bankability; financial modelling basics; project cash flow; tariff and revenue mechanisms; viability gap funding; government support mechanisms; lifecycle costing; affordability and fiscal implications; sensitivity analysis and financial risk assessment.

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

Module-5

Implementation, Monitoring, and Best Practices:

Implementation challenges in PPP projects; contract management and performance monitoring; key

performance indicators; stakeholder management; transparency and accountability; renegotiation and resolution of disputes; case studies of successful and failed PPPs in roads, water supply, urban transport, and social infrastructure; sustainability and innovation in PPP delivery.

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

Suggested Learning Resources:

Textbooks:

1. *Yescombe, E. R., Public–Private Partnerships: Principles of Policy and Finance, 2nd Edition, Butterworth-Heinemann.*
2. *Grimsey, D. and Lewis, M. K., Public Private Partnerships: The Worldwide Revolution in Infrastructure Provision and Project Finance, 1st Edition, Edward Elgar.*
3. *Hodge, G. A. and Greve, C., The Challenge of Public–Private Partnerships, 1st Edition, Edward Elgar.*
4. *Akintoye, A., Beck, M. and Hardcastle, C., Public–Private Partnerships: Managing Risks and Opportunities, 1st Edition, Wiley-Blackwell.*

Reference Books:

1. *Kerzner, H., Project Management: A Systems Approach to Planning, Scheduling, and Controlling, latest edition, Wiley.*
2. *Yescombe, E. R., Principles of Project Finance, latest edition, Academic Press.*
3. *World Bank, Public–Private Partnership Reference Guide, 3rd Edition, World Bank Group.*
4. *Asian Development Bank, Public–Private Partnership Operational Plan and Guidance Materials, latest edition, ADB.*

Web links and Video Lectures (e-Resources)

1. *NPTEL/SWAYAM courses on Environmental Impact Assessment and Environmental Management*
2. *MoEFCC environmental clearance and EIA notification resources*
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4. *United Nations Environment Programme resources on EIA and sustainability*
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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):

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- *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)

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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]

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Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	*TW-1: Prepare a PPP concept report for a selected infrastructure sector.*	*24*
2	*TW-2: Develop a project screening and feasibility checklist for a proposed PPP project.*	*24*
3	*TW-3: Prepare a risk allocation matrix for a PPP road or water supply project.*	*24*
4	*TW-4: Draft a basic concession framework including roles, obligations, and performance indicators.*	*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 presentation on a successful PPP infrastructure project.*	*24*
2	*SL-2: Seminar on financing models and viability gap funding in PPPs.*	*24*
3	*SL-3: Review of a failed PPP project and submission of a reflective report.*	*24*
4	*SL-4: Assignment on stakeholder management and dispute resolution in PPP contracts.*	*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 applied.*	*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*
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.*

INFRASCTUCTURE PROJECT MANAGEMENT LABORATORY			
Course Code	**1MCEML207**	*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 highway-project management software (MS Project/Primavera/GIS) and set project parameters for highway works.*
2. *CO2 — L4: Prepare and interpret WBS, activity lists, network diagrams and CPM/PERT schedules specific to highway projects.*
3. *CO3 — L4: Analyse resource requirements, leveling, and productivity for highway operations (earthworks, pavement, drainage, structures).*
4. *CO4 — L5: Design time–cost trade-offs, crashing and optimization strategies for highway construction.*
5. *CO5 — L6: Apply BIM/GIS/IoT outputs and dashboards for progress monitoring, safety zoning, quality checks and asset maintenance planning for highways*

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

Note: *The project context described in this laboratory is indicative only. The course coordinator may select any suitable infrastructure project, such as water supply systems, bridges, tunnels, solid waste management, sewage treatment plants, stormwater drainage systems, railways, airports, ports, canals, dams, or similar works, based on local relevance and laboratory resources.*

1. *Introduction to highway project in management software: create highway project, set working calendars, define phases (survey, earthworks, subgrade, pavement, drainage, structures), and enter baseline data. CO1*
2. *Prepare a highway Work Breakdown Structure (WBS), activity list, precedence relationships and draw the network diagram for a typical two-lane rural highway section. CO1, CO2*
3. *Project scheduling: generate bar charts, CPM schedule, identify critical path and milestones for earthwork and pavement works. CO2, CO3*
4. *Resource estimation and allocation: labour, plant (dozers, graders, compactors), and materials for earthwork and pavement; perform resource leveling and resource histograms. CO3, CO4*
5. *Cost estimation & cash-flow: prepare itemized activity-wise cost estimates (earthwork, subgrade*

preparation, base, surfacing) and prepare cash-flow (time-phased cost) for the project. CO2, CO3

6. *Productivity analysis: measure and analyse productivity for excavation/haulage, subgrade compaction, and bituminous surfacing using sample field data and compute rates, variances and impacts on schedule. CO2, CO4*
7. *Time–cost trade-off and crashing: perform crashing on selected highway activities (e.g., pavement surfacing) and present accelerated schedule vs additional cost and recommend optimal strategy. CO3, CO4*
8. *Site layout & safety zoning for highway construction: plan site facilities, traffic diversion, temporary works, and safety zones using GIS/BIM snippets or drawings. CO3, CO4*
9. *Progress monitoring & reporting: planned vs actual comparison, S-curve, earned value (EV) metrics, dashboard outputs and variance analysis for highway projects. 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 full smart highway construction management plan for a 5 km rural highway stretch including scope, WBS, schedule, resource plan, traffic management and digital tracking strategy. CO2, CO4, CO5*
3. *Develop a time–cost trade-off and resource-constrained optimization for a highway contract suffering weather delays and propose an execution-recovery plan. CO3, CO4, CO5*
4. *Prepare material procurement, storage and inventory control plan for aggregates, bitumen and binders including just-in-time delivery schedule using software tools. CO2, CO4, CO5*
5. *Analyse the effect of variability in earthwork productivity (due to soil type & moisture) on project duration and cost; propose mitigation and contingency allocation. CO3, CO4, CO5*
6. *GIS/BIM-based coordination for highway alignments: clash detection for utilities, drainage design coordination, and sequencing for construction traffic management. CO4, CO5*
7. *Prepare a comprehensive project execution report for a real or simulated highway project including schedule, budget, safety plan, quality plan and maintenance/asset management 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 Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	G	F	NI

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