VISVESVARAYA TECHNOLOGICAL UNIVERSITY

BELAGAVI

Scheme of Teaching and Examinations (2026)

M.Tech., in Civil Engineering

(Specialization in Construction Technology)

Choice-Based Credit System (CBCS) and Outcome-Based Education (OBE)

Specialization in Construction Technology

II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching S Learning Scheme					Examination				Credits
				CI		LI	TW S SL	Total Hours	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P							
1	PCC/ IPCC	1MCCT201	Advanced Construction Planning & Scheduling	42	0	28	50	120	03	50	50	100	4
2	PCC	1MCCT202	Modern Construction Equipment productivity & Automation	42	0	0	48	90	03	50	50	100	3
3	PCC	1MCCT203	Advanced BIM for Construction Management	42	0	0	48	90	03	50	50	100	3
4	PCC	1MCIM204/1MCEM204/1MCCT204	Advanced Construction Contract Administration, Claims and Procurement	42	0	0	48	90	03	50	50	100	3
5	PEC	1MCCT205X	Professional Elective – III	42	0	0	48	90	03	50	50	100	3
6	PEC	1MCCT206X	Professional Elective – IV	42	0	0	48	90	03	50	50	100	3
7	PCC L	1MCCTL207	Construction Management Lab	0	0	28	02	30	03	50	50	100	1
8	PCC	1MCCTS208	Minor Project / Skill Development Project	0	0	0	60	60	03	50	50	100	2
									Total	**400**	**400**	**800**	**22**

Professional Elective Courses (PECs)			
PEC-III		**PEC-IV**	
Code	**Title of the Course**	**Code**	**Title of the Course**
1MCCT205A	Lean Construction & Productivity Engineering	1MCCT206A	Digital Twin for Construction Projects
1MCCT205B	Construction Economics & Financial Management	1MCCT206B	AI, ML & Data-Driven Construction Management
1MCCT205C	Urban infrastructure Planning and Construction	1MCIM206C/1MCEM206C/1MCCT206C	Infrastructure Asset Management
1MCCT205D	Cyber Security and Urban infrastructure Management	1MCCT206D	Legal and Contractual Risk Management
1MCCT205E	Digital and Robotic Construction Equipment Systems	1MCCT206E	ESG & Sustainability Reporting for Infrastructure
1MCIM205F/1MCEM205F/1MCCT205F	Quality & Safety Management	1MCIM206G/1MCCT206F	Smart Construction Materials & Nanotechnology

ADVANCED CONSTRUCTION PLANNING & SCHEDULING			
Course Code	**1MCCT201**	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):TWSSL	120 (42:0:28:50)	SEE Marks	50
Credits	4	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Understand the principles, terminology, and workflow of construction planning, scheduling, and project control.
2. CO2: Develop and analyse project schedules using network methods, duration estimation, and schedule logic.
3. CO3: Apply resource management, optimization, and time-cost trade-off techniques for construction projects.
4. CO4: Use project management software to prepare, update, and monitor construction schedules and progress reports.
5. CO5: Evaluate project control systems, delay analysis, risk management, and earned value-based tracking.
6. CO6: Integrate BIM, lean construction, safety, and sustainability considerations into advanced scheduling workflows.

Module-1

Foundations of Construction Planning and Scheduling

- Project life cycle, objectives of planning, levels of planning, and role of the scheduler in construction projects.
- Work Breakdown Structure (WBS), activity definition, precedence relationships, coding systems, and planning deliverables.
- Duration estimation methods: expert judgment, productivity-based estimation, analogous and parametric approaches.
- Planning documents: milestone charts, bar charts, network plans, and baseline schedules**.**

Linked COs: CO1, CO2 **Number of Hours: 8**

Module-2

Network Scheduling and Critical Path Methods

- Activity-on-node and activity-on-arrow representations, network logic, and sequencing rules.
- CPM calculations: forward pass, backward pass, total float, free float, independent float, and critical path identification.
- PERT concepts: three-time estimates, expected duration, variance, and probability of completion.
- Schedule compression, lag/lead relations, and schedule recalculation under changes and constraints.

Linked COs: CO2, CO3 **Number of Hours: 10**

Module-3

Resource Management and Optimization:

- Resource planning for labour, equipment, materials, and money; resource histograms and demand profiles.
- Resource levelling and resource smoothing methods; practical constraints and project prioritization.
- Time-cost trade-off analysis, crashing techniques, and optimum project duration selection.

- Introduction to linear programming and heuristic methods for construction resource optimization.

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

Module-4

Project Monitoring, Control and Software Tools:

- Baseline schedule preparation, progress measurement, and schedule updating procedures.
- Earned Value Management (EVM): PV, EV, AC, CV, SV, CPI, SPI, EAC, ETC, and forecast interpretation.
- Use of scheduling software such as MS Project / Primavera P6 for planning, updating, tracking, and reporting.
- Dashboard reporting, S-curves, milestone monitoring, and stakeholder communication in construction control.

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

Module-5

Advanced Control, Delay Analysis, BIM and Lean Integration

- Risk-based scheduling, uncertainty in durations, contingency planning, and schedule risk awareness.
- Delay analysis methods: as-planned vs as-built, impacted as-planned, time impact analysis, and concurrent delay basics.
- BIM-enabled 4D scheduling, logistics planning, clash awareness, and sequencing in complex projects.
- Lean construction principles, Last Planner System, safety planning, and sustainability-driven schedule optimization.

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

PRACTICAL COMPONENTS OF IPCC

LIST OF EXPERIMENTS (LI=28 Hrs)

1. Prepare a WBS and activity list for a building or infrastructure project.
2. Develop a bar chart and milestone chart for the given project.
3. Construct a CPM network and identify the critical path.
4. Compute floats and project duration using network analysis.
5. Prepare a resource histogram for labour and equipment.
6. Carry out resource levelling for a constrained schedule.
7. Perform time-cost trade-off analysis for selected activities.
8. Create a baseline schedule in MS Project / Primavera P6.
9. Update progress and compare planned versus actual status.
10. Generate a progress report with S-curve and milestone summary.

Suggested Learning Resources:

Text Books:

1. B. S. Patil, Construction Planning and Management, 3rd Edition, Khanna Publishers, New Delhi.
2. R. L. Peurifoy, Construction Planning, Equipment and Methods, 6th Edition, McGraw Hill Education, New Delhi.
3. Chitkara, Construction Project Management: Planning, Scheduling and Control, 3rd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi.
4. Halpin and Woodhead, Construction Management, 2nd Edition, John Wiley S Sons, New Delhi. Halpin and Woodhead, Construction Management.
5. Mubarak, S. (2019). Construction Project Scheduling and Control, Wiley.
6. Hinze, J. W. (2011). Construction Planning and Management, Pearson.
7. Hardin, B., S McCool, D. (2015). BIM and Construction Management: Proven Tools, Methods, and Workflows, Sybex.

Reference Books / Manuals

1. PMI, A Guide to the Project Management Body of Knowledge (PMBOK Guide), 7th Edition, Project Management Institute, Pennsylvania.
2. James O'Brien, Construction Scheduling, 2nd Edition, McGraw Hill Education, New York.
3. Chris Hendrickson and Tung Au, Project Management for Construction, Prentice Hall, New Jersey.
4. Relevant BIS / IRC / CPWD manuals on project execution and control

Web links and Video Lectures (e-Resources) S 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 S Scheduling: Oracle Primavera P6 Professional, Microsoft Project (MSP).
- BIM, 4D/5D Simulation, S 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% 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:

(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 / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
Subtotal		10
Total		25

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 – Project Scheduling Case Study:** Prepare a complete schedule for a real or simulated project, including WBS, CPM network, floats, and resource profile. **Linked COs:** CO1, CO2, CO3	25
2	**TW2 – Software-Based Schedule Development:** Create and update a schedule in MS Project / Primavera P6 with progress tracking and reporting. **Linked COs:** CO4, CO5	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**SL1 – Delay Analysis Review:** Study one delay analysis method and prepare a note with an example. **Linked COs:** CO	25
2	**SL2 – BIM / 4D Planning Review:** Review a case on BIM-enabled construction sequencing and logistics planning. **Linked COs:** CO6	25
3	**SL3 – Lean Construction Review:** Prepare a short report on Last Planner System and its role in construction scheduling. **Linked COs:** CO6, CO3.	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.
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 S 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 S 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 SAnalysis (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)

MODERN CONSTRUCTION EQUIPMENT PRODUCTIVITY & AUTOMATION			
Course Code	**1MCCT202**	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):TWSSL	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, classification, operating features, and applications of modern construction equipment used in earthwork, concreting, lifting, and finishing operations.
2. CO2: Evaluate equipment productivity using standard output relationships, cycle time analysis, utilization factors, and site conditions.
3. CO3: Select suitable equipment combinations for construction activities based on project requirements, cost, safety, and productivity.
4. CO4: Apply automation, sensor-based monitoring, telematics, and digital control concepts to modern construction equipment and site operations.
5. CO5: Analyze equipment-related decision making in terms of lifecycle cost, environmental impact, sustainability, and site logistics.
6. CO6: Demonstrate familiarity with BIM-linked planning, Industry 4.0 concepts, data-driven equipment management, and smart construction practices.

Module-1

Construction Equipment Fundamentals and Classification:

- Introduction to construction equipment and mechanization in civil engineering projects.
- Classification of equipment based on function, mobility, power source, and operation: earthmoving, hoisting, hauling, concreting, compaction, pavement, tunneling, demolition, and finishing equipment.
- Equipment selection criteria: project size, site conditions, soil type, material characteristics, accessibility, productivity, safety, and economics.
- Power transmission systems, prime movers, diesel engines, hydraulic and pneumatic systems, electric drives, and hybrid systems.
- Safety aspects, operator skill, maintenance needs, and statutory considerations.
- Introduction to construction automation and smart equipment trends.

Linked COs: CO1, CO3, CO6. **Number of Hours: 08**

Module-2

Earthmoving, Hauling and Material Handling Equipment:

- Excavators, backhoe loaders, draglines, clamshells, bulldozers, scrapers, graders, trenchers, loaders, dumpers, trucks, and conveyors.
- Working principles, attachments, operational cycles, and typical applications.
- Productivity analysis of earthmoving equipment: bucket capacity, fill factor, swell factor, cycle time, haul distance, grade resistance, rolling resistance, and site efficiency.
- Matching of equipment sets for balanced production.
- Soil-condition effects on productivity and fuel consumption.
- Introduction to GPS-enabled grading, machine guidance, and autonomous haulage concepts.

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

Module-3

Lifting, Concreting and Finishing Equipment:

- Cranes: tower cranes, mobile cranes, crawler cranes, gantry cranes, and hoists; selection, erection, load charts, and safety considerations.
- Equipment for concreting: batching plants, concrete mixers, transit mixers, concrete pumps, placing booms, vibrators, screeds, slip-form pavers, and finishing machines.
- Productivity of concreting equipment: output rate, pumping distance, pour rate, placement sequencing, and downtime.
- Compaction equipment: rollers, plate compactors, rammers, vibratory compactors, and their suitability for different materials.
- Pavement and finishing equipment for roads, floors, and industrial works.
- Quality control issues in mechanized concreting and compaction.

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

Module-4

Automation, Digital Monitoring and Smart Site Systems:

- Introduction to automation in construction equipment and site operations.
- Sensors, actuators, controllers, PLCs, telematics, onboard diagnostics, and remote monitoring.
- Machine control systems: 2D and 3D grade control, laser guidance, GNSS/GPS-based machine guidance, and automated paving.
- Data acquisition from equipment: fuel use, idle time, utilization rate, maintenance alerts, and productivity dashboards.
- Equipment planning using BIM, 4D simulation, digital twins, and construction sequencing tools.
- Safety automation: proximity sensors, anti-collision systems, operator assistance systems, and site monitoring.
- Industry 4.0 applications in construction equipment management.

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

Module-5

Equipment Economics, Sustainability and Site Management:

- Equipment ownership and operating cost, depreciation, interest, insurance, repairs, fuel, lubricants, and labor cost.
- Life-cycle cost analysis and economic comparison of owned, rented, and leased equipment.
- Equipment replacement policy, downtime analysis, preventive maintenance, and reliability concepts.
- Environmental aspects: emissions, noise, vibration, energy efficiency, low-carbon equipment, electric and hybrid construction machinery.
- Equipment planning for sustainable construction, resource optimization, and reduction of idle time.
- Logistics, equipment scheduling, and integration with project planning tools.
- Case studies on productivity improvement through mechanization and automation in civil projects.

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

Suggested Learning Resources:

Textbooks:

1. Peurifoy, R. L., *Construction Planning, Equipment and Methods*, McGraw Hill.
2. Sharma, S. C. and Sharma, R., *Construction Equipment and Management*, Khanna Publishers.

3. Mahesh Varma, *Construction Equipment and Methods*, Standard Publishers.
4. Choudhury, A. K., *Construction Equipment and Techniques*, Oxford University Press.

Reference Books

1. Sharma, S. C., Construction Equipment and Management, Khanna Publishers.
2. Deodhar, S. V., Construction Equipment and Job Planning, Khanna Publishers.
3. Harris, F. and McCaffer, R., Modern Construction Management, Wiley-Blackwell.
4. Relevant IS codes, IRC specifications, IRC manuals, and manufacturer technical catalogues.
5. Guidance documents on construction automation, telematics, and machine control from industry sources.

Web links and Video Lectures (e-Resources)

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

Teaching-Learning Process (Innovative Delivery Methods):

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

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

Suggested strategies:

- Problem-based learning on equipment selection, productivity loss, balancing of fleets, and cost escalation.
- Case-based teaching using real project examples involving earthwork, lifting, paving, and mechanized concreting.
- Simulation using equipment cycle-time calculations, fleet balancing, and digital planning tools.
- Industry expert sessions from equipment manufacturers, RMC plants, road contractors, and project management firms.
- Industrial visits to construction sites, batching plants, equipment yards, and smart infrastructure projects.

Assessment Structure (both CIE and SEE)

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

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

Continuous Internal Evaluation:

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

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

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

must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	**TW1 – Equipment Identification and Selection Exercise:** Identify major construction equipment used in an assigned project scenario and justify the selection based on site conditions, output, and safety. Linked COs: CO1, CO3..	24
2	**TW2 – Productivity Analysis of Equipment Fleet:** Calculate productivity of earthmoving, hauling, lifting, or concreting equipment for a given site and recommend balancing measures. Linked COs: CO2, CO3.	24
3	**TW3 – Automation and Smart Site Case Study: Study a smart construction site or equipment with telematics, machine guidance, or digital monitoring and present findings with diagrams and observations. Linked COs: CO4, CO6**	
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**SL1 – Equipment Economics Review:** Compare ownership, rental, and leasing options for a specific construction equipment set and submit lifecycle cost observations. Linked COs: CO3, CO5.	24
2	**SL2 – Digital Construction Review:** Prepare a review on BIM-linked equipment planning, GPS-guided machinery, telematics, or automation in construction. Linked COs: CO4, CO6.	24

Sample rubrics for TW activities:

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs Improvement
Problem understanding	Problem is clearly defined with strong justification and clear objectives.	Problem is mostly clear with minor gaps in framing or justification.	Problem is stated but lacks clarity or detailed justification.	Problem is poorly defined or unclear.
Data and method	Data collected/used is appropriate and sufficient; methods/tools are well chosen 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 argued and results	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.

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs Improvement
	are valid.			
Recommendations	Recommendations are feasible, context-specific, and clearly derived from analysis.	Recommendations are relevant but may have minor limitations or lack detail.	Recommendations are generic or only loosely connected to analysis.	Recommendations are incomplete, unrealistic, or absent.
Presentation	Work is very well organized, neat, and professionally presented.	Work is well organized with minor issues in formatting or clarity.	Presentation is acceptable but uneven.	Work is poorly organized, difficult to follow, or untidy.

ADVANCED BIM FOR CONSTRUCTION MANAGEMENT			
Course Code	**1MCCT203**	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):TWSSL	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 BIM concepts, standards, model development levels, and collaborative workflows.
2. Apply BIM tools for coordination, clash detection, and information management across project disciplines.
3. Use BIM for 4D scheduling, 5D quantity/cost integration, and construction sequencing.
4. Analyze BIM applications in quality control, safety planning, sustainability, and risk management.
5. Develop BIM execution plans, workflows, and data-sharing protocols for construction projects.
6. Evaluate advanced BIM applications in digital twins, facility management, and smart construction management.

Module-1

Fundamentals of BIM and Information Management:

- Introduction to BIM, evolution from CAD to object-based modelling, BIM as a process and methodology, levels of development, information requirements, common data environment, interoperability, and BIM standards. BIM roles, responsibilities, and collaboration workflows in construction **projects.**

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

Module-2

BIM Authoring, Coordination and Clash Detection:

- BIM authoring tools, coordination platforms, model federation, discipline-wise model integration, hard clashes, soft clashes, workflow clashes, issue management, model review, and coordination cycles. Introduction to IFC and data exchange in multi-disciplinary projects.

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

Module-3

4D Planning and 5D Cost Integration:

- Linking BIM with project scheduling, work breakdown structure, sequencing, construction simulation, 4D visualization, quantity take-off from model, 5D cost planning, cash flow support, and productivity-oriented planning. Application of BIM in resource planning, procurement, and progress monitoring.

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

Module-4

BIM for Quality, Safety and Sustainability:

- Use of BIM for quality planning, inspection coordination, safety planning, hazard visualization, temporary works planning, and risk communication. Sustainable construction through BIM, embodied carbon awareness, material optimization, waste reduction, and lifecycle perspectives.

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

Module-5

Advanced BIM Applications and Digital Delivery:

- Digital twins, facility management integration, asset information models, GIS-BIM integration, cloud collaboration, mobile field BIM, IoT-enabled monitoring, BIM execution plan preparation, and case studies on BIM-enabled project delivery. Industry 4.0 and smart construction practices using BIM-linked data environments.

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

Suggested Learning Resources

Textbooks:

1. Eastman, C., Teicholz, P., Sacks, R., S Liston, K. BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers, Wiley.
2. Kensek, K. M. Building Information Modeling (Routledge Pocket Architecture Guides), Routledge.
3. Kymmell, W., Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations, 1st Edition, McGraw-Hill, New York.
4. Hardin, B. and McCool, D., BIM and Construction Management: Proven Tools, Methods, and Workflows, 2nd Edition, Wiley.

Reference Books:

1. Hardin, B., and McCool, D. — BIM and Construction Management: Proven Tools, Methods, and Workflows. John Wiley S Sons; 2015.
2. Turkan, Y. — BIM and Digital Construction Workflows. (If you need a specific book/edited volume citation, please confirm which Turkan publication you mean — Turkan has papers and invited lectures on digital workflows; see her profile.)
3. Sacks, R., and Eastman, C.M. — (Representative major works) BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers. John Wiley S Sons; 2018. (Also see numerous Sacks research reports and journal papers on BIM coordination and model-based management.)

Standards and normative guidance

4. ISO — Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — ISO 19650 series (e.g., ISO 19650-1:2018). International Organization for Standardization; 2018.

Government and industry guidance (select examples)

5. buildingSMART and National BIM guides — Guidance and technical reports for national BIM exchange specifications and development of BIM standards (example: "A Guide for Development and Preparation of a National BIM Exchange Standard", buildingSMART / technical reports). (See Sacks / Eastman involvement in national-standard technical reports.).

Web links and Video Lectures (e-Resources)

1. NPTEL and SWAYAM courses on BIM, construction planning, and digital construction.
2. Official BIM standards and ISO 19650 guidance documents.
3. Manufacturer and software vendor technical resources on BIM coordination and 4D/5D workflows.
4. Industry white papers on digital twins, smart construction, and integrated project delivery.

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
- Industrial visits to BIM-enabled project sites.

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:** BIM-based coordination exercise for a small project model. Linked COs: CO1, CO2.	24
2	**TW2:** 4D simulation and construction sequencing activity. Linked COs: CO3, CO5.	24
3	**TW3: BIM execution plan preparation for a sample project. Linked COs: CO5, CO6.**	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**SL1:** Literature review on digital twins, BIM-GIS integration, or 5D cost management. Linked COs: CO4, CO6.	**24**
2	**SL2:** Case study on BIM-enabled project delivery in an infrastructure or building project. Linked COs: CO3, CO6.	**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	Mostly appropriate	Limited data or partial method.	Inadequate or incorrect method.

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
	methodology.	with minor issues.		
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.

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):TWSSL	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: 08**

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: 08**

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 S 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	24

	recommend a procurement route.	
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 documents.	24
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.

LEAN CONSTRUCTION & PRODUCTIVITY ENGINEERING			
Course Code	**1MCCT205A**	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):TWSSL	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 Lean Construction and Productivity Engineering:

Concept of lean thinking, origin and evolution of lean construction, differences between conventional and lean approaches, principles of value, waste, flow, pull, and continuous improvement. Productivity engineering in construction, importance of productivity improvement, sources of productivity loss, and overview of lean culture in project delivery.

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

Module-2

Waste Elimination and Lean Tools:

Identification of waste in construction processes, types of waste, root cause analysis, value stream mapping, 5S, visual management, standard work, Kaizen, poka-yoke, and just-in-time concepts. Application of lean tools for material handling, labor deployment, and site logistics.

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

Module-3

Productivity Measurement and Analysis:

- Productivity concepts, labor productivity, equipment productivity, and material productivity. Methods of productivity measurement, work sampling, time study, method study, crew balance, performance indices, benchmarking, and statistical analysis of productivity trends. Identification of productivity losses due to design, planning, labor, equipment, and site conditions.

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

Module-4

Lean Planning and Site Execution:

Lean planning concepts, Last Planner System, look-ahead planning, constraint removal, reliable promising, takt planning, line of balance, and workflow stabilization. Resource planning, daily huddles, production control, coordination among trades, and lean implementation in construction site operations.

Linked COs: CO2, CO4, CO5. **Number of Hours: 08**

Module-5

Continuous Improvement and Lean Implementation:

Lean implementation roadmap, performance monitoring, visual dashboards, root cause correction, improvement cycles, standardization, and change management. Case studies on lean construction applications in buildings and infrastructure projects, integration of digital tools for productivity monitoring, and strategies for sustaining lean practices in organizations.

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

Suggested Learning Resources

Textbooks

1. Howell, G. A., **Lean Construction: Principles and Practice**, 1st edition, Routledge.
2. Koskela, L., **Application of the New Production Philosophy to Construction**, technical report, Stanford University.
3. Ballard, G., **The Last Planner System of Production Control**, 1st edition, Lean Construction Institute.
4. González, V. A., Hamzeh, F., and Alarcón, L. F. (Eds.), **Lean Construction 4.0: Driving a Digital Revolution of Production Management in the AEC Industry**, 1st edition, Routledge.

Reference Books

1. Howell, G. A., Lean Construction: Principles and Practice, 1st edition, Routledge.
2. Koskela, L., Application of the New Production Philosophy to Construction, technical report, Stanford University.
3. Ballard, G., The Last Planner System of Production Control, 1st edition, Lean Construction Institute.
4. González, V. A., Hamzeh, F., and Alarcón, L. F. (Eds.), Lean Construction 4.0: Driving a Digital Revolution of Production Management in the AEC Industry, 1st edition, Routledge. Taylor Francis

Web links and Video Lectures (e-Resources) :

1. Lean Construction Institute – Tools S Resources. A curated collection of videos, guides, assessments, articles, research, and lean books for design and construction education.
2. Lean Construction Institute – Learning. A structured learning pathway for beginners and advanced learners, with role-based resources.
3. Lean Construction Institute – eLearning. On-demand online learning modules covering core lean concepts; available free to members and individually purchasable for others.
4. Institute for Lean Construction Excellence (ILCE), India – Resources. Includes lean implementation cases, SOPs, MOOCs, research articles, and event materials.
5. Lean Construction Ireland – Resources. Offers books, webinars, podcasts, blogs, a MOOC, and knowledge-development resources.
6. ATU / Lean Construction Ireland MOOC. A free online introduction to lean construction with modules on value stream mapping, waste, lean tools, and visual management.
7. NPTEL Civil Engineering archive. Useful for online learning support and lecture resources related to productivity and construction management topics

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
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- 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: Value Stream Mapping of a Construction Process.** Students identify a construction workflow, map value-added and non-value-added steps, and propose waste elimination measures. This supports lean thinking, process analysis, and workflow improvement.	24
2	**TW2: 5S and Visual Management Audit of a Site or Workshop.** Students conduct a 5S audit, prepare an improvement checklist, and recommend visual controls for materials, tools, and safety. This supports site organization and lean workplace discipline.	24
3	**TW3: Productivity Study of a Construction Activity.** Students measure labor, equipment, or material productivity for one activity, analyze bottlenecks, and suggest corrective actions. This supports productivity measurement and performance analysis.	24
4	**TW4: Last Planner System or Look-Ahead Plan Preparation.** Students prepare a weekly plan, identify constraints, and propose reliable task sequencing. This supports lean planning and production control.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**SL1: Literature review on lean construction tools.** Topics may include 5S, Kaizen, Last Planner System, takt planning, or value stream mapping.	24
2	**SL2: Case study on lean implementation in a building or infrastructure project.** Students analyze the lean practices adopted, challenges faced, and measurable benefits.	24
3	**SL3: Review of digital tools supporting lean construction.** Topics may include dashboards, mobile site reporting, BIM-enabled planning, and production tracking.	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.
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.

CONSTRUCTION ECONOMICS & FINANCIAL MANAGEMENT			
Course Code	**1MCCT205B**	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):TWSSL	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: Apply time value of money formulations to evaluate capital engineering investment options over project lifecycles.
2. CO2: Perform comprehensive cost-benefit analysis, break-even assessments, and sensitivity analyses for construction infrastructure.
3. CO3: Analyze corporate construction financial statements, balance sheets, and profit-and-loss balances using accounting ratio analytics.
4. CO4: Design operational working capital cycles, cash flow projections, and budgetary control systems for construction projects.
5. CO5: Evaluate capital budgeting strategies, infrastructure project financing methods, and risk-adjusted economic options.

Module-1

Engineering Economics S Time Value of Money

- Foundations of engineering economics: Role of economic analysis in construction management engineering.
- Time Value of Money: Simple and compound interest, nominal and effective interest rates.
- Discrete compounding formulas: Present worth (P), Future worth (F), Uniform series (A), and Gradient series (G) factors.
- Applications of equivalence: Evaluating uniform, deferred, and perpetual cash flow sequences.
- Impact of inflation and economic depreciation on the purchasing power of capital investments.

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

Module-2

Capital Investment Evaluation S Comparison Methods

- Criteria for evaluating investment alternatives: Net Present Value (NPV), Future Worth (FW), Annual Equivalent (AE), and Internal Rate of Return (IRR) methods.
- Benefit-Cost (B/C) ratio analysis for public sector infrastructure projects.
- Payback period calculation (simple and discounted payback frameworks).
- Break-even analysis: Linear and non-linear cost-volume-profit modeling for construction equipment and plants.
- Sensitivity analysis and probabilistic decision-tree modeling for fluctuating market variables.

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

Module-3

Construction Accounting S Financial Statement Analysis

- Principles of accounting: Double-entry bookkeeping system, journal entries, ledger accounts, and trial balance preparation.
- Construction accounting specialties: Percentage-of-completion vs. completed-contract methods of revenue recognition.
- Financial Statements: Structure and preparation of the Balance Sheet, Profit and Loss (PSL) Statement, and Cash Flow Statement.
- Financial Ratio Analysis: Liquidity ratios, leverage (debt) ratios, activity (turnover) ratios, and profitability metrics.

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

Module-4

Working Capital Management S Project Cash Flows

- Concept of working capital: Gross vs. Net working capital, and the operating liquidity cycle in construction operations.
- Managing project cash flows: Preparing project-level cash inflow and outflow forecasts (S-Curve cash flow integration).
- Elements of cost budgeting: Direct costs, indirect costs, overhead margins, and contingency allocation methods.
- Budgetary control systems: Variance analysis, variance monitoring, and financial corrective frameworks.

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

Module-5

Corporate Financing, Risk, S Infrastructure Capital Budgeting

- Capital budgeting strategies: Cost of capital components (equity, debt, and Weighted Average Cost of Capital - WACC).
- Sources of construction funding: Short-term vs. long-term instruments, corporate bonds, and venture banking.
- Infrastructure project financing: Project Finance structures, Special Purpose Vehicles (SPV), and Public-Private Partnership (PPP) concessions.
- Risk analysis in capital budgeting: Certainty-equivalent approaches and risk-adjusted discount rates (RADR).

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

Suggested Learning Resources

Textbooks

1. Blank, L., S Tarquin, A. Engineering Economy, McGraw-Hill Education.
2. Prasanna Chandra. Financial Management: Theory and Practice, McGraw-Hill.
3. Halpin, D. W., Senior, B. A., S Constantinescu, G. Financial and Cost Concepts for Construction Management, John Wiley S Sons.

Reference Books

1. Peterson, S. J. Construction Accounting and Financial Management, Pearson.
2. Khan, M. Y., S Jain, P. K. Financial Management, Tata McGraw-Hill.
3. Collier, C. A., S Ledbetter, W. B. Engineering Cost Analysis, Harper S Row.

Web links and Video Lectures (e-Resources)

1. Online Resources: NPTEL Course on "Engineering Economic Analysis", Harvard Business Review financial analytical briefs.
2. Software Tools: Microsoft Excel (Financial Solver Toolsets S Internal Data Analysis packages), commercial financial forecasting models.

Teaching-Learning Process (Innovative Delivery Methods):

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- Role Play

Assessment Structure (both CIE and SEE)

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

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Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Infrastructure Feasibility S NPV Study:** Develop an economic evaluation profile for a proposed infrastructure asset (e.g., toll highway, bridge, or mass transit line). Construct a 20-year cash flow forecast worksheet, compute NPV/IRR values across variable discount rates, and execute a multi-variable sensitivity analysis.	24
2	**Corporate Financial Health Audit:** Extract the annual audited balance sheet and income statement of a publicly listed major construction company. Execute a detailed financial ratio critique, analyze revenue recognition anomalies, and present structural recommendations on liquidity and debt leverages.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**Project S-Curve Cash Flow Simulation:** Construct a dynamic, automated Microsoft Excel workbook to model cash requirements for a 12-month commercial building schedule. Simulate billing cycles, retainage withholdings, and overdraft requirements against unexpected milestone adjustments.	24
2	**PPP Financing and SPV Structure Review:** Perform independent research analyzing the funding mechanism and structural SPV configuration of a landmark Public-Private Partnership (PPP) infrastructure project, outlining risk-sharing mechanics.	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 INFRASTRUCTURE PLANNING AND CONSTRUCTION			
Course Code	**1MCCT205C**	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):TWSSL	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: Analyze urban growth dynamics, master plans, and spatial planning frameworks for infrastructure development.
2. CO2: Evaluate engineering components, planning criteria, and modern technologies for urban water and wastewater systems.
3. CO3: Formulate sustainable municipal solid waste management systems and integrated urban drainage networks.
4. CO4: Appraise urban transit systems, multimodal corridors, and advanced pavement construction techniques.
5. CO5: Synthesize smart city technologies, utility corridor designs, and project financing mechanisms for urban assets.

Module-1

Urbanization Frameworks S Spatial Planning

- Dynamics of urbanization: Population projections, demographic shifts, and infrastructure demand modeling.
- Structure of urban master plans, zonal plans, and statutory development regulations (building bye-laws).
- Land use zoning techniques and Transit-Oriented Development (TOD) principles.
- Environmental impact considerations in macro-level urban infrastructure planning.
- Application of GIS and Remote Sensing in urban spatial mapping and asset management.

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

Module-2

Urban Water Supply S Wastewater Systems

- Demand assessment: Per capita water consumption patterns, peak factors, and industrial allowances.
- Layout design of water distribution networks; mitigating Non-Revenue Water (NRW) through smart metering.
- Wastewater generation, sewer network hydraulic design, and localized vs. centralized treatment philosophies.
- Modern construction methods for deep underground utility pipelines: Trenchless technology, micro-tunneling, and Horizontal Directional Drilling (HDD).

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

Module-3

Urban Drainage S Solid Waste Infrastructure

- Urban hydrology: Rational method for stormwater runoff estimation, rainfall intensity-duration-frequency (IDF) curves.
- Sustainable Urban Drainage Systems (SuDS), rain-gardens, permeable pavements, and flood mitigation barriers.
- Municipal Solid Waste Management (MSWM) cycle: Integrated collection routes, transfer stations, material recovery facilities (MRF).
- Construction and environmental lining systems for engineered sanitary landfills and waste-to-energy conversion plants.

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

Module-4

Urban Transportation S Transit Corridors:

- Urban travel demand modeling (Four-Step traffic forecasting sequence).
- Hierarchy of urban roads, multi-modal transport corridors, and pedestrian infrastructure design.
- Mass transit configurations: Bus Rapid Transit (BRTS), Mass Rapid Transit (MRTS/Metro Rail), and Light Rail Transit (LRT).
- Construction mechanics for urban expressways: White-topping of pavements, precast segment erection for elevated metro viaducts, and underground tunnel boring machines (TBM).

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

Module-5

Smart Cities, Utility Networks S Project Financing:

- Smart Cities and AMRUT missions, and National/State policies affecting infrastructure planning. Concepts of integrated urban infrastructure planning, city master plans, and infrastructure service levels.
- Smart City architecture: IoT sensor arrays, centralized command and control centers, and smart street lighting.
- Integrated utility corridors (utilidors): Design, safety protocols, and co-location of electrical, telecom, gas, and water lines.
- Funding mechanisms for urban assets: Municipal bonds, Land Pooling policies, Value Capture Financing (VCF).
- Public-Private Partnerships (PPP) models in civic urban infrastructure delivery.

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

Suggested Learning Resources

Textbooks

1. Goodman, A. S., S Hastak, M. Infrastructure Planning Handbook: Planning, Engineering, and Economics, McGraw-Hill Education.
2. Jentsch, R. Urban Infrastructure: Planning and Management, Wiley.
3. Mays, L. W. Urban Water Supply Handbook, McGraw-Hill.

Reference Books

1. Ministry of Housing and Urban Affairs (MoHUA), Govt. of India. URDPFI Guidelines (Urban and Regional Development Plans Formulation and Implementation).
2. CPHEEO Manuals: Manual on Water Supply and Treatment S Manual on Sewerage and Sewage Treatment Systems, Government of India.
3. K. C. Mehta S A. Sharma (Editors), *Urban Infrastructure Planning & Management*,
4. Papacostas, C. S., S Prevedouros, P. D. Transportation Engineering and Planning, Pearson.

Web links and Video Lectures (e-Resources)

1. NITTT/NPTEL courses on Urban Infrastructure, Urban Transport and Water Supply.
2. Government portals for Smart Cities Mission and AMRUT for project reports and data.

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	**Urban Sector Infrastructure Master Plan Audit:** Select an active municipal corporation ward or zone. Map out the existing utility distribution bottlenecks (water shortages, flooding nodes, or traffic gridlocks). Develop a structured infrastructure improvement proposal complete with GIS mapping overlays and capacity sizing metrics.	24
2	**Trenchless Pipeline Retrofit Engineering Design:** Simulate a design project to install a major trunk sewer line under a dense, active urban corridor. Compare the structural, cost, and community disruption implications of traditional cut-and-cover excavation against micro-tunneling options.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**Stormwater Runoff S SuDS Simulation:** Utilize open-source software (such as EPA-SWMM) to model a localized urban watershed during high-intensity rainfall events. Evaluate the quantitative impact of adding permeable pavements and retention basins on peak discharge rates.	24
2	**Financing Review of Landmark Transport PPPs:** Perform independent academic research reviewing the fiscal structuring of a prominent metro rail project or urban tollway. Map out the revenue risk-sharing arrangements between private concessions and governmental agencies.	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.

CYBER SECURITY AND URBAN INFRASTRUCTURE MANAGEMENT			
Course Code	**1MCCT205D**	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):TWSSL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (PCC):	Theory- CIE +SEE	Exam Hours	03

Course outcome (Course Skill Set):

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

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

Module-1

Cyber Security Foundations:

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

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

Module-2

Urban Infrastructure Digital Systems:

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

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

Module-3

Threats and Risk Assessment:

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

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

Module-4

Security Design and Resilience:

- Security-by-design principles for urban infrastructure projects. Network segmentation, secure configuration, backup strategies, redundancy, disaster recovery, business continuity, and fail-safe design. Protection of IoT devices, sensors, controllers, and communication systems. Incident detection, monitoring, logging, alerting, and response coordination. Resilience planning for essential public services and critical infrastructure continuity.

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

Module-5

Governance, Policy, and Management:

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

Linked COs: CO5, CO6 **Number of Hours: 10**

Suggested Learning Resources:

Textbooks:

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

Reference Books:

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

Web links and Video Lectures (e-Resources) :

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

Teaching-Learning Process (Innovative Delivery Methods):

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

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

Assessment Structure (both CIE and SEE)

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

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

Continuous Internal Evaluation:

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

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

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

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

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

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

Sample rubrics for TW activities:

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

DIGITAL AND ROBOTIC CONSTRUCTION EQUIPMENT SYSTEMS			
Course Code	**1MCCT205E**	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):TWSSL	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, architecture, and evolution of digital and robotic construction equipment systems.
2. Identify sensors, control systems, navigation methods, and digital workflows used in automated construction equipment.
3. Analyze applications of autonomous and semi-autonomous equipment in earthmoving, demolition, material handling, and inspection.
4. Apply digital planning, machine data, and site analytics for productivity, safety, and quality improvement.
5. Evaluate industry case studies and propose integration strategies for robotic equipment in construction projects.

Module-1

Introduction to Digital and Robotic Construction Equipment:

Concept of construction automation, digital construction equipment, and robotic systems. Evolution from mechanized to autonomous equipment, Industry 4.0 in construction, and overview of machine connectivity, remote operation, telematics, and digital jobsite integration. Classification of robotic construction systems, advantages, limitations, and implementation challenges in project environments.

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

Module-2

Sensing, Control, and Navigation Systems:

Sensors and perception systems used in construction equipment: GPS, GNSS, LiDAR, cameras, IMU, proximity sensors, and machine vision. Control architecture, actuator systems, feedback control, obstacle detection, geofencing, path guidance, and safety interlocks. Principles of semi-autonomous operation, teleoperation, and operator-assist systems in construction equipment**.**

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

Module-3

Robotic Construction Equipment Applications:

Applications in autonomous excavation, grading, trenching, demolition, rebar tying, layout marking, 3D printing, and inspection. Equipment platforms and use cases such as autonomous earthmoving, remote-controlled demolition robots, layout robots, and site-monitoring robots. Productivity, safety, and quality implications of robotics in repetitive, risky, or precision-driven construction tasks.

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

Module-4

Digital Workflow and Equipment Data Integration:

Digital twins, BIM-enabled equipment control, machine data capture, fleet monitoring, progress tracking, and site dashboards. Integration of equipment data with scheduling, quantity tracking, quality control, and maintenance planning. Concepts of interoperability, cloud-based jobsite platforms, data-driven decision-making, and predictive maintenance for construction fleets.

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

Module-5

Implementation, Safety, and Future Trends:

Deployment strategy for robotic equipment systems in construction projects, including cost-benefit analysis, training, and change management. Safety standards, human-machine collaboration, cybersecurity, and risk management in autonomous operations. Future trends in construction robotics, AI-enabled decision systems, modular automation, and sustainable equipment operations. Case studies on real-world robotic construction deployment and industry adoption barriers**.**

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

Suggested Learning Resources:

Textbooks

1. Asadi, S. and Han, K., Construction Automation and Robotics: A Practical Guide, Springer, 2022.
2. Bock, T., The Future of Construction Automation, Elsevier, 2015.
3. Dawood, N., Digital Construction and Robotics in the Built Environment, publisher/year to be verified from the exact book edition.
4. Bock, T., S Linner, T. Robot-Oriented Design (Construction Robotics Series Volume 1), Cambridge University Press.
5. Bock, T., S Linner, T. Site Automation: Automated/Robotic On-Site Production (Construction Robotics Series Volume 3), Cambridge University Press.
6. Peurifoy, R. L., Schexnayder, C. J., Aviad, S., S Schmitt, C. L. Construction Planning, Equipment, and Methods, McGraw Hill.

Reference books

1. Kim, H., *Robotics and Automation in Construction Equipment*, latest edition.
2. Eastman, C. et al., *BIM Handbook*, latest edition.
3. Chui, C. and Bock, T., *Construction Robotics and Digital Fabrication*, latest edition.

Web links and Video Lectures (e-Resources)

1. Construction Digital – Top 10: Construction Robotics.constructiondigital
2. Built Robotics overview.constructiondive
3. BuiltWorlds Robotics Top 50.builtworlds
4. NPTEL / SWAYAM resources on construction equipment automation, BIM, and digital construction.
5. Industry case repositories on autonomous earthmoving, robotic inspection, and equipment telematics.

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

Suggested innovative delivery methods may include:

- Simulation and virtual labs.
- Demonstration of digital machine control workflows.
- Industry expert lectures and site visits.
- Mini-projects using equipment data, BIM, or productivity dashboards.

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	**3D Grade Control Optimization Blueprint:** Develop a digital operational profile for an autonomous site grading project. Translate a complex highway CAD surface profile into machine guidance coordinates, configure the RTK-GNSS base station networks, and define precision tolerance margins for automated graders.	24
2	**3DCP Robotic Trajectory Project:** Design the toolpath execution layout (G-code generation) for a customized 3D concrete printed architectural element. Formulate the extrusion pump rate speeds, plot directional curves avoiding spatial print colapses, and calculate total layer cycle timelines.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**Intelligent Compaction Telematics Audit:** Access and evaluate real-world or simulated intelligent compaction sensor logs. Track structural stiffness variances (CCV/CMV records) across pass counts, map moisture correlation variables, and draft a site QA report.	24
2	**Exoskeleton Application S Safety Review:** Conduct an independent academic case evaluation exploring the ergonomics and physical load mitigation impacts of deploying upper-body passive exoskeletons during structural ceiling overhead installations.	24

Sample rubrics for TW activities:

Criterion	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem understanding	Clearly identifies the task, scope, objectives, and expected output.	Identifies most of the task correctly with minor gaps.	Understands the task partially; scope is somewhat unclear.	Misunderstands the task or misses the main objective.
Technical content	Strong use of relevant concepts, methods, data, and references.	Mostly correct technical content with minor omissions.	Basic technical content with limited depth or accuracy.	Weak or incorrect technical content.
Application and analysis	Applies concepts effectively and shows sound analysis and reasoning.	Applies concepts fairly well with adequate analysis.	Limited application; analysis is shallow.	Little or no application or analysis.
Presentation and organization	Well-structured, neat, logically arranged, and easy to follow.	Generally organized with minor formatting issues.	Acceptable structure but lacks polish or consistency.	Poorly organized and difficult to follow.
Creativity / innovation	Highly original, practical, and industry-oriented.	Shows some original ideas and practical relevance.	Minimal originality; mostly conventional.	No originality or practical value.
Timeliness and participation	Submitted on time and demonstrates full participation.	Minor delay or slight participation gaps.	Noticeable delay or partial participation.	Late submission and poor participation.

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):TWSSL	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 S 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 S 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 S 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 S 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 S 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 hazard 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., S Gryna, F. M. Quality Planning and Analysis, McGraw-Hill.
2. Davies, V. J., S 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 S 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 S 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 S 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.

DIGITAL TWIN FOR CONSTRUCTION PROJECTS			
Course Code	**1MCCT206A**	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):TWSSL	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, components, and life-cycle of digital twins in the built environment, and their relationship with BIM, IoT, cyber-physical systems, and data platforms.
2. Design high-level architectures and data models for digital twins of construction projects, considering interoperability, information requirements, and integration with existing BIM workflows.
3. Apply digital twin technologies for planning, monitoring, and control of construction processes with respect to time, cost, quality, safety, and resource utilization.
4. Analyze performance, risk, sustainability, and predictive maintenance aspects of buildings and infrastructure using data-driven digital twin applications.
5. Develop basic workflows for creating and updating digital twins for construction projects using industry tools and standards, including integration with BIM and sensor data.
6. Evaluate standards, governance, cybersecurity, and organizational readiness issues associated with deploying and operating digital twins in construction projects.

Module-1

Fundamentals of Digital Twins for Construction Projects

- Introduction to digital twins: definitions, evolution from simulation and BIM, key characteristics (bi-directional data flow, synchronization with physical assets, real-time monitoring, analytics, and control). Digital twin typologies (component twin, asset twin, system twin, process twin, and city twin) in the context of construction and infrastructure projects.
- Enabling technologies: BIM and 4D/5D models, IoT and sensor networks, cyber-physical systems, cloud computing, big data platforms, AI/ML analytics for construction data. Levels of fidelity, update frequencies, and model granularity for construction and built environment applications
- Role of digital twins across project life cycle: planning and design, construction execution, commissioning, operation and maintenance, and decommissioning. Benefits and limitations of digital twins for stakeholders including owners, consultants, contractors, facility managers, and regulators.

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

Module-2

Frameworks, Standards, and Data-Driven BIM Integration:

- Digital twin frameworks and reference architectures relevant to construction and infrastructure (overview of ISO 23247 series, manufacturing-origin concepts adapted to construction, layers such as physical entities, data acquisition, digital representations, and applications).
- Data-driven BIM for digital twins: information requirements, parametric and semantic modeling, object libraries, attribute-rich BIM, and regulatory/standards data integration. Approaches to linking BIM models with digital twin platforms, including common data environments (CDE), APIs, and middleware.
- Information management frameworks for the built environment (IET guidance on digital twins for the built environment, ISO 19650 overview) and implications for data governance and model

coordination.

- Interoperability, data exchange formats (IFC, CityGML, GIS integrations), and challenges in synchronizing BIM and digital twins across multiple software ecosystems and stakeholders.

Linked COs: CO1, CO2, CO6. **Number of Hours: 08**

Module-3

Digital Twins for Construction Planning, Execution, and Control:

- Digital twins in preconstruction and planning: scenario analysis using 4D/5D BIM, constructability review, logistics planning, site layout optimization, and clash detection linked with dynamic project data.
- Digital twins during construction execution: integrating sensor data (equipment telematics, environmental monitoring, worker safety wearables), progress tracking, and status visualization in near real-time. Use of dashboards, KPIs, and alerts for time, cost, quality, and safety performance monitoring.
- Process-level twins for specific construction operations such as concrete pouring, earthworks, prefabrication and modular construction, and heavy lifting. Simulation of alternative sequences and resource usage, and feedback loops for updating schedules and work packages.
- Applications of digital twins for collaborative planning (Last Planner System support, constraint removal), change management, and integration with project management tools (e.g., Primavera, MS Project) via data interfaces.

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

Module-4

Performance Analytics, Operations, Maintenance, and Sustainability:

- Digital twins for structural and asset health monitoring: integrating sensor measurements (strain, vibration, displacement, crack detection) with analytical models for bridges, buildings, and other structures; threshold-based alerts and predictive maintenance planning.
- Energy and environmental performance twins: building energy models linked with operational data, carbon performance assessment, indoor environmental quality tracking, and optimization of HVAC, lighting, and envelope systems. Sustainability assessment using digital twins for lifecycle emissions and resource consumption.
- Lifecycle management of infrastructure assets using digital twins: condition assessment, performance benchmarking, risk-based maintenance strategies, and rehabilitation/retrofit decision support for roads, bridges, water infrastructure, and urban systems.
- Data analytics and visualization: use of AI/ML techniques for anomaly detection, forecasting, optimization, and decision-support; dashboards and immersive visualization **(VR/AR) for communicating performance insights to stakeholders.**

Linked COs: CO3, CO4, CO5. **Number of Hours: 09**

Module-5

Implementation Strategies, Case Studies, and Emerging Trends:

- Implementation roadmap for digital twins in construction projects: stakeholder analysis, maturity assessment, business case development, defining scope and use cases, selecting platforms and tools, and incremental deployment strategies. Procurement, contracts, and organizational change management for adopting digital twin solutions.
- Case studies of digital twin applications in construction and infrastructure (e.g., port developments, bridges, tunnels, smart buildings, campuses, and city-scale twins), highlighting objectives, architectures, data flows, benefits, and challenges.
- Governance, cybersecurity, ethics, and data privacy considerations for digital twin deployments in construction, including access control, data ownership, regulatory compliance, and resilience of digital infrastructures.
- Emerging trends: integration with smart cities and urban digital platforms, twin-to-twin

collaboration, edge computing, autonomous systems, and future research directions for digital twins in construction.

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

Suggested Learning Resources

Textbooks

1. Sacks, R., Brilakis, I., Pikas, E., S Xie, H. Construction 4.0: Advanced Technology, Tools and Processes for the Built Environment, Routledge.
2. Grieves, M. Digital Twin: Mitigating Risk in the Product Lifecycle, Professional Engineering Publishing.
3. Eastman, C., Teicholz, P., Sacks, R., S Liston, K. BIM Handbook: A Guide to Building Information Modeling, John Wiley S Sons.
4. Digital Twins in Construction and the Built Environment, ASCE Library, latest edition.
5. Digital Twin and the Construction Industry: Dissected – Conceptual Lenses, Benefits, Opportunities, Challenges, Nova Science Publishers.
6. Digital twins for the built environment, IET Guidance Document.
7. Relevant textbooks on BIM-enabled construction project management, smart infrastructure, and cyber-physical systems (latest editions).

Reference Books

1. Marr, B. Tech Trends in Practice: The 25 Technologies that are Driving the 4th Industrial Revolution, Wiley.
2. ISO 23247 Standard Suite: Automation systems and integration — Digital Twin framework for manufacturing / production components.
3. buildingSMART International. Technical Specifications for openBIM Data Governance Linked Data Structures.
4. ISO 23247 series – Digital twin framework for manufacturing (adaptation and relevance for construction).
5. Data-driven BIM frameworks and ISO-based integration approaches for digital twin systems.
6. Industry white papers and e-books on optimizing digital twins over the building lifecycle (e.g., Nemetschek eBook).
7. Reports and guidelines on digital twins for infrastructure and smart cities from professional bodies and government agencies.

Web links and Video Lectures (e-Resources)

1. Online Frameworks: Digital Twin Consortium Whitepapers, buildingSMART Linked Data Working Groups, NPTEL course on "Introduction to Industry 4.0 and Industrial Internet of Things".
2. Software Tools: Cloud Compare (point cloud tool), Autodesk Tandem / Bentley iTwin Platform (commercial digital twin engines), Node-RED (IoT data wiring), Microsoft Azure Digital Twins console.
3. NPTEL/SWAYAM courses related to Building Information Modeling (BIM), smart infrastructure, and digital transformation in construction.
4. ISO and professional organization portals providing overviews of ISO 23247 and related standards on digital twin frameworks.
5. Online tutorials, webinars, and vendor documentation for digital twin platforms and BIM/digital twin integrations in the construction industry.

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

Suggested Strategies for TLP"

- Demonstrations and hands-on sessions using BIM software and basic digital twin platforms for simple construction scenarios, emphasizing data flows between models, sensors, and dashboards.
- Case-study based learning using documented examples of digital twin applications in construction and infrastructure, with group discussions and presentations focusing on objectives, architectures, and lessons learned.
- Mini-projects where student teams conceptualize and model a digital twin for a chosen construction project, defining information requirements, data sources, and performance indicators aligned to COs.
- Industry expert lectures (physical or virtual) on current practice and future trends in digital twins for construction projects, followed by reflection assignments.
- Use of flipped classroom, problem-based learning, and collaborative tools to engage students in analyzing standards, frameworks, and implementation challenges of digital twins in real projects.

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	Case study discussion, on real construction digital twin applications such as site monitoring, progress tracking, asset health, and facility management, followed by group presentation and critique.	24

2	BIM-to-digital-twin workflow demo, where students trace how a BIM model is enriched with sensor data, dashboards, and feedback loops for project control.	24
3	**Mini project**, in which student teams design a conceptual digital twin for a selected construction project, defining objectives, stakeholders, data sources, and implementation steps	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**Virtual lab / simulation exercise**, using sample project data to create a basic digital twin view for a building or infrastructure project, with emphasis on data update, visualization, and status interpretation.	24
2	**BIM-to-digital-twin workflow demo**, where students trace how a BIM model is enriched with sensor data, dashboards, and feedback loops for project control.	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.

AI, ML & DATA-DRIVEN CONSTRUCTION MANAGEMENT			
Course Code	**1MCCT206B**	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):TWSSL	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 role of artificial intelligence, machine learning, and data analytics in construction management.
2. Apply data preprocessing, feature engineering, and model selection methods to construction datasets.
3. Analyze project data for productivity, cost, schedule, quality, safety, and risk decision-making.
4. Develop predictive insights using machine learning techniques for construction planning and control.
5. Evaluate digital data sources such as BIM, IoT, drones, sensors, and site reports for construction intelligence.
6. Prepare data-driven dashboards, reports, and decision-support outputs for construction projects.

Module-1

Introduction to AI, ML, and Data-Driven Construction Management:

Introduction to AI, machine learning, data science, and analytics in construction. Need for data-driven decision-making in planning, execution, monitoring, and control. Types of construction data: project schedules, cost data, site records, productivity data, quality data, safety data, sensor data, BIM data, and progress images. Overview of supervised, unsupervised, and reinforcement learning. Role of AI in construction productivity, automation, and decision support.

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

Module-2

Construction Data Engineering and Visualization:

Data acquisition from site records, ERP systems, BIM platforms, drones, mobile apps, IoT devices, and inspection logs. Data cleaning, normalization, encoding, missing value handling, and feature selection. Fundamentals of databases, spreadsheets, and structured datasets for construction projects. Data visualization techniques using charts, dashboards, and performance indicators. Introduction to Python/R-based analytics tools and construction data workflows.

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

Module-3

Machine Learning for Project Performance:

Regression, classification, clustering, and time-series forecasting in construction applications. Predictive models for cost overrun, delay risk, productivity, material demand, and equipment utilization. Model training, testing, validation, and performance metrics such as accuracy, precision, recall, F1 score, RMSE, and MAE. Introduction to overfitting, bias, variance, and model interpretability. Case applications in schedule prediction, risk scoring, and resource planning.

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

Module-4

AI Applications in Construction Operations:

AI-based applications in progress monitoring, quality inspection, safety surveillance, equipment management, and defect detection. Computer vision for site image analysis, object detection, and progress

tracking. Predictive maintenance and anomaly detection using sensor and equipment data. AI-enabled BIM integration, digital twins, and information management. Ethical issues, data privacy, reliability, and human oversight in AI-assisted construction management.

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

Module-5

Decision Support and Contemporary Practice:

Data-driven dashboards for project control, earned value analysis, risk monitoring, and executive reporting. Use of AI/ML for procurement analytics, claim trend analysis, contract performance, and portfolio-level decision-making. Case studies on intelligent construction management systems. Introduction to generative AI tools for documentation, summarization, and knowledge support in construction workflows. Future trends: automation, robotics, digital twins, smart construction, and integrated project controls.

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

Suggested Learning Resources

Textbooks

1. Smith, P., Project Analytics in Construction, 2nd ed., Springer, 2024.
2. Sacks, R., Eastman, C., Lee, G., and Teicholz, P., BIM Handbook, 3rd ed., Wiley, 2018.
3. Geron, A., Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd ed., O'Reilly Media, 2022.
4. Goodfellow, I., Bengio, Y., and Courville, A., Deep Learning, 1st ed., MIT Press, 2016.Goodfellow, I., Bengio, Y., S Courville, A. Deep Learning, MIT Press.
5. James, G., Witten, D., Hastie, T., S Tibshirani, R. An Introduction to Statistical Learning: with Applications in R/Python, Springer.
6. Sacks, R., Brilakis, I., Pikas, E., S Xie, H. Construction 4.0: Advanced Technology, Tools and Processes for the Built Environment, Routledge.

Reference Books

1. Borrmann, A. et al., Building Information Modeling and Construction Informatics, 1st ed., Springer, 2018.
2. Relevant standards and guidance on BIM, digital twins, and data governance from recognized publishers.
3. Research papers and case studies on construction analytics and predictive modeling. Russell, S., S Norvig, P. Artificial Intelligence: A Modern Approach, Pearson.
4. Soibelman, L., S Kim, H. Data Mining in Design and Construction, Momentum Press.
5. Current Academic Research Journals: Elsevier Automation in Construction S ASCE Journal of Computing in Civil Engineering (Selected case studies on AI/ML applications).

Web links and Video Lectures (e-Resources)

1. NPTEL/SWAYAM courses on artificial intelligence, machine learning, BIM, and construction management.
2. Open-access materials on data analytics, Python for engineering, and construction informatics.
3. Industry webinars on digital construction, smart site monitoring, and AI adoption.Online Repositories: Kaggle engineering datasets,
4. NPTEL course on "Data Science for Engineers", Courva/Udemy Machine Learning micro-credentials.
5. Software Tools: Python Data Science Libraries (NumPy, Pandas, Scikit-Learn), Deep Learning platforms (TensorFlow, PyTorch), OpenCV (Computer vision library), Anaconda Suite / Google Colab environments.

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Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**TW-1: Construction Data Audit** — Students shall identify available project data sources, classify data types, and prepare a data inventory sheet.	24
2	**TW-2: Dashboard for Project KPIs** — Students shall prepare a dashboard for cost, time, safety, and productivity indicators using a sample dataset.	24
3	**TW-3: Delay Risk Prediction Exercise** — Students shall analyze a project case and estimate delay risk using a simple predictive model or rule-based logic.	24
4	**TW-4: AI-Based Site Monitoring Review** — Students shall review an AI-supported site monitoring workflow and prepare a structured technical 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 Predictive Analytics in Construction	24
2	SL-2: Review of Smart Construction Platforms	24
3	SL-3: BIM and Digital Twin Data Workflow Study	24
4	SL-4: Mini Report on Ethical Use of AI in Construction	24

Sample rubrics for TW activities:

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Data understanding	Correctly identifies relevant project data and context.	Identifies most data correctly.	Basic identification with gaps.	Incomplete or incorrect.
Analytical accuracy	Demonstrates sound interpretation and analysis.	Minor errors in analysis.	Several conceptual gaps.	Major errors in interpretation.
Documentation quality	Professional format, clear structure, complete records.	Mostly well organized.	Adequate but inconsistent.	Poorly organized or incomplete.
Practical application	Strong linkage to construction practice and decision-making.	Good linkage with some depth.	Basic application only.	No meaningful practical linkage.

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):TWSSL	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., S 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 S 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.

LEGAL AND CONTRACTUAL RISK MANAGEMENT			
Course Code	**1MCCT206D**	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):TWSSL	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 legal principles governing construction and engineering contracts, contractual obligations, and administrative responsibilities.
2. Analyze contractual risks, liabilities, and entitlement issues arising from variations, delays, non-performance, and breaches.
3. Apply risk allocation, mitigation, and compliance strategies in procurement and contract administration.
4. Evaluate claims, notices, remedies, and dispute-related implications in project delivery.
5. Prepare contract risk registers, compliance records, and supporting documentation for legal and contractual decisions.
6. Assess dispute avoidance, negotiation, mediation, arbitration, and litigation pathways in construction and infrastructure projects.

Module-1

Legal foundations of contracts:

Introduction to law of contracts, essentials of valid contract, offer, acceptance, consideration, capacity, free consent, legality of object, and void agreements. Contract documents, interpretation of clauses, hierarchy of documents, notices, instructions, and records. Parties to contract, roles and responsibilities of employer, consultant, contractor, subcontractor, and surety. Types of contracts in construction and infrastructure projects.

Linked COs: CO1, CO5. **Number of hours: 09**

Module-2

Contractual risk and risk allocation:

Concept of risk in contracts, sources of legal and contractual risk, risk identification, risk register, and risk allocation principles. Procurement-linked risks, contract packaging, liability transfer, indemnity, warranties, insurance, bonds, and performance security. Risk review during tendering, award, and contract finalization. Risk mitigation through documentation, approvals, and governance controls.

Linked COs: CO3, CO5. **Number of hours: 08**

Module-3

Claims, variations, and breaches:

Definition and classification of claims: variation claims, delay claims, disruption claims, prolongation cost claims, acceleration claims, and loss and expense claims. Causes of claims, entitlement, causation, concurrent delay, notice requirements, supporting records, and claim submission process. Breach of contract, non-performance, remedies, suspension, termination, damages, liquidated damages, and penalty provisions. Introduction to claim prevention through proactive administration.

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

Module-4

Time, cost, and compliance control:

Time impact of variations, extension of time, critical path implications, change management, and contract

administration controls. Measurement, valuation, interim payment, retention, final account preparation, and price adjustment mechanisms. Legal compliance in project execution, statutory obligations, documentation standards, and audit trails. Administrative responses to disputes, delayed decisions, and contractual deviations.

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, expert evidence basics, and claim defence preparation. Contemporary practices in digital contract records, collaborative contracting, and information management. 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., Hudson's Building and Engineering Contracts, 14th Edition, Sweet S 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.
2. Society of Construction Law, Delay and Disruption Protocol, 2nd Edition.
3. AACE International, Recommended Practice on Forensic Schedule Analysis, latest edition.
4. Kale, V. S., Construction Management and Planning, 5th Edition, PHI Learning.
5. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, American Society of Civil Engineers (ASCE), 2009–present

Web links and Video Lectures (e-Resources) :

1. NPTEL/SWAYAM courses on construction law, contract administration, procurement, claims, and dispute resolution.
2. ISO 19650 resources for information management, common data environments, and digital contract records in construction projects.
3. FIDIC guidance and contract forms for contemporary construction contracting practice.
4. Society of Construction Law resources, especially delay and disruption guidance for claim analysis.
5. e-Procurement and public procurement portals, manuals, and tendering guidance relevant to infrastructure projects.

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
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- Simulation and Virtual Labs
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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: Contract Clause Analysis:** Analyze a construction contract and extract clauses on notices, variations, payment, delay, and claims	24
2	**TW-2: Claim Notice Drafting:** Draft a notice for delay, variation, or latent condition with contractual basis and reservation of rights	24
3	**TW-3: Variation and EOT Worksheet:** Prepare a variation valuation sheet and extension-of-time worksheet for a case scenario	24
4	**TW-4: Procurement Plan and Bid Evaluation:** Develop a procurement strategy and comparative bid evaluation matrix for a project scenario.	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:** Study a delay/variation/dispute case and present claim causes, entitlement, and likely outcome	24
2	**SL-2: Mock Procurement Review:** Role-play employer, consultant, and bidder teams to review tenders and recommend a procurement route	24
3	**SL-3: BIM-Enabled Contract Administration:** Discuss how digital records, CDE, and structured information support claim prevention and administration	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 contractual basis.	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/risk 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.

ESG & SUSTAINABILITY REPORTING FOR INFRASTRUCTURE			
Course Code	**1MCCT206E**	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):TWSSL	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, scope, and business relevance of ESG in infrastructure development.
2. CO2 Analyze environmental, social, and governance impacts of infrastructure projects across planning, construction, operation, and maintenance phases.
3. CO3 Apply sustainability indicators, materiality assessment, and reporting frameworks for infrastructure organizations and projects.
4. CO4 Evaluate ESG risks, climate resilience measures, and compliance obligations in infrastructure delivery.
5. CO5 Prepare a structured sustainability report for an infrastructure project using recognized disclosure standards.

Module-1

ESG Fundamentals and Infrastructure Context:

- Concept of sustainability, ESG, and responsible infrastructure development.
- Linkage between infrastructure, climate change, resource efficiency, and social equity.
- Life-cycle perspective in infrastructure planning, design, construction, operation, and decommissioning.
- Stakeholders in infrastructure ESG reporting: government, financiers, contractors, users, and communities.
- Introduction to SDGs, green taxonomy, and net-zero transition in infrastructure.

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

Module-2

The "E" in ESG – Environmental Reporting for Infrastructure:

- Environmental aspects of infrastructure projects: energy, water, materials, emissions, waste, biodiversity, and pollution.
- Carbon footprint assessment, embodied carbon, operational carbon, and Scope 1, 2, and 3 emissions.
- Energy and water performance indicators for buildings, transport, utilities, and urban infrastructure.
- Environmental compliance, permits, EIA linkages, and monitoring plans.
- Tools and methods for environmental data collection, baseline assessment, and target setting.

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

Module-3

The "S" and "G" – Social Impact S Governance Structures:

- Social impact dimensions: land acquisition, resettlement, livelihood, accessibility, safety, and community inclusion.
- Occupational health and safety, labor welfare, gender sensitivity, and stakeholder grievance mechanisms.
- Governance principles: ethics, anti-corruption, transparency, accountability, and board oversight.
- Risk management, internal controls, and ESG assurance requirements.
- Social and governance indicators for public and private infrastructure organizations.

Linked COs: CO@, CO3 **Number of Hours: 08**

Module-4

Sustainability Reporting Frameworks:

- Materiality assessment and stakeholder prioritization.
- Global Reporting Initiative GRI, Integrated Reporting IR, and SASB/ISSB overview.
- ESG rating concepts, disclosure structures, and data quality requirements.
- BRSR framework and sustainability reporting expectations in the Indian context.
- Report preparation process: data capture, KPI selection, performance benchmarking, and narrative disclosure.

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

Module-5

ESG Application in Infrastructure Projects S Digital ESG Tech

- ESG risk assessment for transport, water, energy, housing, and urban infrastructure projects.
- Climate resilience, adaptation planning, and disaster risk reduction in infrastructure assets.
- Green procurement, circular economy, low-carbon materials, and sustainable construction practices.
- Financing implications: green bonds, ESG-linked financing, and disclosure requirements for investors.
- Introduction to Carbon Markets: Carbon tax mechanisms, cap-and-trade operations, and carbon offset/credit certification protocols.
- Digital Twin and IoT telemetry solutions for continuous, automated real-time site ESG data collection.
- Utilizing AI-driven data dashboards and blockchain tracking networks to build auditable, tamper-proof supply chain carbon reporting pipelines.
- Preparation of a sample sustainability report for an infrastructure project or organization.

Linked COs: CO4, CO5 **Number of Hours: 10**

Suggested Learning Resources:

Textbooks

1. Schoenmaker, D., Samp; Schramade, W. Principles of Sustainable Finance, Oxford University Press.
2. 2. Kibert, C. J. Sustainable Construction: Green Building Design and Delivery, John Wiley Samp; Sons.
3. 3. Eccles, R. G., Samp; Krzus, M. P. The Integrated Reporting Movement: Meaning, Momentum, Motives, and Materiality, Wiley.
4. B. Chatterjee — Sustainability Reporting and ESG Disclosure — Routledge.
5. R. Sinha, A. Kumar — Green Infrastructure and Sustainable Development — Elsevier.
6. M. E. Porter et al. — Environmental, Social and Governance (ESG): Strategy and Reporting — Harvard Business Review Press

Reference Books

1. Global Reporting Initiative — GRI Standards — Global Reporting Initiative.
2. IFRS Foundation — ISSB Sustainability Disclosure Standards — IFRS Foundation.
3. Ministry of Corporate Affairs — Business Responsibility and Sustainability Reporting (BRSR) Framework — Government of India, Ministry of Corporate Affairs.
4. World Bank — Sustainable Infrastructure and Climate Resilience Guidance — World Bank Publications.
5. United Nations Global Compact — Guidance on ESG and Sustainable Infrastructure — UN Global Compact Office

Web links and Video Lectures (e-Resources)

1. Online Repositories: GHG Protocol educational training portals, World Green Building Council (WGBC) open-access reports, NPTEL course on "Sustainability Through Green Manufacturing Systems".
2. Software Tools: OpenLCA / SimaPro (Life cycle assessment software), Athena Impact Estimator for Buildings, MS Excel Solver (for carbon calculation matrices), commercial ESG reporting dashboard trial platforms (e.g., IBM Envoy / Novisto models).

3. GRI Standards portal for reporting guidelines and indicators.
4. IFRS / ISSB resources for global sustainability disclosure standards.
5. SEBI and MCA pages for Indian sustainability disclosure regulation

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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- Simulation and Virtual Labs
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- 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.

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Continuous Internal Evaluation:

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

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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	**ESG Audit of an Infrastructure Project:** Select a real or model infrastructure project and identify key environmental, social, and governance risks with mitigation measures.	24
2	**Sustainability Report Preparation** Prepare a mini sustainability report for a selected infrastructure asset using defined KPIs and disclosure structure.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**Materiality Matrix Development:** Develop a materiality matrix for an infrastructure organization based on stakeholder priorities.	24
2	**Carbon and Resource Accounting:** Estimate carbon emissions, water use, and material intensity for a small infrastructure case study.	24

Sample rubrics for TW activities:

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

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

Course outcome (Course Skill Set):

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

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

Module-1

Fundamentals of Smart Construction Materials:

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

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

Module-2

Nanotechnology in Construction Materials:

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

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

Module-3

Smart and Functional Concrete Systems:

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

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

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

Module-4

Smart Materials for Buildings and Infrastructure:

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

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

Module-5

Sustainability, Life-Cycle Performance, and Applications:

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

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

Suggested Learning Resources:

Textbooks

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

Reference Books

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

Web links and Video Lectures (e-Resources)

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

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

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

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

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

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

1	**Seminar presentation:** Each student presents on one topic such as nano-silica in concrete, self-healing concrete, smart glass, or self-sensing materials., charting the density growth of Calcium Silicate Hydrate (C-S-H) gels.	24
2	**Poster presentation:** Students create a poster on a smart material system, highlighting mechanism, application, and advantages.	24

Sample rubrics for TW activities:

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

CONSTRUCTION MANAGEMENT LAB			
Course Code	**1MCCTL207**	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: Prepare project planning, site logistics, and construction management models using suitable software tools.
2. CO2 --- L4: Interpret schedules, resource allocations, quantities, productivity, and cost information for construction projects.
3. CO3 --- L4: Analyze network logic, time-cost trade-offs, material requirements, and project execution constraints.
4. CO4 --- L5: Design and evaluate construction management alternatives for planning, monitoring, and control.
5. CO5 --- L6: Apply digital tools and model outputs to prepare professional reports and practical recommendations.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

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

PART – A

FIXED EXPERIMENTS

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

CO3, CO4

8. Construction progress monitoring and reporting using planned vs actual comparison, S-curve, and variance analysis. CO4, CO5

PART – B

OPEN ENDED EXPERIMENTS

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

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

Textbooks:

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

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, or equivalent for drawing, BIM, and coordination.
4. Excel, MATLAB, or Python for estimation, tabulation, graphs, and analysis.
5. Any equivalent project management or BIM 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.

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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.