MK UNIVERSITY

PATAN, GUJARAT

ESTABLISHED BY THE GUJARAT GOVT. **RECOGNIZED BY UGC UNDER SECTION 2(f) OF UGC ACT,1956**

MK University, Patan
Faculty of Engineering Technology,
Department of Civil Engineering

M. TECH (CIVIL ENGINEERING) SEM-I									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	MTCE101	ADVANCED MATHEMATICS FOR ENGINEERS	4	0	4	40	60	100
2	MAJOR	MTCE102	ADVANCED STRUCTURAL ANALYSIS	4	2	6	90	60	150
3	MAJOR	MTCE103	RESEARCH METHDOLOGY & TECHNICAL COMMUNICATION	4	0	4	40	60	100
4	MINOR	MTCE104	ADVANCED GEOTECHNICAL ENGINEERING	4	2	6	90	60	150
5	SEC	MTME105	ENTERPRENURSHIP DEVELOPMENT	4	0	4	40	60	100
TOTAL				20	4	24	300	300	600

M. TECH (CIVIL ENGINEERING) SEM-II									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	MTCE201	ADVANCED CONCRETE TECHNOLOGY	4	0	4	40	60	100
2	MAJOR	MTCE202	FINITE ELEMENT METHODS IN CIVIL ENGINEERING	4	2	6	90	60	150
3	MAJOR	MTCE203	TRANSPORTATION INFRASTRUCTURE PLANNING	4	2	6	90	60	150
4	MINOR	MTCE204	WATER RESOUCES SYSTEMS ENGINEERING	4	2	6	90	60	150
5	VAC	MTCE205	BUSINESS COMMUNICATION-I	2	0	2	0	50	50
TOTAL				18	6	24	310	290	600

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M. TECH (CIVIL ENGINEERING) SEM-III									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	MTCE301	EARTHQUAKE RESISTANT DESIGN	4	2	6	90	60	150
2	MAJOR	MTCE302	CONSTRUCTION PROJECT MANAGEMENT	4	2	6	90	60	150
3	MINOR	MTCE303	MOOC/SWAYAM COURSE	3	0	3	100	00	100
4	VAC	MTCE304	DISSERTATION PHASE-I	0	8	8	100	100	200
TOTAL				11	12	23	380	220	600

M. TECH (CIVIL ENGINEERING) SEM-IV									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	MTCE401	INDUSTRY SEMINARS/WORKSHOPS/INTERNSHIP	0	2	2	50	00	50
2	MINOR	MTCE402	COMPREHENSIVE VIVA VOCE	0	2	2	50	00	50
3	MAJOR	MTCE403	DISEERTATION PHASE-II	0	16	16	200	200	400
4	VAC	MTCE404	BUSINESS COMMUNICATION-II	2	0	2	00	50	50
TOTAL				2	20	22	300	250	550

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SEMESTER-I

SUBJECT CODE: MTCE101

SUBJECT NAME: ADVANCED MATHEMATICS FOR ENGINEERS

Course Objectives:

- To provide a rigorous mathematical foundation for advanced engineering modeling and analysis.
- To bridge theoretical mathematics with practical engineering applications.
- To develop problem-solving skills using analytical and computational tools.
- To prepare students for research and development in engineering domains requiring mathematical sophistication.

Course Outcomes: At the end of the course students shall be able to

CO1	Formulate and solve engineering problems using advanced techniques in linear algebra and tensor analysis.
CO2	Apply partial differential equations (PDEs) and transform methods to model dynamical systems and boundary value problems.
CO3	Use variational calculus and optimization methods for engineering design and control problems.
CO4	Analyze stochastic systems and uncertainty propagation using probability theory and statistical methods.

Unit	Content	Credit	Weightage
I	**Advanced Linear Algebra & Tensors for Engineers** ○ Review of vector spaces, eigenvalues, SVD, Jordan form ○ Matrix decompositions (LU, QR, Cholesky, Schur) ○ Tensor algebra: notation, operations, invariants ○ Tensor applications: stress-strain, inertia, constitutive models ○ Numerical linear algebra (conditioning, iterative solvers) • **Applications:** Structural analysis, continuum mechanics, control systems, data compression.	1	25%
II	**Partial Differential Equations & Transform Methods** ○ Classification of PDEs (elliptic, parabolic, hyperbolic) ○ Separation of variables, eigenfunction expansions ○ Green's functions for ODEs and PDEs ○ Integral transforms (Fourier, Laplace, Hankel) for PDEs ○ Introduction to finite element and finite volume concepts	1	25%

	• **Applications:** Heat transfer, wave propagation, fluid dynamics, signal processing.		
III	**Calculus of Variations & Optimization** ○ Functional derivatives, Euler–Lagrange equation ○ Constraints (Lagrange multipliers, isoperimetric problems) ○ Direct methods (Ritz, Galerkin) ○ Optimal control theory (Pontryagin's principle, Hamiltonian formulation) ○ Convex optimization basics (gradient descent, KKT conditions) • **Applications:** Optimal design, trajectory optimization, energy minimization, control systems.	1	25%
IV	**Stochastic Processes & Uncertainty Quantification** ○ Probability spaces, random variables, distributions ○ Stochastic processes (Brownian motion, Poisson process, Markov chains) ○ Itô calculus basics (stochastic differential equations) ○ Uncertainty quantification (Monte Carlo, polynomial chaos, sensitivity analysis) ○ Statistical estimation and regression for engineering data • **Applications:** Risk analysis, reliability engineering, random vibrations, financial engineering, signal noise modeling	1	25%

TEXT BOOKS:

- Kreyszig, E. – *Advanced Engineering Mathematics* (10th ed.) – Wiley.
- Strang, G. – *Linear Algebra and Its Applications* (5th ed.) – Cengage.
- Arfken, G.B., Weber, H.J., Harris, F.E. – *Mathematical Methods for Physicists* (7th ed.) – Academic Press.
- J.N. Reddy – *Applied Functional Analysis and Variational Methods in Engineering* – McGraw-Hill.
- Papoulis, A., & Pillai, S.U. – *Probability, Random Variables and Stochastic Processes* (4th ed.) – McGraw-Hill.

REFERENCE BOOKS:

- Riley, K.F., Hobson, M.P., Bence, S.J. – *Mathematical Methods for Physics and Engineering* (3rd ed.) – Cambridge.
- Gelfand, I.M., & Fomin, S.V. – *Calculus of Variations* – Dover.
- Oksendal, B. – *Stochastic Differential Equations: An Introduction with Applications* (6th ed.) – Springer.
- Holmes, M.H. – *Introduction to Numerical Methods in Differential Equations* – Springer.
- Gould, P. – *Introduction to Linear Elasticity* (for tensor applications) – Springer.

ONLINE RESOURCES:

- Coursera:
  - *Mathematics for Engineers Specialization* (The Hong Kong University of Science and Technology)
  - *Data Science Math Skills* (Duke University)

SUBJECT CODE: MTCE102

SUBJECT NAME: ADVANCED STRUCTURAL ANALYSIS

Course Objectives:

- To provide in-depth understanding of matrix, energy, and finite element methods for structural analysis.
- To develop skills in analyzing structures for dynamic and stability considerations.
- To bridge theoretical concepts with computational implementation.
- To prepare students for advanced design, research, and consultancy in structural engineering.

Course Outcomes: At the end of the course students shall be able to

CO1	Formulate and analyze statically indeterminate structures using advanced matrix and energy methods.
CO2	Apply finite element method principles to model and analyze 2D/3D structural systems under various loading conditions.
CO3	Evaluate dynamic response of structures to seismic, wind, and blast loads using modal and time-history analysis.
CO4	Analyze stability and nonlinear behavior of structures including geometric and material nonlinearities.

Unit	Content	Credit	Weightage

I	**Advanced Matrix and Energy Methods**
	• **Topics:**
	  ○ Review of flexibility and stiffness methods.
	  ○ **Matrix analysis of grids and space frames:** Transformation matrices, assembly of global stiffness matrix.
	  ○ **Analysis of shear walls, cores, and coupled systems.**
	  ○ **Energy methods:** Virtual work, Castigliano's theorems, principle of minimum potential energy.
	  ○ **Influence lines for indeterminate structures** using Muller-Breslau principle.
	  ○ **Analysis of cable structures and arches.**
	• **Applications:** High-rise buildings, long-span bridges, transmission towers.
		1	25%

II	**Finite Element Method for Structural Systems**
	• **Topics:**
	  ○ FEM fundamentals: Shape functions, isoparametric formulation, numerical integration.
	  ○ **2D elements:** Plane stress, plane strain,
		1	25%

	axisymmetric analysis. ○ **Plate and shell elements:** Kirchhoff and Mindlin plate theories, curved shells. ○ **Modeling techniques:** Mesh refinement, convergence, aspect ratio, error estimation. ○ **Special elements:** Spring, gap, tension-only, compression-only elements. ○ **Substructuring and superelement techniques.** • **Applications:** Slabs, shear walls, domes, pressure vessels, composite sections.		
III	**Structural Dynamics and Seismic Analysis** • **Topics:** ○ **Single and multi-degree of freedom systems:** Equation of motion, free and forced vibration. ○ **Modal analysis:** Eigenvalue problem, orthogonality, modal superposition. ○ **Response spectrum analysis:** Concept, design spectra per IS 1893, Eurocode 8. ○ **Time-history analysis:** Direct integration methods (Newmark, Wilson-θ). ○ **Damping models:** Rayleigh damping, modal damping. ○ **Soil-structure interaction** basics. ○ **Wind-induced vibration** and dynamic wind load analysis. • **Applications:** Earthquake-resistant design, tall buildings, industrial structures.	1	25%
IV	**Stability and Nonlinear Analysis** • **Topics:** ○ **Stability of structures:** Elastic buckling of columns, frames, and plates. ○ **Geometric nonlinearity:** P-Delta analysis, large displacement theory. ○ **Material nonlinearity:** Plastic hinge analysis, yield criteria, pushover analysis. ○ **Nonlinear finite element analysis:** Iterative methods (Newton-Raphson, arc-length). ○ **Analysis of cable-supported structures** with geometric nonlinearity. ○ **Progressive collapse analysis** and robustness. ○ **Introduction to fracture mechanics** in concrete/steel structures. • **Applications:** Slender structures, seismic performance evaluation, progressive collapse	1	25%

	assessment.		

TEXT BOOKS:

- Weaver, W., and Gere, J.M. – *Matrix Analysis of Framed Structures* (3rd ed.) – Springer.
- Bathe, K.J. – *Finite Element Procedures* (2nd ed.) – Prentice Hall.
- Chopra, A.K. – *Dynamics of Structures: Theory and Applications to Earthquake Engineering* (6th ed.) – Pearson.
- McGuire, W., Gallagher, R.H., and Ziemian, R.D. – *Matrix Structural Analysis* (2nd ed.) – Wiley.

REFERENCE BOOKS:

- Cook, R.D., Malkus, D.S., Plesha, M.E., and Witt, R.J. – *Concepts and Applications of Finite Element Analysis* (5th ed.) – Wiley.
- Tedesco, J.W., McDougal, W.G., and Ross, C.A. – *Structural Dynamics: Theory and Applications* – Pearson.
- Bazant, Z.P., and Cedolin, L. – *Stability of Structures: Elastic, Inelastic, Fracture and Damage Theories* – World Scientific.
- Hibbeler, R.C. – *Structural Analysis* (10th ed.) – Pearson.
- IS 1893 (Part 1): *Criteria for Earthquake Resistant Design of Structures* – Bureau of Indian Standards.

ONLINE RESOURCES:

- Coursera: *"Engineering of Structures"* series (Dartmouth), *"Fundamentals of Structural Analysis"* (MIT).
- edX: *"Structural Engineering"* (Purdue University).
- NPTEL: *"Advanced Structural Analysis"* (IIT Madras), *"Finite Element Method"* (IIT Kanpur).

PRACTICAL LIST:

1. Matrix Analysis of a High-Rise Building Frame (Module 1):
   - *Task:* Develop a MATLAB/Python program to perform stiffness matrix analysis of a 10-story, 3-bay planar frame. Calculate nodal displacements, member forces, and plot bending moment diagrams. Compare with results from ETABS/SAP2000.
2. Finite Element Analysis of a Composite Floor Slab (Module 2):
   - *Task:* Model a composite floor system (steel beam + concrete slab) in ANSYS/ABAQUS using 2D shell elements for the slab and 1D beam elements for the beams. Apply live loads as per IS 875. Analyze for deflections and stresses. Perform mesh sensitivity study and report convergence.
3. Seismic Analysis of a Multi-Story Building (Module 3):
   - *Task:* Using ETABS/SAP2000, model a G+7 RC building. Perform:
     1. Response spectrum analysis as per IS 1893 for seismic zone V.
     2. Time-history analysis using the El Centro earthquake record.
     3. Compare base shear, story drifts, and modal participation factors from both methods.
     4. Propose retrofitting measures if drift limits are exceeded.
4. Nonlinear Pushover Analysis of a Moment-Resisting Frame (Module 4):
   - *Task:* In SAP2000/OpenSees, model a steel moment-resisting frame with plastic hinges defined as per FEMA 356.
     1. Conduct a pushover analysis to obtain capacity curve.

2. Determine performance point using ATC-40 capacity spectrum method.

SUBJECT CODE: MTCE103

SUBJECT NAME: RESEARCH METHDOLOGY AND TECHNICAL COMMUNICATION

Course Objectives:

- To equip engineering graduates with a structured approach to scientific inquiry and problem-solving.
- To develop proficiency in selecting and applying appropriate research methods for engineering investigations.
- To enhance technical communication skills for academia and industry.
- To foster an understanding of research ethics, scholarly publishing, and lifelong learning in research.

Course Outcomes: At the end of the course students shall be able to

CO1	Formulate a research problem, conduct systematic literature reviews, and develop a viable research proposal.
CO2	Design and execute appropriate research methodologies (experimental, numerical, analytical) with consideration for ethics and data integrity.
CO3	Apply statistical tools and software for data analysis, interpretation, and validation of research findings.
CO4	Produce high-quality technical documents (research papers, proposals, theses) and deliver effective technical presentations.

Unit	Content	Credit	Weightage

I	**Foundations of Engineering Research & Problem Formulation**
	• **Topics:**
	  ○ Philosophy of research: inductive vs. deductive reasoning, scientific method in engineering.
	  ○ Types of engineering research: fundamental, applied, experimental, computational, empirical.
	  ○ Problem identification and formulation: research gap analysis.
	  ○ Literature review strategies: databases (Scopus, Web of Science, IEEE Xplore), citation management tools (Zotero, Mendeley), critical analysis of literature.
	  ○ Developing a research proposal: objectives, scope, significance, and work plan.
	• **Applications:** Thesis topic selection, grant proposal writing, project planning.
		1	25%

II	**Research Design, Methods & Ethics** • **Topics:** ○ Research design: experimental, quasi-experimental, case study, modeling &	1	25%

	simulation. ○ Data collection methods: sensors, surveys, instrumentation, simulation outputs. ○ Design of Experiments (DoE): factorial design, Taguchi methods, response surface methodology. ○ Research ethics: plagiarism, fabrication/falsification, authorship, informed consent. ○ Ethical approval process and responsible conduct of research (RCR). • **Applications:** Planning a lab/field experiment, setting up a CFD/FEA study, survey design.		
III	**Data Analysis, Statistics & Software Tools** • **Topics:** ○ Data preprocessing: outlier detection, missing data, normalization. ○ Descriptive and inferential statistics: hypothesis testing (t-test, ANOVA), confidence intervals. ○ Regression analysis: linear, multiple, logistic. ○ Introduction to multivariate analysis and machine learning for engineering data. ○ Software tools: MATLAB/Python (NumPy, SciPy, pandas), R, MiniTab. ○ Data visualization principles: effective graphs, charts, and plots. • **Applications:** Analyzing experimental results, validating computational models, interpreting sensor data.	1	25%
IV	**Technical Communication & Research Dissemination** • **Topics:** ○ Structure of technical documents: research papers, theses, technical reports. ○ Writing strategies: clarity, conciseness, coherence, and argument development. ○ Graphical abstracts, data presentation, and table/figure design. ○ Oral presentations: conference talks, thesis defense, poster design. ○ Publication process: journal selection, peer review, responding to reviewers. ○ Intellectual Property Rights (IPR): patents, copyrights, licensing. ○ Research dissemination: repositories, academic social networks (ResearchGate,	1	25%

	LinkedIn), and impact metrics (h-index, citations). • **Applications:** Paper writing, thesis compilation, conference presentation, patent filing.		

TEXT BOOKS:

- Kothari, C.R. – *Research Methodology: Methods and Techniques* (4th ed.) – New Age International.
- Day, R.A., and Gastel, B. – *How to Write and Publish a Scientific Paper* (9th ed.) – Greenwood.
- Montgomery, D.C. – *Design and Analysis of Experiments* (10th ed.) – Wiley.
- Alley, M. – *The Craft of Scientific Writing* (4th ed.) – Springer.

REFERENCE BOOKS:

- Bordens, K.S., and Abbott, B.B. – *Research Design and Methods: A Process Approach* (11th ed.) – McGraw-Hill.
- Wallwork, A. – *English for Writing Research Papers* (2nd ed.) – Springer.
- Box, G.E.P., Hunter, J.S., and Hunter, W.G. – *Statistics for Experimenters* (2nd ed.) – Wiley.
- IEEE Author Center Guides – *IEEE Publication Services and Products Board*.
- Laplante, P.A. – *Technical Writing: A Practical Guide for Engineers and Scientists* – CRC Press.

ONLINE RESOURCES:

- edX Courses:
  1. *"Principles of Statistical Analysis"* (Microsoft)
  2. *"How to Write and Publish a Scientific Paper"* (KU Leuven)

SUBJECT CODE: MTCE104

SUBJECT NAME: ADVANCED GEOTECHNICAL ENGINEERING

Course Objectives:

- To provide advanced understanding of soil behavior, constitutive modeling, and modern geotechnical analysis.
- To develop expertise in design of deep foundations, retaining structures, and ground improvement.
- To equip students with skills for analyzing geotechnical problems under dynamic and environmental conditions.
- To prepare students for geotechnical consultancy, research, and specialized design roles.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze soil stress-strain behavior using advanced constitutive models and critical state soil mechanics.
CO2	Design and analyze deep foundations, earth retaining structures, and ground improvement techniques.
CO3	Evaluate slope stability under static and seismic conditions using advanced analytical and numerical methods.
CO4	Apply principles of geoenvironmental engineering, soil dynamics, and rock mechanics to practical problems.

Unit	Content	Credit	Weightage
I	**Advanced Soil Mechanics & Constitutive Modeling** • **Topics:**	1	25%

	○ **Critical State Soil Mechanics:** Cam-Clay models (Modified, Original), state parameters. ○ **Stress-strain behavior:** Elastic-plastic models, nonlinear elasticity, anisotropic behavior. ○ **Constitutive models:** Mohr-Coulomb, Drucker-Prager, Duncan-Chang hyperbolic model. ○ **Unsaturated soil mechanics:** Soil-water characteristic curve, effective stress in unsaturated soils, shear strength. ○ **Soil creep and time-dependent behavior:** Secondary compression, viscoplastic models. ○ **Laboratory testing interpretation:** Triaxial (CU, CD, UU), consolidation, direct shear tests. • **Applications:** Embankment design, settlement analysis, forensic investigations.		
II	**Deep Foundations & Earth Retaining Structures** • **Topics:** ○ **Deep foundations:** Pile types (driven, bored, micropiles), load transfer mechanisms. ○ **Pile capacity analysis:** Static methods (α, β, λ methods), dynamic formulas, pile load tests. ○ **Pile group analysis:** Efficiency, settlement, negative skin friction. ○ **Laterally loaded piles:** p-y curves, Broms method, finite difference solutions. ○ **Earth retaining structures:** Cantilever, anchored, and braced walls. ○ **Design of mechanically stabilized earth (MSE) walls and soil nailing.** ○ **Seismic design of retaining structures.** • **Applications:** High-rise foundations, bridge piers, underground structures, highway cuts.	1	25%
III	**Slope Stability & Ground Improvement** • **Topics:** ○ **Slope stability methods:** Limit equilibrium (Bishop, Spencer, Morgenstern-Price), finite element slope stability. ○ **Seismic slope stability:** Pseudostatic analysis, Newmark's sliding block method. ○ **Progressive failure and residual strength.**	1	25%

	○ **Ground improvement techniques:** ▪ **Mechanical:** Vibro-compaction, dynamic compaction. ▪ **Hydraulic:** Preloading with vertical drains, vacuum consolidation. ▪ **Chemical:** Grouting, deep mixing, jet grouting. ▪ **Reinforcement:** Geosynthetics, soil nailing, micropiles. ○ **Design of reinforced soil slopes and embankments.** • **Applications:** Landslide mitigation, highway embankments, soft ground improvement.		
IV	**Geoenvironmental Engineering & Soil Dynamics** • **Topics:** ○ **Soil dynamics:** Wave propagation, dynamic soil properties, liquefaction analysis (SPT, CPT, Vs-based methods). ○ **Liquefaction mitigation:** Densification, drainage, reinforcement. ○ **Geoenvironmental engineering:** Contaminant transport, landfill liner design, soil remediation techniques. ○ **Rock mechanics:** Rock mass classification (RMR, Q-system), failure criteria (Hoek-Brown). ○ **Tunnel support design** using convergence-confinement method. ○ **Geotechnical instrumentation and monitoring** (inclinometers, piezometers, settlement plates). ○ **Introduction to geosynthetics:** Functions, design principles, applications. **Applications:** Earthquake geotechnics, waste containment, tunneling, dam foundations.	1	25%

TEXT BOOKS:

- Das, B.M. – *Principles of Foundation Engineering* (9th ed.) – Cengage Learning.
- Craig, R.F. – *Craig's Soil Mechanics* (9th ed.) – CRC Press.
- Budhu, M. – *Soil Mechanics and Foundations* (3rd ed.) – Wiley.
- Bowles, J.E. – *Foundation Analysis and Design* (5th ed.) – McGraw-Hill.

REFERENCE BOOKS:

- Terzaghi, K., Peck, R.B., and Mesri, G. – *Soil Mechanics in Engineering Practice* (3rd ed.) – Wiley.
- Poulos, H.G., and Davis, E.H. – *Pile Foundation Analysis and Design* – Wiley.
- Holtz, R.D., Kovacs, W.D., and Sheahan, T.C. – *An Introduction to Geotechnical*

Engineering (2nd ed.) – Pearson.
- Kramer, S.L. – *Geotechnical Earthquake Engineering* – Pearson.
- Koerner, R.M. – *Designing with Geosynthetics* (6th ed.) – Pearson.
- IS Codes: IS 6403, IS 2911, IS 1498, IS 1893 (Part 1).

ONLINE RESOURCES:
- Coursera: *"Soil Mechanics"* (Georgia Tech), *"Geotechnical Engineering"* (TU Delft).
- edX: *"Foundations of Geotechnical Engineering"* (MITx).
- NPTEL: *"Advanced Foundation Engineering"* (IIT Madras), *"Soil Dynamics"* (IIT Kanpur).

PRACTICAL LIST:
1. Constitutive Model Calibration & Settlement Analysis (Module 1):
   - *Task:* Using provided triaxial test data on clay, calibrate Modified Cam-Clay parameters (M, λ, κ, Γ). Develop a MATLAB/Python script to predict consolidation settlement of a footing and compare with conventional 1D consolidation (Terzaghi's) method. Validate with PLAXIS consolidation analysis.
2. Design of Pile Foundation & Load Test Analysis (Module 2):
   - *Task:* Design a pile group for a 10-story building on clayey soil. Determine pile length, diameter, and group configuration. Calculate settlement using elastic and empirical methods. Analyze provided pile load test data (static/dynamic) to determine capacity and verify design. Use GROUP or PLAXIS 3D for group analysis.
3. Slope Stability Analysis under Seismic Conditions (Module 3):
   - *Task:* For a given embankment cross-section, perform:
     1. Limit equilibrium analysis using SLOPE/W or similar (Bishop, Spencer methods).
     2. Pseudostatic seismic analysis using IS 1893 design acceleration.
     3. Newmark's sliding block analysis to estimate permanent displacement.
     4. Propose ground improvement (e.g., geosynthetic reinforcement) to achieve required factor of safety (>1.5).
4. Liquefaction Assessment & Ground Improvement Design (Module 4):
   - *Task:* Using provided SPT and CPT data from a site in seismic zone V:
     1. Evaluate liquefaction potential using simplified procedure (Youd et al., 2001).
     2. Estimate lateral spreading and settlement due to liquefaction.
     3. Design a stone column/drainage scheme for mitigation.
     4. Use QUAKE/W to simulate pore pressure generation and dissipation.

SUBJECT CODE: MTCE105

SUBJECT NAME: ENTERPRENURSHIP DEVELOPMENT

Course Objectives:
- To cultivate an entrepreneurial mindset among engineering graduates.
- To provide practical tools for transforming technical ideas into viable business ventures.
- To develop skills in business modeling, financial planning, and venture funding.
- To prepare students for startup creation, intrapreneurship, or technology commercialization roles.

Course Outcomes: At the end of the course students shall be able to

CO1	Identify and evaluate entrepreneurial opportunities emerging from technological trends and market gaps.
CO2	Develop a comprehensive business model and validate it using lean startup methodologies and customer discovery.
CO3	Create financial projections, evaluate startup costs, and understand funding mechanisms for technology ventures.
CO4	Formulate a complete investor-ready business plan and deliver an effective pitch to potential stakeholders.

Unit	Content	Credit	Weightage
I	**Entrepreneurial Mindset & Opportunity Identification** • **Topics:** ○ The Entrepreneurial Engineer: Mindset, traits, and role in economic development. ○ Sources of Innovation: Technology push vs. market pull, disruptive vs. sustaining innovation. ○ Opportunity Recognition: Identifying problems worth solving, trend analysis (STEEP), blue ocean strategy. ○ Idea Validation: Lean canvas, hypothesis testing, conducting problem-solution interviews. ○ Intellectual Property Strategy for Startups: Patents, trademarks, trade secrets, and licensing basics. • **Applications:** Spotting opportunities in cleantech, Industry 4.0, medtech, and digital transformation.	1	25%
II	**Business Model Design & Customer Development** • **Topics:** ○ Business Model Innovation: Business Model Canvas (Osterwalder), Value Proposition Canvas. ○ Customer Discovery & Validation: The "Get Out of the Building" approach, creating MVP (Minimum Viable Product). ○ Market Analysis: TAM, SAM, SOM, competitive analysis, positioning. ○ Pricing Strategies for Tech Products: Cost-plus, value-based, subscription, freemium models. ○ Go-to-Market Strategy: Sales channels, partnerships, digital marketing fundamentals.	1	25%

	• **Applications:** Designing scalable models for SaaS, hardware-as-a-service, platform businesses.		

III	**Startup Finance, Funding & Legal Foundations**
	• **Topics:**
	  ○ Startup Financials: Building financial models, unit economics, burn rate, runway.
	  ○ Pro Forma Statements: Income statement, cash flow, balance sheet projections.
	  ○ Funding Sources: Bootstrapping, angels, venture capital, crowdfunding, government grants (SBIR, DST).
	  ○ Valuation Methods for Early-Stage Startups: Scorecard, Berkus, risk factor summation.
	  ○ Legal Structures & Compliance: Company registration (LLP, Pvt Ltd), shareholder agreements, ESOPs, compliance essentials.
	  ○ Term Sheet Fundamentals: Key clauses, negotiation basics.
	• **Applications:** Preparing for seed funding, managing cash flow, cap table management.
		1	25%

IV	**Business Planning, Pitching & Scaling Ventures**
	• **Topics:**
	  ○ The Business Plan: Executive summary, company description, product/service, market analysis, marketing plan, management team, financial projections.
	  ○ The Art of Pitching: Investor pitch deck structure, storytelling, demo preparation.
	  ○ Building the Team: Co-founder selection, hiring early employees, advisory boards.
	  ○ Operational Planning: Supply chain, quality, scaling production.
	  ○ Growth Strategies: Scaling challenges, pivoting, exit strategies (acquisition, IPO).
	  ○ Social Entrepreneurship & Ethics: Creating social impact, ethical leadership.
	• **Applications:** Crafting investor pitches, developing operational roadmaps, planning for scale.
		1	25%

TEXT BOOKS:

- Osterwalder, A., and Pigneur, Y. – *Business Model Generation* – Wiley.
- Ries, E. – *The Lean Startup* – Penguin.
- Blank, S., and Dorf, B. – *The Startup Owner's Manual* – K & S Ranch.
- Barrow, C., Barrow, P., and Brown, R. – *The Business Plan Workbook* (10th ed.) – Kogan

Page.

REFERENCE BOOKS:

- Aulet, B. – *Disciplined Entrepreneurship* – Wiley.
- Mullins, J. – *The New Business Road Test* (5th ed.) – FT Publishing.
- Kawasaki, G. – *The Art of the Start 2.0* – Portfolio Penguin.
- Thiel, P. – *Zero to One* – Crown Business.
- Maurya, A. – *Running Lean* (2nd ed.) – O'Reilly.

ONLINE RESOURCES:

- Coursera: *"Entrepreneurship Specialization"* (Wharton), *"Startup Entrepreneurship"* (Technion).
- edX: *"Entrepreneurship in Emerging Economies"* (HarvardX), *"Innovation and Entrepreneurship"* (DelftX).
- Udemy: Courses on Business Plan Writing, Startup Funding, and Digital Marketing.

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SEMESTER-II

SUBJECT CODE: MTCE201

SUBJECT NAME: ADVANCED CONCRETE TECHNOLOGY

Course Objectives:

- To provide an in-depth understanding of advanced concrete materials, mix design, and performance.
- To develop expertise in durability modeling, microstructural analysis, and service life prediction.
- To explore innovative concrete systems and sustainable construction practices.
- To prepare students for research, consultancy, and specialized roles in concrete technology and infrastructure management.

Course Outcomes: At the end of the course students shall be able to

CO1	Design and proportion advanced concrete mixes (HPC, SCC, HSC) using modern admixtures and supplementary cementitious materials.
CO2	Analyze concrete microstructure and its influence on mechanical, thermal, and durability properties.
CO3	Evaluate durability performance under aggressive environments and design for service life using modeling approaches.
CO4	Apply principles of fiber-reinforced, self-healing, and sustainable concrete systems in construction.

Unit	Content	Credit	Weightage
I	**Advanced Concrete Materials & Mix Design** • **Topics:** ○ **Cement chemistry:** Hydration kinetics, C-S-H gel, ettringite, pore structure. ○ **Supplementary cementitious materials:** Fly ash, slag, silica fume, metakaolin, rice husk ash. ○ **Chemical admixtures:** Superplasticizers, retarders, accelerators, air-entraining agents, viscosity modifiers. ○ **Advanced mix design methods:** ACI 211, DOE, particle packing models (Furnas, Andreasen). ○ **Special concretes:** High-performance concrete (HPC), high-strength concrete (HSC), self-consolidating concrete (SCC). ○ **Lightweight and heavyweight concrete.** • **Applications:** High-rise buildings, bridges, marine structures, nuclear shielding. **Module 2: Microstructure, Properties & Testing**	1	25%
II	**Microstructure, Properties & Testing** • **Topics:**	1	25%

	○ **Concrete microstructure:** Interfacial transition zone (ITZ), porosity, permeability. ○ **Mechanical properties:** Strength, modulus of elasticity, creep, shrinkage (plastic, drying, autogenous). ○ **Fracture mechanics of concrete:** Fracture energy, size effect, brittleness. ○ **Thermal properties:** Heat of hydration, thermal cracking, insulation. ○ **Testing methods:** Destructive (compression, flexure, split tensile) and non-destructive testing (NDT) – rebound hammer, ultrasonic pulse velocity, pull-out, maturity method. ○ **Statistical quality control** of concrete. • **Applications:** Quality assurance, forensic investigation, performance evaluation.		
III	**Durability & Service Life Modeling** • **Topics:** ○ **Durability mechanisms:** Permeation, diffusion, sorption. ○ **Deterioration processes:** ▪ **Chloride ingress:** Fick's laws, chloride threshold, time-to-corrosion. ▪ **Carbonation:** Prediction models, effect on pH. ▪ **Sulfate attack:** Internal (DEF) and external. ▪ **Alkali-silica reaction (ASR):** Prevention and mitigation. ▪ **Freeze-thaw damage:** Air-void system, deicer scaling. ○ **Service life prediction models:** FIB Model Code, Life-365, Duracrete. ○ **Corrosion of reinforcement:** Electrochemical principles, corrosion rate measurement. • **Applications:** Marine structures, parking garages, industrial floors, cold climate construction.	1	25%
IV	**Special Concretes & Sustainable Systems** • **Topics:** ○ **Fiber-reinforced concrete:** Steel, glass, synthetic, and natural fibers; structural applications. ○ **Self-compacting concrete (SCC):** Design,	1	25%

	testing (slump flow, V-funnel, L-box), applications. ○ **Ultra-high-performance concrete (UHPC):** Mix design, mechanical properties, ductility. ○ **Self-healing concrete:** Autogenous (crystalline), autonomous (microcapsules, bacteria). ○ **Sustainable concrete systems:** ▪ **Green concrete:** Low-carbon binders (geopolymer, calcium sulfoaluminate). ▪ **Recycled aggregates:** Processing, properties, standards. ▪ **Permeable concrete** for stormwater management. ○ **Repair materials:** Polymer-modified, shrinkage-compensating, rapid-hardening. ○ **Smart concrete:** Self-sensing, self-heating. • **Applications:** Precast industry, seismic retrofitting, sustainable infrastructure, pavements.		

TEXT BOOKS:

- Mehta, P.K., and Monteiro, P.J.M. – *Concrete: Microstructure, Properties, and Materials* (4th ed.) – McGraw-Hill.
- Neville, A.M., and Brooks, J.J. – *Concrete Technology* (2nd ed.) – Pearson.
- Shetty, M.S. – *Concrete Technology: Theory and Practice* (8th ed.) – S. Chand.
- Kosmatka, S.H., Kerkhoff, B., and Panarese, W.C. – *Design and Control of Concrete Mixtures* (15th ed.) – Portland Cement Association.

REFERENCE BOOKS:

- Aïtcin, P.C. – *High-Performance Concrete* – Taylor & Francis.
- Malhotra, V.M., and Carino, N.J. – *Handbook on Non-Destructive Testing of Concrete* (2nd ed.) – CRC Press.
- Bentur, A., and Mindess, S. – *Fibre Reinforced Cementitious Composites* (2nd ed.) – Taylor & Francis.
- RILEM Publications: *State-of-the-Art Reports on Durability, SCC, UHPC.*
- IS Codes: IS 456, IS 10262, IS 13311, IS 516.
- ACI Publications: *ACI 318, ACI 363R, ACI 237R, ACI 544R.*

ONLINE RESOURCES:

- Coursera: *"Concrete Technology"* (TU Delft), *"Durability of Concrete Structures"* (École des Ponts).
- edX: *"Concrete and Sustainability"* (MITx).
- NPTEL: *"Advanced Concrete Technology"* (IIT Madras, IIT Kharagpur).

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SUBJECT CODE: MTCE202

SUBJECT NAME: FINITE ELEMNET METHODS IN CIVIL ENGINEERING

Course Objectives:

- To provide a rigorous theoretical foundation in finite element formulation and numerical techniques.
- To develop practical skills in modeling and analyzing civil engineering problems using FEM.
- To bridge theoretical concepts with software implementation for real-world applications.
- To prepare students for advanced analysis, research, and consultancy in structural and geotechnical engineering.

Course Outcomes: At the end of the course students shall be able to

CO1	Derive element stiffness matrices and formulate FEM equations for 1D, 2D, and 3D structural elements.
CO2	Implement isoparametric formulation, numerical integration, and assembly procedures for complex civil engineering systems.
CO3	Analyze linear and nonlinear problems in structural mechanics, geotechnics, and fluid-structure interaction using FEM.
CO4	Apply commercial FEM software (ANSYS, ABAQUS, SAP2000) and validate results through hand calculations and scripting.

Unit	Content	Credit	Weightage

I	**Fundamentals & 1D Finite Element Analysis**
	• **Topics:**
	  ○ **Introduction:** Historical development, basic steps of FEM, comparison with other numerical methods.
	  ○ **Weighted residual methods:** Galerkin, Ritz, and variational approaches.
	  ○ **1D element formulation:** Bar element, beam element (Euler-Bernoulli, Timoshenko), frame element.
	  ○ **Coordinate transformation:** Local to global transformation, assembly of global stiffness matrix.
	  ○ **Boundary conditions:** Elimination method, penalty method.
	  ○ **Solution techniques:** Direct stiffness method, static condensation.
	• **Applications:** Trusses, beams, planar frames, axial and flexural members.
		1	25%

II	**2D & 3D Finite Element Formulation** • **Topics:** ○ **2D elasticity:** Plane stress, plane strain, axisymmetric problems.	1	25%

	○ **Element types:** Constant strain triangle (CST), linear strain triangle (LST), quadrilateral elements (Q4, Q8). ○ **Isoparametric formulation:** Shape functions, Jacobian transformation, numerical integration (Gauss quadrature). ○ **3D solid elements:** Tetrahedral (TET4, TET10), hexahedral (HEX8, HEX20) elements. ○ **Plate and shell elements:** Kirchhoff plate theory, Mindlin-Reissner plate theory, shell elements (degenerated, continuum-based). • **Applications:** Shear walls, slabs, dams, pressure vessels, thin-walled structures.		
III	**Advanced Topics & Nonlinear Analysis** • **Topics:** ○ **Modeling considerations:** Mesh refinement, aspect ratio, distortion sensitivity, convergence criteria. ○ **Dynamic analysis:** Mass matrix formulation (consistent, lumped), eigenvalue extraction, modal analysis. ○ **Nonlinear FEM:** ▪ **Geometric nonlinearity:** Large displacements, P-Delta, buckling analysis. ▪ **Material nonlinearity:** Plasticity models (von Mises, Drucker-Prager), concrete smeared cracking, reinforcement modeling. ○ **Contact analysis:** Surface-to-surface contact, penalty method, Lagrange multipliers. ○ **Substructuring and superelements.** • **Applications:** Seismic analysis, progressive collapse, soil-structure interaction, crack propagation.	1	25%
IV	**Specialized Applications & Software Implementation** • **Topics:** ○ **Geotechnical applications:** Consolidation, seepage, slope stability using FEM. ○ **Heat transfer and thermal stress analysis** in mass concrete structures. ○ **Fluid-structure interaction** basics for hydraulic structures. ○ **FEM software overview:** ANSYS, ABAQUS, SAP2000, PLAXIS – capabilities and limitations. ○ **Pre-processing & post-processing:** Meshing techniques, result interpretation, validation.	1	25%

	○ **Introduction to extended FEM (XFEM)** for discontinuities. ○ **Code verification and validation** (ASME V&V 10). • **Applications:** Retaining walls, tunnels, dams, pavements, bridge decks, foundation settlements.		

TEXT BOOKS:

- Bathe, K.J. – *Finite Element Procedures* (2nd ed.) – Prentice Hall.
- Zienkiewicz, O.C., Taylor, R.L., and Zhu, J.Z. – *The Finite Element Method: Its Basis and Fundamentals* (7th ed.) – Elsevier.
- Logan, D.L. – *A First Course in the Finite Element Method* (6th ed.) – Cengage Learning.
- Cook, R.D., Malkus, D.S., Plesha, M.E., and Witt, R.J. – *Concepts and Applications of Finite Element Analysis* (5th ed.) – Wiley.

REFERENCE BOOKS:

- Reddy, J.N. – *An Introduction to the Finite Element Method* (4th ed.) – McGraw-Hill.
- Hughes, T.J.R. – *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis* – Dover.
- Smith, I.M., and Griffiths, D.V. – *Programming the Finite Element Method* (5th ed.) – Wiley.
- Desai, C.S., and Kundu, T. – *Introductory Finite Element Method* – CRC Press.
- Madenci, E., and Guven, I. – *The Finite Element Method and Applications in Engineering Using ANSYS* – Springer.

ONLINE RESOURCES:

- Coursera: *"The Finite Element Method for Problems in Physics"* (University of Michigan), *"Finite Element Analysis"* (Georgia Tech).
- edX: *"Introduction to Finite Element Method"* (MITx).
- NPTEL: *"Finite Element Method"* (IIT Kanpur, IIT Madras).

PRACTICAL LIST:

1. 1D FEM Implementation in MATLAB/Python (Module 1):
   - *Task:* Write a FEM code to analyze a 2D truss or frame. Generate element stiffness matrices, assemble global matrix, apply boundary conditions and loads. Output nodal displacements and member forces. Validate with hand calculations and SAP2000 results.
2. 2D Stress Analysis of a Dam Section (Module 2):
   - *Task:* Model a gravity dam cross-section under hydrostatic pressure and self-weight using plane strain elements in ANSYS/ABAQUS. Perform mesh sensitivity study with three mesh densities. Compare principal stresses with analytical solution (gravity method). Present contour plots and convergence graph.
3. Nonlinear Analysis of a Reinforced Concrete Beam (Module 3):
   - *Task:* Model a simply supported RC beam with flexural cracks in ABAQUS/ANSYS using:
     1. Concrete: Smeared cracking model with tension stiffening.
     2. Reinforcement: Embedded truss elements with elastic-plastic material.
     3. Perform nonlinear static analysis to obtain load-deflection curve. Compare with experimental data (provided). Identify cracking load, yield point, and ultimate load.
4. Geotechnical Application: Slope Stability using FEM (Module 4):
   - *Task:* Using PLAXIS 2D or similar, model a soil slope with weak clay layer. Perform:

1. Strength Reduction Method (SRM) to compute factor of safety.
2. Compare with Limit Equilibrium Method (Bishop) using SLOPE/W.
3. Analyze effect of geogrid reinforcement on stability.

SUBJECT CODE: MTCE203

SUBJECT NAME: TRNSPORTATION INFRASTRUCTURE PLANNING

Course Objectives:

- To provide a comprehensive understanding of transportation planning processes, methods, and tools.
- To develop skills in demand forecasting, project evaluation, and sustainable infrastructure planning.
- To explore integration of technology, policy, and environmental considerations in planning.
- To prepare students for careers in transportation planning, infrastructure development, and public policy.

Course Outcomes: At the end of the course students shall be able to

CO1	Apply systematic planning processes and forecasting methods for transportation infrastructure.
CO2	Evaluate transportation projects using economic, financial, and multi-criteria decision analysis.
CO3	Integrate sustainability, resilience, and equity principles in transportation planning.
CO4	Analyze emerging trends (smart mobility, MaaS, ITS) and develop comprehensive transportation plans.

Unit	Content	Credit	Weightage

I	**Fundamentals of Transportation Planning & Demand Forecasting**
	• **Topics:**
	  ○ **Planning process:** Rational planning model, stakeholder engagement, public participation.
	  ○ **Data collection & surveys:** O-D surveys, traffic counts, household interviews, GPS data.
	  ○ **Travel demand modeling:** Four-step model (Trip generation, distribution, mode choice, assignment).
	  ○ **Forecasting techniques:** Regression, time-series, activity-based modeling.
	  ○ **Land use-transportation interaction:** Accessibility measures, transit-oriented development (TOD).
	  ○ **National/State policy frameworks:** National Transport Policy, Master Plans.
	• **Applications:** Urban transport plans, corridor studies, regional transportation plans.
		1	25%

II	**Economic Evaluation & Project Appraisal**	1	25%

	• **Topics:**
	  ○ **Project lifecycle:** Planning, design, construction, operation, maintenance.
	  ○ **Economic analysis:** Cost-benefit analysis (CBA), life-cycle cost analysis (LCCA).
	  ○ **Financial analysis:** Funding mechanisms (public, PPP, bonds), tariff setting.
	  ○ **Multi-criteria decision analysis (MCDA):** Analytical Hierarchy Process (AHP), Goal Programming.
	  ○ **Risk assessment:** Sensitivity analysis, Monte Carlo simulation.
	  ○ **Case studies:** Highway projects, metro rail, airport expansion.
	• **Applications:** Feasibility studies, PPP project evaluation, investment prioritization.		

III	**Sustainable & Resilient Transportation Planning**
	• **Topics:**
	  ○ **Sustainable transportation:** Low-carbon modes, non-motorized transport (NMT) planning.
	  ○ **Environmental impact assessment:** Air quality, noise, energy consumption, carbon footprint.
	  ○ **Resilience planning:** Climate adaptation, disaster-responsive infrastructure, flood-resilient roads.
	  ○ **Equity and social inclusion:** Accessibility for disabled/elderly, gender-sensitive planning.
	  ○ **Green infrastructure:** Permeable pavements, urban greening, sustainable drainage systems (SuDS).
	  ○ **Performance metrics:** Level of Service (LoS), mobility vs. accessibility indicators.
	• **Applications:** Green urban corridors, BRTS planning, pedestrianization projects.
		1	25%

IV	**Advanced Topics & Emerging Technologies**
	• **Topics:**
	  ○ **Intelligent Transportation Systems (ITS):** Architecture, traffic management, traveler information.
	  ○ **Smart mobility:** Mobility as a Service (MaaS), shared mobility, electric vehicle infrastructure.
	  ○ **Big data in transportation:** Mobile phone data, satellite imagery, AI/ML for traffic prediction.
	  ○ **Freight and logistics planning:** Intermodal terminals, last-mile connectivity.
	  ○ **Urban air mobility (UAM) and hyperloop planning** concepts.
		1	25%

	○ **Transportation safety planning:** Vision Zero, blackspot analysis, road safety audits. • **Applications:** Smart city transportation, logistics hubs, future-ready infrastructure planning.		

TEXT BOOKS:

- Meyer, M.D., and Miller, E.J. – Urban Transportation Planning (3rd ed.) – McGraw-Hill.
- Ortúzar, J.D., and Willumsen, L.G. – Modelling Transport (5th ed.) – Wiley.
- Black, J.A., and Black, J. – Transportation Economics: Theory and Application – Routledge.
- FHWA – Transportation Planning Handbook (4th ed.) – Institute of Transportation Engineers.

REFERENCE BOOKS:

- Litman, T. – *Well Measured: Developing Indicators for Sustainable and Livable Transport Planning* – Victoria Transport Policy Institute.
- Rodrigue, J.P., Comtois, C., and Slack, B. – *The Geography of Transport Systems* (5th ed.) – Routledge.
- Khisty, C.J., and Lall, B.K. – *Transportation Engineering: An Introduction* (3rd ed.) – Pearson.
- Morlok, E.K. – *Introduction to Transportation Engineering and Planning* – McGraw-Hill.
- IRC/ MoRTH/ MoHUA – *Indian Road Congress Codes, Urban Transport Guidelines*.

ONLINE RESOURCES:

- Coursera: *"Transportation Infrastructure and Systems"* (University of Toronto), *"Sustainable Urban Mobility"* (EIT Urban Mobility).
- edX: *"Transportation for Sustainable Development"* (MITx), *"Urban Transportation Planning"* (DelftX).
- NPTEL: *"Transportation Planning"* (IIT Bombay), *"Urban Transportation Planning and Management"* (IIT Roorkee).

PRACTICAL LIST:

1. Travel Demand Forecasting for a Corridor (Module 1):
   - *Task:* Using provided O-D survey data for a city corridor, apply the four-step model in TransCAD/TP+ to forecast future traffic (2035). Calibrate and validate the model. Analyze the impact of a proposed metro line on mode shift and road traffic. Present demand matrices, mode split, and assignment maps.
2. Economic & Financial Appraisal of a BRT Project (Module 2):
   - *Task:* Conduct a Cost-Benefit Analysis for a proposed Bus Rapid Transit (BRT) corridor. Estimate capital, O&M costs, and benefits (time savings, reduced accidents, emissions). Calculate NPV, IRR, B/C ratio. Perform sensitivity analysis on key variables (ridership, discount rate). Use Excel or specialized CBA software.
3. Sustainable Mobility Plan for a University Campus (Module 3):
   - *Task:* Develop a campus mobility plan focusing on sustainability. Propose measures: pedestrianization, cycle lanes, EV charging, shuttle services. Assess carbon footprint reduction and accessibility improvement. Use QGIS for spatial analysis (service area, network connectivity). Prepare an implementation plan with phasing and funding options.
4. Smart Mobility Integration Plan (Module 4):

- *Task:* For a selected urban area, design a Mobility as a Service (MaaS) integration plan combining existing modes (bus, metro, taxi, bike-share). Define digital platform architecture, fare integration, and policy support. Analyze big data potential (mobile data, smart card data) for demand-responsive services. Use VISUM/Vissim to simulate before/after scenarios for key indicators (VKT, modal share, congestion).

SUBJECT CODE: MTCE204

SUBJECT NAME: WATER RESOURCES SYSTEMS ENGINEERING

Course Objectives:

- To provide a systems engineering perspective on planning, design, and management of water resources.
- To develop skills in mathematical modeling, optimization, and simulation for complex water systems.
- To integrate hydrological, environmental, economic, and social dimensions in water resources decision-making.
- To prepare students for careers in water resources planning, consulting, research, and policy development.

Course Outcomes: At the end of the course students shall be able to

CO1	Apply advanced hydrological analysis and climate data processing for water resources assessment.
CO2	Formulate and solve water resources systems problems using optimization, simulation, and multi-criteria decision-making.
CO3	Design and evaluate reservoir operations, water allocation, and conjunctive use strategies.
CO4	Analyze water quality systems, groundwater management, and climate change impacts on water resources.

Unit	Content	Credit	Weightage

I	**Advanced Hydrology & Climate Data Analysis**
	• **Topics:**
	  ○ **Hydrologic processes:** Precipitation analysis (IDF curves, PMP), evaporation, infiltration, runoff generation.
	  ○ **Watershed modeling:** Lumped vs. distributed models, HEC-HMS, SWAT.
	  ○ **Flood frequency analysis:** Extreme value distributions (Gumbel, Log-Pearson III), regional flood frequency.
	  ○ **Climate data analysis:** Downscaling (statistical, dynamical), climate indices, trend detection (Mann-Kendall).
	  ○ **Remote sensing in hydrology:** TRMM, GPM, GRACE, soil moisture and evapotranspiration products.
	  ○ **Uncertainty analysis:** Monte Carlo simulation, Bayesian methods.
	• **Applications:** Flood risk assessment, water balance studies, climate impact studies.
		1	25%

II	**Systems Analysis & Optimization Methods**
	• **Topics:**
	  ○ **Systems approach:** Components, interactions, boundaries, feedback.
	  ○ **Optimization techniques:** Linear programming (LP), nonlinear programming (NLP), dynamic programming (DP).
	  ○ **Multi-objective optimization:** Pareto optimality, weighting method, ε-constraint method.
	  ○ **Decision support systems (DSS):** Structure, implementation, case studies.
	  ○ **Simulation modeling:** Deterministic vs. stochastic simulation, reservoir simulation.
	  ○ **Risk and reliability analysis** in water resources.
	• **Applications:** Reservoir sizing, water allocation, conjunctive use planning.
		1	25%

III	**Reservoir & River Basin Management**
	• **Topics:**
	  ○ **Reservoir operation:** Standard operating policy (SOP), rule curves, hedging rules.
	  ○ **River basin planning:** Integrated Water Resources Management (IWRM), conflict resolution.
	  ○ **Water allocation models:** WEAP, MIKE BASIN.
	  ○ **Conjunctive use:** Surface water-groundwater interaction, management models.
	  ○ **Transboundary water issues:** International water law, treaties, cooperative management.
	  ○ **Environmental flows:** Estimation methods, implementation strategies.
	• **Applications:** Multi-purpose reservoir operation, basin master plans, environmental flow compliance.
		1	25%

IV	**Water Quality & Groundwater Systems**
	• **Topics:**
	  ○ **Water quality modeling:** Streeter-Phelps, QUAL2K, WASP.
	  ○ **Groundwater flow modeling:** Governing equations, MODFLOW basics, parameter estimation.
	  ○ **Groundwater contamination:** Advection-dispersion, source identification, remediation design.
	  ○ **Urban water systems:** Water distribution network optimization (EPANET), stormwater management.
		1	25%

	○ **Climate change adaptation:** Water security assessment, adaptive management. ○ **Economics of water resources:** Cost-benefit analysis, water pricing, valuation of ecosystem services. • **Applications:** Pollutant transport, wellfield management, urban water security, adaptation planning.		

TEXT BOOKS:

- Loucks, D.P., van Beek, E., Stedinger, J.R., Dijkman, J.P.M., and Villars, M.T. – *Water Resources Systems Planning and Management* – UNESCO.
- Mays, L.W. – *Water Resources Engineering* (3rd ed.) – Wiley.
- Singh, V.P. – *Hydrologic Systems* (Vol. I & II) – Prentice Hall.
- Jain, S.K., and Singh, V.P. – *Water Resources Systems Planning and Management* – Elsevier.

REFERENCE BOOKS:

- McMahon, T.A., and Adeloye, A.J. – *Water Resources Yield* – Water Resources Publications.
- Wurbs, R.A., and James, W.P. – *Water Resources Engineering* – Pearson.
- Labadie, J.W. – *Optimal Operation of Multireservoir Systems: State-of-the-Art Review* – Journal of Water Resources Planning and Management.
- Anderson, M.P., and Woessner, W.W. – *Applied Groundwater Modeling* (2nd ed.) – Academic Press.
- Dingman, S.L. – *Physical Hydrology* (3rd ed.) – Waveland Press.
- ReVelle, C., and McGarity, A.E. – *Design and Operation of Civil and Environmental Engineering Systems* – Wiley.

ONLINE RESOURCES:

- Coursera: *"Water Resources Management and Policy"* (University of Geneva), *"River Basin Management"* (TU Delft).
- edX: *"Water: Addressing the Global Crisis"* (SDG Academy), *"Introduction to Water and Climate"* (TU Delft).
- NPTEL: *"Water Resources Systems Planning and Management"* (IIT Roorkee), *"Hydrology"* (IIT Kharagpur).

PRACTICAL LIST:

1. Hydrologic Modeling & Flood Frequency Analysis (Module 1):
   - *Task:* Using HEC-HMS, develop a rainfall-runoff model for a given watershed. Calibrate and validate using historical storm events. Perform flood frequency analysis using Gumbel and Log-Pearson III distributions. Estimate design flood for 25, 50, and 100-year return periods. Compare with regional formulas.
2. Reservoir Optimization for Multiple Uses (Module 2 & 3):
   - *Task:* Formulate and solve a linear programming model for a multi-purpose reservoir (irrigation, hydropower, water supply) using Python (PuLP) or LINGO. Maximize benefits subject to storage, release, and demand constraints. Develop rule curves and compare with standard operating policy using reservoir simulation.
3. Water Allocation Modeling using WEAP (Module 3):
   - *Task:* Build a WEAP model for a river basin with multiple demand sites (agricultural, municipal, industrial). Analyze baseline and future scenarios (climate change, demand

growth). Evaluate water scarcity indicators and propose allocation strategies. Include environmental flow requirements.

4. Groundwater Contamination & Management (Module 4):
    - *Task:* Using MODFLOW/MT3DMS, model groundwater flow and contaminant transport from a point source. Calibrate the model using observed head and concentration data. Design a pump-and-treat remediation system. Optimize well locations and pumping rates to contain the plume at minimum cost.

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SEMESTER-III

SUBJECT CODE: MTCE301

SUBJECT NAME: EARTHQUAKE RESISTANT DESIGN

Course Objectives:

- To provide in-depth understanding of seismic behavior of structures and design philosophy.
- To develop skills in seismic analysis methods and code-based design procedures.
- To integrate ductility, capacity design, and detailing principles in seismic-resistant structures.
- To prepare students for seismic design, assessment, retrofitting, and research.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze seismic hazard, ground motion characteristics, and response spectra as per codal provisions.
CO2	Perform equivalent static, response spectrum, and time-history analysis for buildings and bridges.
CO3	Design and detail reinforced concrete and steel structures for ductility and energy dissipation.
CO4	Evaluate seismic performance using nonlinear static (pushover) and dynamic analysis.

Unit	Content	Credit	Weightage

I	**Seismology & Seismic Hazard Analysis**
	• **Topics:**
	  ○ **Engineering seismology:** Plate tectonics, fault types, seismic waves, magnitude, intensity.
	  ○ **Ground motion parameters:** PGA, PGV, PGD, spectral acceleration, duration, frequency content.
	  ○ **Seismic hazard analysis:** Deterministic (DSHA) and probabilistic (PSHA) methods.
	  ○ **Response spectra:** Construction, design spectra per IS 1893, IBC, Eurocode 8.
	  ○ **Site effects:** Soil amplification, liquefaction, seismic microzonation.
	  ○ **Seismic codes:** Overview of IS 1893, IS 13920, IS 4326, FEMA, Eurocode 8.
	• **Applications:** Seismic zoning, site-specific ground motion, hazard mapping.
		1	25%

II	**Seismic Analysis of Structures**
	• **Topics:**
	  ○ **Single and multi-degree of freedom systems:** Equation of motion, damping models.
	  ○ **Analysis methods:**
	  ▪ **Equivalent static method** as per IS 1893.
	  ▪ **Response spectrum analysis:** Modal superposition, combination rules (CQC, SRSS).
		1	25%

	▪ **Time-history analysis:** Direct integration methods (Newmark-β, Wilson-θ), selection of accelerograms. ○ **Seismic analysis of irregular structures:** Torsion, soft story, vertical irregularities. ○ **Soil-structure interaction (SSI)** basics. ○ **Seismic analysis of bridges** and elevated structures. • **Applications:** Regular and irregular building analysis, bridge seismic analysis.		
III	**Design for Ductility & Detailing** • **Topics:** ○ **Design philosophy:** Capacity design, strong-column weak-beam, ductile detailing. ○ **Reinforced concrete structures:** ▪ **Beams:** Flexural design, shear design, confinement, lap splices. ▪ **Columns:** Axial-flexural interaction, shear, confinement as per IS 13920. ▪ **Joints:** Design, detailing, shear reinforcement. ○ **Steel structures:** ▪ **Moment-resisting frames (MRF):** Beam-column connections, panel zones. ▪ **Braced frames:** Concentric (CBF), eccentric (EBF), buckling-restrained braces (BRB). ▪ **Shear walls and composite structures.** ○ **Masonry and timber structures** seismic design basics. • **Applications:** Ductile RC/steel frame design, connection detailing, shear wall design.	1	25%
IV	**Performance-Based Design & Retrofitting** • **Topics:** ○ **Performance-based seismic design (PBSD):** Performance levels (IO, LS, CP), objectives. ○ **Nonlinear analysis:** ▪ **Pushover analysis:** Capacity spectrum method, target displacement. ▪ **Nonlinear time-history analysis (NLTHA).**	1	25%

	○ **Seismic vulnerability assessment:** Rapid visual screening (RVS), detailed evaluation. ○ **Retrofitting techniques:** ▪ **Global:** Shear walls, bracing, base isolation, dampers (viscous, tuned mass). ▪ **Local:** Jacketing (RC, steel, FRP), strengthening of joints. ○ **Base isolation and seismic isolation devices** design principles. ○ **Case studies:** Past earthquake failures, retrofitted structures. • **Applications:** Seismic evaluation, retrofitting design, base isolation systems.		

TEXT BOOKS:

- Chopra, A.K. – *Dynamics of Structures: Theory and Applications to Earthquake Engineering* (6th ed.) – Pearson.
- Paulay, T., and Priestley, M.J.N. – *Seismic Design of Reinforced Concrete and Masonry Buildings* – Wiley.
- IS 1893 (Part 1): *Criteria for Earthquake Resistant Design of Structures* – Bureau of Indian Standards.
- IS 13920: *Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces* – BIS.

REFERENCE BOOKS:

- FEMA P-1050, FEMA P-750, FEMA 356 – *NEHRP Recommended Seismic Provisions* – FEMA.
- Eurocode 8: *Design of Structures for Earthquake Resistance* – CEN.
- Goel, R.K., and Chopra, A.K. – *Earthquake-Resistant Design of Building Structures* – Wiley.
- Taranath, B.S. – *Structural Analysis and Design of Tall Buildings* – CRC Press.
- Jain, S.K., and Nigam, N.C. – *Historical Developments and Current Status of Earthquake Engineering in India* – Indian Concrete Journal.
- ATC-40, FEMA 440 – *Seismic Evaluation and Retrofit of Concrete Buildings*.

ONLINE RESOURCES:

- Coursera: *"Earthquake Engineering"* (University of Buffalo), *"Seismic Design of Structures"* (IIT Kanpur).
- edX: *"Earthquake-Resistant Design of Foundations"* (Tokyo Tech), *"Structural Dynamics"* (MITx).
- NPTEL: *"Earthquake Resistant Design of Structures"* (IIT Kanpur, IIT Roorkee).

PRACTICAL LIST:

1. Seismic Analysis of a Multi-Story Building (Module 1 & 2):
   - *Task:* Using ETABS/SAP2000, model a G+7 RC building. Perform:
     - Equivalent static analysis as per IS 1893.
     - Response spectrum analysis using site-specific spectrum.
     - Compare base shear, story drifts, and torsion.

- Check for irregularities and suggest modifications.

2. Ductile Detailing Design of an RC Frame (Module 3):
   - *Task:* Design a 3-bay, 4-story RC moment frame for seismic zone V. Provide:
     - Beam and column design (flexure, shear) with capacity design checks.
     - Ductile detailing drawings as per IS 13920 (confining reinforcement, lap splices).
     - Joint design and shear reinforcement.
3. Pushover Analysis & Performance Assessment (Module 4):
   - *Task:* For a given existing RC building model in ETABS/SeismoStruct:
     - Perform nonlinear static (pushover) analysis.
     - Plot capacity curve and determine performance point using ATC-40 method.
     - Assess performance level (IO, LS, CP) for design basis earthquake.
     - Identify weak elements and propose retrofitting measures.
4. Design of a Base Isolation System (Module 4):
   - *Task:* Design lead-rubber bearings (LRB) for a 5-story hospital building.
     - Calculate required isolation period, damping, and bearing dimensions.
     - Model isolated structure in SAP2000 and compare response with fixed-base.
     - Perform nonlinear time-history analysis with selected ground motions.
5. Prepare a report on cost-benefit analysis of isolation vs. conventional design.

SUBJECT CODE: MTCE302

SUBJECT NAME: CONSTRUCTION PROJECT MANAGEMENT

Course Objectives:

- To provide a systematic understanding of construction project lifecycle, planning, and control.
- To develop skills in scheduling, costing, contract administration, and risk management.
- To explore modern trends in construction technology, sustainability, and digital transformation.
- To prepare students for leadership roles in construction management, consulting, and entrepreneurship.

Course Outcomes: At the end of the course students shall be able to

CO1	Plan and schedule construction projects using CPM, PERT, and resource optimization techniques.
CO2	Estimate costs, manage budgets, and conduct financial analysis for construction projects.
CO3	Apply principles of contract management, risk analysis, and dispute resolution.
CO4	Integrate sustainable practices, safety management, and digital tools (BIM, PM software) in construction.

Unit	Content	Credit	Weightage
I	**Project Planning, Scheduling & Resource Management** • **Topics:** ○ **Project lifecycle:** Initiation, planning, execution, monitoring, closure. ○ **Work breakdown structure (WBS)**, organization breakdown structure (OBS).	1	25%

	○ **Scheduling techniques:** Bar charts, CPM, PERT, precedence diagramming method (PDM). ○ **Resource planning:** Labor, equipment, materials, cost-loaded schedules. ○ **Time-cost trade-off** analysis, crashing, fast-tracking. ○ **Software applications:** MS Project, Primavera P6, Smartsheet. • **Applications:** Building construction, infrastructure projects, industrial projects.		
II	**Cost Estimation, Budgeting & Financial Management** • **Topics:** ○ **Cost estimation:** Detailed, parametric, analogous, bottom-up estimating. ○ **Budgeting and cost control:** Earned value management (EVM), S-curves, variance analysis. ○ **Financial analysis:** NPV, IRR, payback period, life-cycle costing. ○ **Bidding process:** Tender documents, bid preparation, evaluation. ○ **Value engineering** in construction. ○ **Cash flow forecasting** and management. • **Applications:** Budget preparation, bid management, financial monitoring.	1	25%
III	**Contract Administration & Risk Management** • **Topics:** ○ **Construction contracts:** Types (lump-sum, cost-plus, unit price), clauses, legal aspects. ○ **Contract administration:** Variation orders, claims management, delay analysis. ○ **Risk management:** Identification, qualitative/quantitative analysis, risk response strategies. ○ **Dispute resolution:** Negotiation, arbitration, mediation, litigation. ○ **Insurance and bonds:** Types, requirements, claims. ○ **Labor laws and regulatory compliance.** • **Applications:** Contract drafting, claim settlement, risk mitigation planning.	1	25%
IV	**Advanced Topics & Modern Construction Management** • **Topics:** ○ **Sustainability in construction:** Green building rating (LEED, GRIHA), carbon footprint, waste management. ○ **Safety management:** OSHA standards, safety plans, accident investigation.	1	25%

	○ **Quality management:** TQM, Six Sigma, ISO 9001, quality audits. ○ **Digital construction:** BIM (3D/4D/5D), IoT, drones, digital twins. ○ **Lean construction:** Last planner system, pull planning, waste reduction. ○ **Stakeholder management** and communication planning. ○ **Ethics and professional practice** in construction. • **Applications:** Sustainable projects, BIM implementation, lean construction sites.		

TEXT BOOKS:

- Halpin, D.W., and Senior, B.A. – *Construction Management* (5th ed.) – Wiley.
- Chitkara, K.K. – *Construction Project Management: Planning, Scheduling and Controlling* (3rd ed.) – McGraw-Hill.
- Nunnally, S.W. – *Construction Methods and Management* (8th ed.) – Pearson.
- PMI – *A Guide to the Project Management Body of Knowledge (PMBOK Guide)* (7th ed.) – Project Management Institute.

REFERENCE BOOKS:

- Oberlender, G.D. – *Project Management for Engineering and Construction* (3rd ed.) – McGraw-Hill.
- Harris, F., and McCaffer, R. – *Modern Construction Management* (8th ed.) – Wiley-Blackwell.
- Barrie, D.S., and Paulson, B.C. – *Professional Construction Management* (3rd ed.) – McGraw-Hill.
- Kumar, N.S., and Kumar, S. – *Construction Management and Planning* – McGraw-Hill.
- FIDIC Conditions of Contract (Red, Yellow, Silver Books).
- IS Codes: IS 7272, IS 1200, CPWD Works Manual.

ONLINE RESOURCES:

1. Coursera: *"Construction Project Management"* (Columbia University), *"Project Management Principles and Practices"* (UC Irvine).
2. edX: *"Construction Management"* (MITx), *"BIM Fundamentals"* (Autodesk).
3. NPTEL: *"Construction Project Management"* (IIT Delhi, IIT Madras).

PRACTICAL LIST:

1. CPM Scheduling & Resource Optimization (Module 1):
   - *Task:* Using MS Project/Primavera P6, develop a detailed schedule for a 5-story residential building (WBS with min. 50 activities). Perform resource leveling for labor and equipment. Analyze the critical path and conduct time-cost trade-off (crashing) to reduce duration by 15%. Submit Gantt charts and resource histograms.
2. Cost Estimation & Earned Value Management (Module 2):
   - *Task:* Prepare a detailed cost estimate for a small bridge using CPWD/standard rates. Develop a cash flow S-curve. Given progress data at 40% completion, perform Earned Value Analysis to calculate CV, SV, CPI, SPI, EAC, and VAC. Recommend corrective actions.
3. Contract & Risk Management Plan (Module 3):

- *Task:* Draft a risk management plan for a highway construction project. Identify 15+ risks (technical, financial, legal, environmental). Perform qualitative risk analysis (probability-impact matrix) and quantitative analysis (Monte Carlo simulation for cost contingency). Propose response strategies and draft key contract clauses for risk allocation.

4. BIM-based Construction Management Project (Module 4):
   - *Task:* Using Revit/Navisworks, create a 3D BIM model of a commercial building. Develop a 4D simulation linking model elements to schedule. Perform a clash detection analysis and resolve conflicts. Integrate 5D cost data for selected elements. Prepare a presentation on how BIM improves coordination, reduces rework, and enhances sustainability.