MASTER OF TECHNOLOGY

DEGREE PROGRAMME

in

STRUCTURAL ENGINEERING

(Department of Civil Engineering)

CURRICULUM
(W.e.f. Session 2021-22)

School of Engineering & Technology

CENTRAL UNIVERSITY OF HARYANA
MAHENDERGARH-123031
HARYANA

ABOUT UNIVERSITY

Central University of Haryana is a Central University established under the Central Universities Act, 2009 of the Parliament. It is one of the 15 Central Universities established by MHRD, GoI under the XIth Five Year Plan (2007-12). The University is fully funded by the UGC. The Permanent Campus of the University is situated in 488 acres of land at Jant-Pali Villages, Mahendergarh district of Haryana from where CUH is running its academic operations.

OBJECTIVE

The objective of the University shall be:

- To disseminate and advance knowledge by providing instructional and research facilities in such branches of learning as it may deem fit;
- To make special provisions for integrated courses in humanities, social sciences, science and technology in its educational programmes;
- To take appropriate measures for promoting innovations in teaching-learning process and interdisciplinary studies and research;
- To educate and train manpower for the development of the country;
- To establish linkages with industries for the promotion of science and technology; and
- To pay special attention to the improvement of the social and economic conditions and welfare of the people, their intellectual, academic and cultural development.

VISION OF THE UNIVERSITY

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

MISSION OF THE UNIVERSITY

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

ABOUT CIVIL ENGINEERING DEPARTMENT

The Civil Engineering Department was established under the School of Engineering and Technology, Central University of Haryana in year 2016 with Bachelors of Technology as primary program. Under this program 60 seats are allotted for student admissions via CUCET, LEET etc. The department boasts of its highly competent and research-oriented faculty. The department is equipped with various civil engineering labs having all basic equipment viz: Concrete lab, Hydraulics lab, Transportation lab, Geotechnical lab Structural Analysis lab and Environmental lab. The department has also started Ph.D. program from year 2020 under various specializations like: Water Resources Engineering and Fluvial Hydraulics, Structural Engineering, Transportation engineering, Concrete Technology and related areas to Civil Engineering.

VISION OF THE DEPARTMENT

The Department of Civil Engineering will provide quality education and research facilities that promote fundamental understanding of civil engineering to provide a strong foundation to fulfil the industrial needs for the future change and improve the condition of humanity.

MISSION OF THE DEPARTMENT

- To offer Under-Graduate and Postgraduate programmes in civil engineering and other skill development courses that add value to student competencies.
- To promote quality education, research and consultancy for industrial and societal needs.
- To prepare the professional skill for undertaking consultancy assignments for solving Industrial & Non- industrial problems.
- To prepare dynamic entrepreneurial resources, useful for society.

ABOUT PROGRAMME

M.Tech. in Civil Engineering with specialization in Structural Engineering is a two-year postgraduate programme that involves the analysis and design of steel and concrete structures and analysis of structures for dynamic forces and study of advanced materials. It requires knowledge and competence in the areas of materials, response of individual structural components, and the behaviour of entire structural systems. This programme trains individuals in advanced concepts of structural engineering by in-depth coursework, hands-on modelling projects and dissertation work. Students undergo coursework during the first year on various aspects of structural engineering and apply these constructs to a major research project during the second year. Students are imparted advanced learning in Analysis and Design of Structures, Structural Dynamics and Earthquake Resistant Design of Structures, Repair and Rehabilitation of Structures and Advanced Materials. The students are exposed to practical learning by working on real-world projects in the Structure Design lab integrated with the latest design software and construction material lab. The practical lab sessions require students to apply theoretical knowledge to realize their value through implementation. The objective of the program is to produce structural engineers who integrate and build on the Program's core curricular concepts in the pursuit of professional leadership, teamwork, life-long learning, and career advancement.

VISION OF THE PROGRAM

To become a centre of excellence in structural engineering education and research responsive to Global Challenges.

MISSION OF THE PROGRAM

1. To impart quality Structural Engineering Education that leads to innovative professionals who undertake research / investigations / developmental works independently.
2. To develop professionals with masters in the structural engineering field to generate cutting edge technologies & futuristic knowledge, focusing on the socio-economic needs.
3. To prepare professionals with emphasis on leadership, team work, adaptation to changing needs and ethical conduct.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Post-Graduates of the Program will be able to:

PEO1: Identify and analyze the present problems in structural engineering systems.
PEO2: Design the components of structural systems complying with relevant standards and codes.
PEO3: Identify and apply sustainable, alternative and cost-effective recent construction materials adopting quality control practices.

PEO4: Continue to learn changing technologies and new developments in the field of engineering tools, instrumentation and software for solving structural engineering problems.
PEO5: Lead and accomplish their assignments with spirit of teamwork and ethical conduct.

PROGRAMME OUTCOMES (POs)

Post-Graduates of the Program will be able to:

PO1: Solve problems related to structural engineering by acquiring knowledge of science, engineering and mathematics.
PO2: Analyze, design and conduct experiments, interpret and report results of complex structural engineering problems.
PO3: Design civil engineering structures as per specifications and standard codes.
PO4: Apply engineering tools, instrumentation and software for solving structural engineering problems.
PO5: Operate in inter-disciplinary engineering teams with social responsibility and ethical values.

SCHEME OF M. TECH (CIVIL) STRUCTURAL ENGINEERING

SEMESTER-I						
Sr. No.	**Course No.**	**Course Title**	**Teaching Schedule**			**Credits**
			L	**T**	**P**	
1.	**MTCE 101**	ADVANCED SOLID MECHANICS	3	1		4
2.	**MTCE102**	ADVANCED REINFORCED CONCRETE DESIGN	3	1	-	4
3.	**MTCE103**	CONDITION ASSESSMENT & RETROFITTING OF STRUCTURES	3	1	-	4
4.	**PE-I**		3	1	-	4
5.	**PE-II**		3	1	-	4
6.	**MTCE 104**	COMPUTER APPLICATIONS IN STRUCTURAL ENGINEERING LABORATORY	-	-	4	2
7.	**MTCE 105**	SEMINAR-I	-	-	4	2
8.	**Audit-I**	AUDIT COURSE-1	2	-	-	0
			15	**5**	**8**	**24**

SEMESTER-II						
Sr. No.	**Course No.**	**Subject**	**Teaching Schedule**			**Credits**
			L	**T**	**P**	
1.	**MTCE 201**	ADVANCED STRUCTURAL ANALYSIS	3	1	-	4
2.	**MTCE202**	STRUCTURAL DYNAMICS	3	1	-	4
3.	**MTCE203**	ADVANCED CONCRETE TECHNOLOGY	3	1	-	4
4.	**PE-III**		3	1	-	4
5.	**PE-IV**		3	1	-	4
6.	**MTCE 204**	ADVANCED CONCRETE TECHNOLOGY LABORATORY	-	-	4	2
7.	**MTCE 205**	SEMINAR-II	-	-	4	2
8	**Audit-II**	AUDIT COURSE-II	2	-	-	0
			15	**5**	**8**	**24**

SEMESTER-III						
Sr. No.	**Course No.**	**Subject**	**Teaching Schedule**			**Credits**
			L	**T**	**P**	
1.	**MTCE 301**	DISSERTATION PHASE-I (To be continued in the next semester)	-	-	-	10
2.	**MTCE 302**	RESEARCH METHODOLOGY	4	2	-	6
3.	**GEC-I**		3	1	-	4
			7	**3**	**24**	**20**

SEMESTER-IV						
Sr. No.	**Course No.**	**Subject**	**Teaching Schedule**			**Credits**
			L	**T**	**P**	
1.	**MTCE 401**	DISSERTATION PHASE-II (In continuation to the previous semester)	**-**	**-**	-	30

List of Programme Electives (PE)

PROGRAM ELECTIVES FOR SEMESTER-I		
Sr. No.	**Course No.**	**Course Title**
1	**MTCE 111**	EARTHQUAKE RESISTANT DESIGN OF STRUCTURES
2	**MTCE 112**	DESIGN OF PRESTRESSED CONCRETE STRUCTURES
3	**MTCE 113**	ADVANCED FOUNDATION DESIGN
4	**MTCE 114**	CEMENT COMPOSITE MATERIALS
5	**MTCE 115**	FINITE ELEMENT METHOD
6	**MTCE 116**	ANALYSIS AND DESIGN OF HIGH-RISE BUILDINGS
7	**MTCE 117**	STRUCTURAL HEALTH MONITORING
8	**MTCE 118**	SMART CITIES: INFRASTRUCTURE, PLANNING AND MANAGEMENT

PROGRAM ELECTIVES FOR SEMESTER-II		
Sr. No.	**Course No.**	**Course Title**
1	**MTCE 211**	DESIGN OF BRIDGES
2	**MTCE 212**	THEORY OF PLATES
3	**MTCE 213**	OFFSHORE STRUCTURES
4	**MTCE 214**	EARTH RETAINING STRUCTURES
5	**MTCE 215**	ADVANCED NUMERICAL ANALYSIS
6	**MTCE 216**	GEOTECHNICAL EARTHQUAKE ENGINEERING
7	**MTCE 217**	ANALYSIS AND DESIGN OF TUNNELS
8	**MTCE 218**	ADVANCED STEEL STRUCTURES DESIGN

List of Audit Courses I and II

Sr. No.	Course Title
1	ENGLISH FOR RESEARCH PAPER WRITING
2	SANSKRIT FOR TECHNICAL KNOWLEDGE
3	DISASTER MANAGEMENT
4	VALUE ADDITION
5	STRESS MANAGEMENT BY YOGA
6	CONSTITUTION OF INDIA

MTCE-101: ADVANCED SOLID MECHANICS
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	--	4

Course Outcomes

CO1: Understand the solving Methods of three-dimensional stress and strain analysis and extend to allow the student to obtain solutions using analytical as well as numerical methods.

CO2: Analysis of principal stresses and strains, state of stress and strain, true stress-true strain and generalized Hooke's law and failure criteria.

CO3: Understand plastic deformation of solids, including the analysis of residual stresses and the collapse load of structures subjected to temperature and mechanical loading.

CO4: Understand the responses of materials to fatigue and fracture, as well as their creep and visco-elastic behavior.

Unit I

Analysis of Stress: Body Force, Surface Force and Stress Vector, The State of Stress at a Point, Normal and Shear Stress Components, Rectangular Stress Components, Principal Stresses, Stress-Invariants Principal Planes, The State of Stress Referred to Principal Axes, Mohr's Circles for the Three-Dimensional State of Stress, Planes of Maximum Shear, Octahedral Stresses, The State of Pure Shear, Lame's Ellipsoid, Differential Equations of Equilibrium.

Unit II

Analysis of Strain: Deformations, Deformation in the Neighbourhood of a Point, Change in Length of a Linear Element—Linear Components, Rectangular Strain Components, The State of Strain at a Point. Cubical Dilatation, Change in the Angle between Two Line Elements, Principal Axes of Strain and Principal Strains, Plane State of Strain, Plane Strains in Polar Coordinates, Compatibility Conditions, Strain Deviator and its Invariants. Hooke's Law and the Principle of Superposition

Unit III

Theories of Failure or Yield Criteria and Introduction to Ideally Plastic Solid, Significance of the Theories of Failure, Use of Factor of Safety in Design, Mohr's Theory of Failure, Stress Space and Strain Space, Prandtl–Reuss Equations, Saint Venant Equations, , Work Done by Forces and Elastic Strain Energy Stored, Maxwell–Betti–Rayleigh Reciprocal Theorem, First Theorem of Castigliano Statically Indeterminate Structures, Theorem of Virtual Work Kirchhoff 's Theorem, Second Theorem of Castigliano or Menabrea's Theorem, Generalisation of Castigliano's Theorem or Engesser's Theorem.

Unit IV

Introduction to Composite Materials, Stress–Strain Relations, Basic Cases of Elastic Symmetry Laminates , Ply Stress and Ply Strain, Failure Criteria of Composite Materials, Micromechanics of Composites.

Fracture Mechanics, Brittle Fracture, Stress Intensity Factor, Fracture Toughness, Fracture Conditions, Fracture Modes, Plane Stress and Plane Strain, Plastic Collapse at a Notch

Suggested readings:

1. Housner,GW and Vreeland JR "*The Analysis of Stress and Deformation*", Mcmillan London, 1998.
3. Kazimi, SMA, "*Solid Mechanics*" Tata McGraw Hill, New Delhi, 1999.

4. Srinath, LS, "*Advanced Mechanics of Solids*" Tata Mcgraw Hill, New Delhi, 2000.
5. Timoshenko, SP and Goodier,JN, "*Theory of Elasticity*", McGraw Hill, New York, 2002.
6. Westergaard, HM, "*Theory of Elasticity and Plasticity*", Harvard University Press, Cambridge, 1998.

MT CE 102: ADVANCED REINFORCED CONCRETE DESIGN
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credits
3	1	--	4

Course Outcome

CO1: Deign of slender columns and shear walls.

CO2: Understand strut-tie model and its applications.

CO3: Determine the failure mechanics and yield line pattern in slabs.

CO4: Design of deep beams and curved beams.

UNIT- I

Slender columns and walls: Effective length, unbraced and braced columns, stability index, columns subjected to combined axial and biaxial bending, braced and unbraced walls, slenderness of walls, design of walls for vertical and in- plane horizontal forces.

Shear walls: Classification of shear walls, classification according to behaviour and design of rectangular and flanged shear walls.

UNIT- II

Deep Beams: General features, behaviour of deep beams, parameters influencing design of deep beams, flexural bending stresses, shear stresses in deep beams, IS code provisions, Introduction to strut-tie models, Strut-tie model for deep beams, design examples. Design parameters of Continuous beams and design examples.

UNIT- III

Yield Line Theory: Basic assumptions, Methods of analysis, yield line patterns and failure mechanisms, analysis of one way and two way rectangular and non-rectangular slabs, effect of top corner steel in square slabs, design examples.

UNIT- IV

Design Bunkers and silos, Airy's theory, Janssen's theory. Design examples

Computation of deflection and crack width: short term and long-term deflection of beams and slabs, calculation of deflection as per IS 456, factors affecting crack width in beams, calculation of crack width as per. IS 456, shrinkage and thermal cracking.

Suggested Books:

1. Jain, AK, "*Reinforced Concrete Limit Slate Design",* Nem chand & Bros, 1999
2. Krishna, Raju, "*Advanced Reinforced Concrete Design"*, C.B.S. Publication, 1986
3. Ferguson, PM, Breen, JE and Jigsa JO, "*Reinforced Concrete fundamentals"*, John wily & sons, 1988
4. Varghese, PC, "*Advanced Reinforced Concrete Design"*, Prentice Hall of India, 2001

MTCE 103: CONDITION ASSESSMENT AND RETROFITTING OF STRUCTURES
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credits
3	1	--	4

Course Outcome

CO1: Understand the background of repair, strengthening, retrofitting and rehabilitations of reinforced concrete structures.

CO2: Understand the concept of distress mapping in the reinforced concrete structures.

CO3: Understand the strategies of surface repair and retrofitting techniques.

CO4: Attain knowledge of rehabilitation of existing buildings.

UNIT-I

Deterioration of Concrete Buildings: Embedded Metal Corrosion, Disintegration Mechanisms, Moisture Effects, Thermal Effects, Structural Effects, Faulty Construction.
Evaluation of Concrete Buildings: Visual Investigation, Destructive Testing Systems, Non-Destructive Testing Techniques, Semi-Destructive Testing Techniques, Chemical Testing.

UNIT-II

Surface Repair & Retrofitting Techniques: Strategy & Design, Selection of Repair Materials, Surface Preparation, Bonding repair Materials to Existing concrete, Placement Methods, Epoxy Bonded Replacement Concrete, Preplaced Aggregate Concrete, Shotcrete/Gunite, Grouting, Injection Grouting, Micro concrete.

UNIT-III

Strengthening Techniques: Strengthening Techniques, Beam Shear Capacity Strengthening, Shear Transfer Strengthening between Members, Column Strengthening, Flexural Strengthening, and Crack Stabilization
Seismic Rehabilitation: Guidelines for Seismic Rehabilitation of Existing Buildings, Seismic Vulnerability and Strategies for Seismic Retrofit.

UNIT-IV

Earthquake Resistant Design: Introduction to IS 1893:2002, Behaviour of buildings and structures during past earthquakes and lessons learnt goals of earthquake resistant design. Linear static procedure for seismic load calculation – IS 1893-2002, Design examples.

Suggested Readings:

1. *ATC- 40: "Seismic Evaluation and Retrofit of Concrete Buildings", Vol. 1 & 2*, 1997.
2. Bohni, H, "*Corrosion in Concrete Structures*", CRC Press, 2005.
3. Bungey, S, Lillard, G and Grantham, MG, "*Testing of Concrete in Structures*", Taylor and Francis, 2006.
4. Emmons, PH, "*Concrete Repair and Maintenance",* Galgotia Publication, 2012.
5. *FEMA 273; NEHRP "Guidelines for the Seismic Rehabilitation of Buildings"*, 1999.
6. Malhotra, VM and Carino, NJ, "*Handbook on Non-destructive Testing of Concrete",* CRC Press, 2004.
7. Priestley, MJN, Seible, F and Calvi, GM, "*Seismic Design and Retrofit of Bridges",* John Wiley, 1996.

MTCE 104: COMPUTER APPLICATIONS IN STRUCTURAL ENGINEERING LABORATORY

M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
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Course Outcome

CO1: Impart knowledge in the latest technology on Computer Aided Design, Analysis of building and Computer Aided Engineering Analysis

CO2: Create ability to work with inter-disciplinary groups in professional and research organizations.

List of Experiments

1. Analysis and design of Multi-storey framed building against earthquake & wind loading using STAAD Pro/ SAP/ETABS.
2. Determine the stress and deformation of one way and two-way slab using ABAQUS/ANSYS/MATLAB
3. Determine the stress and deformation of singly and doubly reinforced concrete beam using ABAQUS/ ANSYS/MATLAB
4. Determination of Settlement of Footing using PLAXIS.
5. Determine the response of building subjected to an earthquake using PLAXIS.
6. Determine the dynamic analysis of a Generator on elastic foundation using PLAXIS

MTCE 105: SEMINAR-I
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
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Seminar will be of 45-minute duration during which the presentation will be followed by questions session by the faculty and students. Every student shall be required to submit the topic of his/her seminar in consultation with the associated faculty/mentor well in advance so that the same may be displayed on the notice board. The presenter has to write a report comprising of abstract, literature review, brief details of the background of the topic, methods used, findings and references/List of sources from where the material for presentation has been collected and students need to submit two copies of the seminar report to the department.

The seminar report, the submitted slides, presentation skills and overall attendance will form the basis of the evaluation. There will be no separate final exam for this course.

MT CE 111: EARTHQUAKE RESISTANT DESIGN OF STRUCTURES
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	-	4

Course Outcome

CO1: Understand the concept of earthquake resistant building.
CO2: Design of earthquake resistant reinforced concrete and masonary building.
CO3: Analyse the seismic forces on reinforced concrete buildings.
CO4: Apply IS 13920 codal provisions of ductile detailing in seismic design of RC buildings.

UNIT I

Seismic-Resistant Building Architecture: Introduction-Functional planning-Continuous load path-Overall form-simplicity and symmetry-elongated shapes-stiffness and strength-Horizontal and Vertical members-Twisting of buildings-Ductility-definition-ductility relationships-flexible buildings-framing systems-choice of construction materials-unconfined concrete-confined concrete-masonry-reinforcing steel.

Introduction to Earthquake Resistant Design: Seismic design requirements-regular and irregular configurations basic assumptions-design earthquake loads-basic load combinations-permissible stresses-seismic methods of analysis-factors in seismic analysis-equivalent lateral force method-dynamic analysis response spectrum method-Time history method.

UNIT II

Design Forces for Buildings Introduction; Equivalent static method; Mode superposition technique; Dynamic in elastic time history analysis; Advantages and disadvantages of these methods; Determination of lateral forces as per IS 1893 (Part 1) – Equivalent static method, Model analysis using response spectrum

Reinforced Concrete Building: Principles of earthquake resistant deign of RC members-Structural models for frame buildings- Seismic methods of analysis- Seismic deign methods-IS code based methods for seismic design- Seismic evaluation and retrofitting- Vertical irregularities- Plan configuration problems- Lateral load resisting systems- Determination of design lateral forces Equivalent lateral force procedure- Lateral distribution of base shear.

UNIT III

Masonry Buildings: Introduction Elastic properties of masonry assemblage- Categories of masonry buildings- Behaviour of unreinforced and reinforced masonry walls- Behaviour of walls- Box action and bands- Behaviour of infill walls- Improving seismic behaviour of masonry buildings- Load combinations and permissible stresses- Seismic design requirements-Lateral load analysis of masonry buildings.

UNIT IV

Ductility Considerations in Earthquake Resistant Design of RC Buildings: Introduction-Impact of Ductility- Requirements for Ductility- Assessment of Ductility- Factors affecting Ductility- Ductile detailing considerations as per IS 13920. Behaviour of beams, columns and joints in RC buildings during earthquakes- Vulnerability of open ground storey and short columns during earthquakes.

Capacity Based Design: Introduction to Capacity Design, Capacity Design for Beams and Columns Case studies

Suggested Readings:

1. Agarwal, P, Shrikhande, M, *"Earthquake resistant design of structures",* Prentice-Hall of India, 2006.
2. *IS: 1893 (Part-1) -2016. Criteria for Earthquake Resistant – Design of structures*. B.I.S., New Delhi.
3. *IS: 4326-1993, Earthquake Resistant Design and Construction of Building*, Code of Practice B.I.S., New Delhi.
4. *IS: 13920- 2016, Ductile detailing of concrete structures subjected to seismic force – Guidelines*, B.I.S., New Delhi
5. Naeim, F, *"The seismic design handbook",* Edited, Kluwer Academic publishers, 2001.
6. Paulay, T, Priestley, MJN, *"Seismic design of reinforced concrete and masonry buildings"*, John Wiley & Sons, 1991.

MT CE 112: DESIGN OF PRESTRESSED CONCRETE STRUCTURES
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	-	4

Course Outcome

CO1: Understand the need for prestressing in a structure.

CO2: Explain the methods, types and advantages of prestressing.

CO3: Design a prestressed concrete structural elements and systems.

CO4: Attain knowledge of IS 11343 code for prestressing of concrete structure.

UNIT I

Introduction: Basic concepts, Advantages, Materials required, Systems and methods of prestressing, Analysis of sections, Stress concept, Strength concept, Load balancing concept, Effect of loading on the tensile stresses in tendons , Effect of tendon profile on deflections , Factors influencing deflections , Calculation of deflections , Short term and long term deflections, Losses of prestress, Estimation of crack width

UNIT II

Flexural Design: Basic assumptions for calculating flexural stresses, Permissible stresses in steel and concrete as per I.S.1343 Code, Design of sections of Type I and Type II post-tensioned and pre-tensioned beams, Check for strength limit based on I.S. 1343 Code, Layout of cables in post-tensioned beams, Location of wires in pre-tensioned beams, Design for shear based on I.S. 1343 Code

UNIT III

Deflection: Factors influencing deflections, Short term deflections of uncracked members, Prediction of long term deflections due to creep and shrinkage, Check for serviceability limit state of deflection.

Anchorage: Determination of anchorage zone stresses in post-tensioned beams by Magnel's method, Guyon's method and IS1343 code, design of anchorage zone reinforcement, Check for transfer bond length in pre-tensioned beams

UNIT IV

Composite Beams: Analysis and design of composite beams, Methods of achieving continuity in continuous beams, Analysis for secondary moments, Concordant cable and linear transformation, Calculation of stresses, Principles of design.

Suggested Readings:

1. Dayaratnam, P, "*Prestressed Concrete Structures*", Oxford and IBH, 2013
2. IS 1343:1980, "*Code of Practice for Prestressed Concrete, Bureau of Indian Standards*", New Delhi, 2012
3. IS 3370- Part 4, "*Indian standard Code of practice for concrete structures for the storage of liquid- Design tables, code of practice",* Bureau of Indian standards, New Delhi, 2008.
4. Krishna Raju, N, *"Prestressed concrete",* 5th Edition, Tata McGraw Hill Company, New Delhi, 2012
5. Lin, TY, and Burns, NH, *"Design of prestressed Concrete Structures",* Third Edition, Wiley India Pvt. Ltd., New Delhi, 2013.
6. Rajagopalan, N, *"Prestressed Concrete"*, Narosa Publishing House, 2002

MTCE 113 ADVANCED FOUNDATION DESIGN
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	-	4

Course outcomes:

CO1: Gain knowledge of about advanced topics of foundation design and analyses, supplementing their comprehensive knowledge acquired in basic foundation engineering course

CO2: Develop profound understanding of shallow and deep foundation analyses

CO3: Develop understanding of choice of foundation design parameters

CO4: Learn about cause and effect of dynamic loads on foundation

UNIT- I

Design of combined footings by Rigid method, Combined footings (rectangular & trapezoidal), strap footings, strip footing, Types of rafts, bearing capacity & settlements of raft foundation, Design of raft foundation – Conventional rigid method, Elastic methods, Coefficient of sub-grade reaction, IS code (IS-2950) procedure

UNIT- II

Introduction Necessity of pile foundations, Classification, Load bearing capacity of single pile by Static formula, Dynamic formula, Pile load test and Penetration tests. Introduction, Pile groups, group action of piles in sand and clay, group efficiency of piles, settlement of piles, negative skin friction, laterally loaded piles and under reamed piles, Proportioning and Design of Pile foundations

UNIT- III

Machine Foundations: Introduction, free and forced vibrations, Types of Machine foundations, degrees of freedom of a block foundation, general criteria for design of machine foundation, vibration analysis of a machine foundation, determination of natural frequency, vibration isolation and control.

Sheet Piles: Types, Design of Cantilever sheet piling wall, Design of Anchored Bulkheads, Anchorage methods, Design of Braced sheeting cuts, Design of Cellular cofferdams.

UNIT- IV

Bridge Substructures: Elements of Bridge substructure, Discharge for design of foundations, Design of pier cap, Design of Pier, Types of Well foundations, Design of well cap, well steining, Well curb, Cutting Edge, Bottom plug, Sinking of wells, tilts and shifts.

Suggested Books

1. Bowles, JE, "*Foundation Analysis & Design*", McGraw-Hill Companies, 2017.
2. Donald P Coduto, "*Foundation Design Principles and Practices*", Pearson, Indian edition, Phi Learning, 2014.
3. Murthy, VNS, "*Advanced Foundation Engineering*", CBS Publishers and Distributors Pvt. Ltd., 2017.
4. Poulos, HG and Davis, E H, "*Pile Foundation Analysis and Design*", John wiley & sons,1980.
5. Tomlinson, M J, "*Foundation Design and Construction*", Prentice Hall, 2003.

MT CE 114: CEMENT COMPOSITE MATERIALS
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	--	4

Course Outcomes:

CO1: Understand the concepts and practical knowledge of modern Civil Engineering techniques for design of steel structures.
CO2: Understand the concepts of plastic analysis and design.
CO3: Analysis and design of elevated circular tanks.
CO4: Analysis and design of light gauge steel.

Unit I

Fibre Reinforced Concrete: Properties of Constituent Materials, Mix Proportions, Mixing and Casting Procedures, Properties of Freshly mixed FRC, Mechanics and properties of Fibre reinforced concrete, Composite Material approach, Application of fibre reinforced concrete.

Unit II

Fly Ash Concrete: Classification of Indian Flyashes, Properties of Flyash, Reaction Mechanism, Proportioning of Flyash concretes, Properties of Flyash concrete in fresh and hardened state, Durability of flyash concrete.

Unit III

Polymer Concrete: Terminology used in polymer concrete, Properties of constituent materials, Ploymer impregnated concrete, Polymer modified concrete, Properties and applications of polymer concrete and polymer impregnated concrete.
Ferro Cement: Constituent materials and their properties, Mechanical properties of fero cement, Construction techniques and application of ferro cement.

Unit IV

High Performance Concrete: Materials for high performance concrete, Supplementary cementing materials, Properties and durability of high performance concrete, Introduction to silica fume concrete, Properties and applications of silica fume concrete.
Light Weight Concrete: Properties of light weight concretes, Pumice concrete, Aerated cement mortars, No fines concrete, Design and applications of light weight concrete
.

Suggested readings:

1. Neville, Adam M., and Jeffrey John Brooks. "*Concrete technology"*. England: Longman Scientific & Technical, 1987.
2. Gambhir, Murari Lal. "*Concrete technology: theory and practice"*. Tata McGraw-Hill Education, 2013.

MT CE 115: FINITE ELEMENT METHOD
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credits
3	1	-	4

Course Outcomes

CO1: Understand basics of FEM to relate stresses and strains.
CO2: Analyse one, two and three dimensional and dynamic problems using FEM.
CO3: Understand the use of the basic finite elements for structural applications using truss, beam, frame, and plane elements;

Unit-I

Differential equilibrium equations - strain displacement relation - linear constitutive relation special cases - Principle of stationary potential energy - application to finite element methods. Some numerical techniques in finite element analysis.

Unit-II

Displacement models - convergence requirements. Natural coordinate systems – Shape function. Interpolation function - Linear and quadratic elements - Lagrange and Serendipity elements - Strain displacement matrix - element stiffness matrix and nodal load vector. Numerical Integration and Modelling Considerations, Element characteristics, Two Dimensional Isoparametric Elements, Some practical applications, some improved elements in two dimensional problems.

Unit-III

Finite elements of a column, Element characteristics, Beams and Frames, Bending of plates, Techniques for Nonlinear Analysis, Three Dimensional Problems in Stress Analysis.

Unit-IV

Analysis of framed Structures, Analysis of plate bending: Basic theory of plate bending - displacement functions - plate bending Elements. Plane stress and plane strain analysis: Triangular elements - Rectangular elements.

Suggested readings:

1. Abel, JF and Desai, CA, "*Finite Element Method*", Van Nostrand Reinhold, New York, 2004.
2. Bathe, KJ, "*Finite Element Procedures*", India Private Limited, New Delhi, 1997.
3. Chandrupatla, TR and Belegundu AD, "*Introduction to Finite Elements in Engineering*", India Private Limited, New Delhi, 1997.
4. Reddy, JN, "*An Introduction to the Finite Element Method*", Tata McGraw Hill, New Delhi, 2003.
5. Zienkiewiez, OC, "*The Finite Element Method*", Mcgraw Hill, London, 1991.

MTCE 116: ANALYSIS AND DESIGN OF HIGH-RISE BUILDINGS
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credits
3	1	-	4

Course Outcomes

CO1: Understand the concepts related to analysis and design of tall buildings.
CO2: Understand the importance of symmetry and regularities in tall buildings.
CO3: Design of Towers and Chimney.
CO4: Understand computer applications for analysis and design of tall buildings.

UNIT-I

Structural systems for multi-storey buildings, gravity and lateral loads on buildings, analysis of multi-storey frames. Behaviour of framed tube, tube-in-tube systems, and bundled tube systems.

UNIT-II

Importance of symmetry and regularity in plan, and regularity in elevation. Analysis for torsion in buildings.
Design of buildings with shear walls and coupled shear walls.

UNIT-III

Chimney Design: General aspects, design factor, stresses in shafts due to self-weight and wind load, stresses in hoop reinforcement, stresses due to temperature gradient, design of chimneys. Design examples

Tower Design: Introduction, design principles, computation of moments due to wind load, wind load analysis with circular group of columns, design examples.

UNIT-IV

Design and detailing of various members and beam-column joints for ductility. The capacity design principle. Performance based design philosophy.
Design of raft and pile foundations. Application of MS-Excel, ETABS and SAFE software for design of tall buildings.

Suggested Books:

1. *Design of Multi Storeyed Buildings, Vol. 1 & 2*, CPWD Publications, 1976
2. Smith, BS and Coull, A, "*Tall Building Structures*", Wiley India, 1991.
3. Schueller, W, "*High Rise Building Structures*", Wiley, 1986
4. Shah, VL, Karve, SR, "*Illustrated Design of Reinforced Concrete Buildings*", (GF+3storeyed), Structures Publications, Pune, 2013
5. Taranath, BS, "*Structural Analysis and Design of Tall Buildings*", Mc-Graw Hill, 1988.
6. Varyani, UH, "*Structural Design of Multi-storeyed Buildings*", 2nd Ed., South Asian Publishers, New Delhi, 2002

MT CE 117: STRUCTURAL HEALTH MONITORING
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	-	4

Course Outcome

CO1: Describe the distress in the structure understanding the causes and factors.

CO2: Assess the health of structure using static field methods.

CO3: Apply dynamic field tests to evaluate the health of structure.

CO4: Apply repairs and rehabilitation measures of the structure

UNIT I

Structural Health: Factors affecting Health of Structures, Causes of Distress, Regular Maintenance. Structural Health Monitoring: Concepts, Various Measures, Structural Safety in Alteration.

UNIT II

Structural Audit: Assessment of Health of Structure, Collapse and Investigation, Investigation Management, SHM Procedures.

Static Field Testing: Types of Static Tests, Simulation and Loading Methods, sensor systems and hardware requirements, Static Response Measurement.

UNIT III

Dynamic Field Testing: Types of Dynamic Field Test, Stress History Data, Dynamic Response Methods, Hardware for Remote Data Acquisition Systems, Remote Structural Health Monitoring.

UNIT IV

Introduction to Repairs and Rehabilitations of Structures: Case Studies (Site Visits), piezo–electric materials and other smart materials, electro–mechanical impedance (EMI) technique, adaptations of EMI technique.

Suggested Readings:

1. Health Monitoring of Structural Materials and Components_Methods with Applications, Douglas E Adams, John Wiley and Sons, 2007.
2. Structural Health Monitoring, Daniel Balageas, Claus_Peter Fritzen, Alfredo Güemes, John Wiley and Sons, 2006.
3. Structural Health Monitoring and Intelligent Infrastructure, Vol1, J. P. Ou, H. Li and Z. D. Duan, Taylor and Francis Group, London, UK, 2006.
4. Structural Health Monitoring with Wafer Active Sensors, Victor Giurglutiu, Academic Press Inc, 2007

MT CE 118: SMART CITIES: INFRASTRUCTURE PLANNING AND MANAGEMENT
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	--	4

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

CO1. Identify the challenges faced by the developing cities.

CO2. Distinguish and understand the similarities and differences among the various definitions of smart cities.

CO3. Understand the dimensions of smart cities.

CO4. Assess current situation of a given city as per the definitions given by Bureau of Indian Standards.

CO5. Understand the concept of smart infrastructure with focus on smart urban energy smart transportation systems and solid waste management.

UNIT –I

Introduction: Introduction to smart cities, urbanization, challenges faced by growing cities, need of transforming a city into a smart city, infrastructure required to enable a smart city. **Global Initiatives and Perspective :** Understanding global and national smart city initiatives, benefits of guidelines to smart and sustainable cities, developing and managing a smart city. Indian perspective for smart infrastructure

UNIT-II

Smart Cities Framework : Smart city as a system, approach by international commission (s), reference framework for smart cities, smart cities reference architecture.
Stakeholders and Challenges : Understanding smart city markets and stake holders, Importance of collaboration withing the city, Indian perspective and challenges.

UNIT –III

Indian Smart City Mission : Indian smart city mission, Key elements of smart city proposals, Features of smart city
ICT Framework: ICT framework for smart infrastructure by Indian Standards, Categorizing standardization activities

UNIT – IV

Societal Integration and Development : Smart Urban Energy Systems, Smart Urban Transportation Systems, Smart Waste Management.
Case studies

Suggested Readings

1. Coletta, C Evans, L, Heaphy, L, Kitchin, R, "*Creating Smart Cities*", published by Routledge, 2019.
2. Sharma, S, "*Smart Cities Unbundled*", published by Bloomsbury, 2018.

3. "*Sustainable Smart Cities in India: Challenges and Future Perspectives",* Editors: Sharma, P, Rajput, S (Eds.), published by Springer, 2017.

MTCE 201: ADVANCED STRUCTURAL ANALYSIS
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credits
3	1	--	4

Course Outcome

CO1: Understand flexibility & stiffness matrix analysis of 2D structures.

CO2: Understand flexibility & stiffness matrix analysis of 3D structures.

CO3: Write computer programs for Matrices of 2D and 3D structural elements.

UNIT- I

Basic Concepts: Degrees of freedom, Static and Kinematic indeterminacy, Stiffness and flexibility, Behaviour of structures - Principle of superposition - Stiffness and flexibility matrices in single, two and n-co-ordinates Stiffness and flexibility for prismatic members and non-prismatic members.

UNIT- II

Direct stiffness method 2D Element: Development of stiffness matrices for Truss element, beam element, Transformation of coordinates, assembly of global matrices-stiffness matrix, load matrix, boundary conditions, and solution techniques. Flexibility method applied to statically determinate and indeterminate structures – Choice of redundant - Transformation of redundant Application to symmetrical structures - Comparison between stiffness and flexibility methods.

UNIT- III

Direct stiffness method 3D Element: Stiffness matrices for Truss element, beam element and grid element, transformation matrix for 3D truss elements & 3D beam element, computer programming, application to practical problems.

UNIT- IV

Analysis of substructures using the stiffness method and flexibility method with tridiagonalization - Analysis by Iteration method - frames with prismatic members - non-prismatic members.

Suggested Books:

1. Jain, AK, "*Advanced Structural Analysis with Computer Applications*", Nem Chand & Bros, Roorkee.
2. Majeed, KI, "*Non-Linear Structural Analysis*", Butterworth Ltd. London.
3. Martin, HC, "*Introduction to Matrix Method of Structural Analysis*", McGraw Hill Book Co.
4. Wang, CK, "*Matrix Method of Structural Analysis*", International Text Book, Pasadena.

MT CE 202: STRUCTURAL DYNAMICS
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	-	4

Course Outcome

CO1: Understand the concept of earthquake occurrence and seismology.
CO2: Attain knowledge of IS 1893:2002 code for earthquake resistant deign of structures.
CO3: Understand the response of structures under dynamic loading.
CO4: Apply the seismic evaluation method for condition assessment of structures

UNIT I

Seismology: Earthquake phenomenon cause of earthquakes-Faults- Plate tectonics Seismic waves- Terms associated with earthquakes-Magnitude/Intensity of an earthquake-scales Energy released-Earthquake measuring instruments- Seismoscope, Seismograph, accelerograph Characteristics of strong ground motions- Seismic zones of India.
Vibrations: Dynamics of Single Degree of Freedom Systems, undamped and damped, free and forced vibrations; Steady-state and transient response, impulse response. Harmonic response

UNIT II

Equation of Motion: Solution of equation of motion; Duhamel Integral method, Response spectra, Fourier transforms and analysis in frequency domain.
Earthquake resistant design: Introduction to IS 1893:2002, Behaviour of buildings and structures during past earthquakes and lessons learnt goals of earthquake resistant design. Linear static procedure for seismic load calculation – IS 1893-2002, Design the 5 storey earthquake resistant structures.

UNIT III

Seismic Waves and Local Site Effects: Body and surface waves; Factors affecting ground motion characteristics; Local site effects basic physical concept, impedance contrast, resonance, basement topography, attenuation, trapping; Basin-edge, topography, ridge, valley, slope; Lateral discontinuity.

UNIT IV

Qualitative Methods of Seismic Evaluation: Rapid visual screening procedure (RVSP) and simplified evaluation of buildings; Visual inspection method and Non-destructive testing (NDT) method.
Quantitative Methods of Seismic Evaluation: Performance based method using nonlinear static push-over analysis (NSP) and non linear dynamic method of analysis (NDP).

Suggested Readings:

1. Chopra, AK, "*Dynamics of Structures*", Pearson Education Limited, 2019.
2. Craig, R R, Jr. and Kurdila, A, "*Fundamentals of Structural Dynamics*", John Wiley & Sons., 2011.
3. Humar, J L, "*Dynamics of Structures",* Taylor & Francis Group, 2012.

4. Katsikadelis, J.T. *Dynamic Analysis of Structures.* Elsevier Science and Technology, 2020.
5. Kramer, S.L. *Geotechnical Earthquake Engineering.* Pearson Education ltd., 2013.
6. Reiter, L. *Earthquake Hazard Analysis.* Columbia University Press, 1991.
7. Paz, Mario and Kim, Y.H. *Structural Dynamics-Theory and Computation.* Springer, 2019.
8. Villaverde, R. *Fundamental Concepts of Earthquake Engineering.* Taylor & Francis., 2009.
9. Wolf, J. P. *Dynamic Soil-Structure Interaction.* Prentice-Hall, 1985.

MTCE 203: ADVANCED CONCRETE TECHNOLOGY
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	--	4

Course Outcome

1. Understand new technology applied in field of advanced construction.
2. Understand, analyze, compare and evaluate the technology used in design of special concretes and special construction methods.
3. Understand the problems associated with construction in extreme weather conditions.
4. Understand the factors affecting fresh and hardened state behaviour of concrete.

UNIT I

Construction Materials: Classifications of Construction Materials. Consideration of physical, mechanical, thermo physical properties, characteristics behaviour under stress, selection criteria for construction materials, green building materials, waste products, reuse and recycling. Materials for making Mortar and concrete, properties, hardening of lime, types of lime, lime concrete uses, cement, aggregates, water, characteristics, properties and uses of Pozzolana materials, Types of mortars, special mortars, properties and applications, admixtures.

UNIT II

Ready-Mix Concrete; Various Methods of Handling and Placing Concrete, accelerated curing, Hot and cold weather concreting, Under water concreting, Rheological behaviour of fresh Concrete-Properties of fresh and hardened concrete-Strength, Elastic properties, Creep and Shrinkage, Variability of concrete strength, Interfacial Transition Zone. Effects of age, aggregate content, and its shape, richness of mix, curing on Strength of Concrete

Pumping of Concrete; Grouting and Mass Concreting Operations, Prestressing, Steel and Composite Construction Methods**,** Fabrication and erection of structures including heavy structures, Prefab construction, Industrialised construction and Modular coordination.

UNIT III

Construction Methods, Construction in Marine Environments, High Rise Construction, Bridge Construction including Segmental Construction, Incremental Construction and Push Launching Techniques; Geosynthetics; Safety, Quality Measures and Reliability.

Corrosion of concrete in various environments. Corrosion of reinforcing steel. Ferro-cement, material and properties. Polymers, fibers and composites, Architectural use and aesthetics of composites. Polymer concrete composites.

UNIT IV

Special concrete such as high strength, Lightweight, heavy weight, vacuum processed, concrete. Mass concrete, high performance concrete, Pumpable concrete, Self-Compacting concrete, Air entrained concrete, Ferro cement, fiber reinforced concrete, Deterioration and repair technology of concrete, Distress and type of repairs.

Non-Destructive testing methods - Semi-destructive testing methods.

Suggested Readings:

1. Duggal, SK, "Building Materials", New Age International Publications, 2006.
2. Gambhir, ML, "*Concrete Technology*", Tata McGraw Hill (Second Edition), 1995.
3. Mehata, PK, Paulo, Monteiro, JM, "*Concrete microstructure, properties & Materials"*, Prentice Hall INC & Mcgraw Hill USA.
4. Neville, AM, Brook, JJ, "*Properties of Concrete*", Addison Wesley, 1999.

5. Orchard, DF, "*Concrete Technology -Vol I. & II*", Applied Science Publishers (Fourth edition), 1963
6. Rangawala, SC, "*Engineering Materials*", Chortor Publications, 1991.
7. Shetty, MS, "*Concrete Technology*" S.Chand & Company New Delhi, 2005.
8. Short, Kenniburg, "*Light Weight Concrete*", Asia Publishing House, Bombay, 1963.

MTCE 204: ADVANCED CONCRETE TECHNOLOGY LABORATORY
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
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Course Outcome

CO1: Design of high-performance concrete.
CO2: Understand the factor affecting properties of concrete.
CO3: Understand the technology used for non-destructive testing of concrete.

List of Experiments

1. Stress-strain behaviour of concrete.
2. Effect of shape and size on compressive strength of concrete.
3. Determination of split tensile strength of concrete its relationship with compressive strength.
4. Determination of modulus of rupture of concrete and its relationship with compressive strength.
5. Effect of curing temperature on concrete strength.
6. Non-destructive testing of concrete.
7. Design of Ultra-high strength concrete
8. Design of High-performance concrete.
9. To determine heat of hydration of Portland Cement and Portland pozzolanic Cement.

Note: The students will be required to carry out atleast 05 experiments / exercises from the above list and any other two experiments either from the above list or designed by the faculty based on the theory course.

MTCE 205: SEMINAR II

M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
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Seminar will be of 45-minute duration during which the presentation will be followed by questions session by the audience comprising faculty and students. Every student shall be required to submit the topic of his/her seminar in consultation with the associated faculty/Mentor well in advance so that the same may be displayed on the notice board. The presenter has to write a report comprising of abstract, literature review, brief details of the background of the topic, methods used, findings and references/list of sources from where the material for presentation has been collected and students need to submit two copies of the seminar report to the department.

The seminar report, the submitted slides, presentation skills and overall attendance will form the basis of the evaluation. There will be no separate final exam for this course.

MTCE 211: DESIGN OF BRIDGES

M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credits
3	1	-	4

Course Outcomes:

1. Understand general consideration and IRC codes related to bridge Engineering
2. Understand the analysis and design of various types of bridges.
3. Analyse the design parameters and response box culverts.
4. Understand the design parameters of bridge substructure.

UNIT-I

General Consideration: Site selection, various types of bridges and their suitability, loads, forces and IRC bridge loading and permissible stresses, Economic Spans.

UNIT-II

Design of RC bridges under concentrated loads using effective width and Pigeauds Method, Courbon's method of load distribution.

UNIT-III

Detail design of T-beam bridge slab culvert and box culverts

UNIT-IV

Bridge substructure and bearings, Design of piers and pier caps. Abutments, Different types of foundations, used for design of substructure.

Suggested readings:

1. Ponnuswamy, S, "*Bridge Engineering*", Tata McGraw Hill
2. Raina, VK, "*Concrete Bridge Practice*", Tata McGraw Hill
3. Raju, NK, "*Design of Bridges*", Oxford & IBH
4. Victor, DJ, "*Essentials of Bridge Engineering*", Oxford & IBH

MTCE 212: THEORY OF PLATES
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credits
3	1	--	4

Course outcomes:
CO1: Understand classical theory of plates and shells
CO2: Importance and applications of plate and shell structures
CO3: Analytical solutions and numerical techniques for design of plate and shells.

Unit-I

Plates: Introduction, Classification of pates, Governing equation of thin rectangular plate, Navier's Method of solution for Rectangular Plates subjected to point load, uniformly distributed load, patch load and linear hydro-static load, Levy's Solution.

Unit-II

Bending of Orthotropic plates and Governing equation of thin rectangular plate, Analysis and Design of Grid flat thin slab system, Governing equation of Circular plate, Triangular plate and Elliptical plate, Structural behaviour of Folded plate roofs, Slab-beam analysis of folded plates, The vibration of plates.

Unit-III

Shells: Introduction, Type of shells, Equation of equilibrium of Spherical Shells, Design of Spherical shells with/without circular ring beam, Equation of Equilibrium of Conical Shells, Umbrella Shells.

Unit-IV

Conical water tank, Design of conical roof including edge beam, Equation of Equilibrium of cylindrical shells, Semi-circular shells, Circular cylindrical shells under axisymmetric loading, Analysis of doubly curved shells, Hipped roof.

Suggested readings:

1. Chatterjee, BK, "*Theory and Design of Concrete Shells*" Spon Press; Revised edition, 1988.
2. Kruas, H, "*Thin Elastic Shells*", John Wiley & Sons Ltd, 1968.
3. Mansfield, EH, "*The Bending and Stretching of Plates*," 2nd edition, Cambridge University Press, 1989.
4. Ramaswamy, GS, "*Design and Construction of Shell Structures*", CBS Publishers, New Delhi, 1996.
5. Timoshenko, SP, and Krieger SW, "*Theory of Plates and Shells*," McGraw-Hill, 1959.

MTCE 213: OFFSHORE STRUCTURES

M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	-	4

Course Outcomes

CO1: Students will acquire knowledge for the Concept of offshore installation
CO2: To get knowledge about transportation of offshore structures
CO3: Students will develop knowledge for the installation of offshore structure
CO4: Student will assimilate the knowledge on various types of offshore materials

UNIT I

Concepts of offshore installations: Fixed and floating structures; Spars and TLP's; Modular topsides and integrated topsides; deck levels and jacket configurations; Spar and TLP hull arrangements;

Fabrication yard, grillage and foundation conditions; Fabrication sequence of Launch jacket, lift jackets, topsides and modules; Weighing and weight control; Skidded, Trailer and lifted Loadout methods;

UNIT II

Transportation: Cargo barges; Launch barges; layout of cargo arrangement; Sea fastening layout and design; Static and dynamic stability of barge; Motion analysis of barge – cargo system; Transportation analysis. Transportation fatigue analysis;

UNIT III

Installation Schemes: Lifting and launch schemes for jackets, upending and setting, on bottom stability; Float-over installations; Dynamics of barge – cargo system;

Installation aids: Launch cradle design; Buoyancy tank design; Lift points – padeyes and trunnions; spreader frame and spreader bar concepts; Mudmat concepts and design methods; Lifting topside modules and towers; Bumpers and guides; Grouting and leveling of jackets;

UNIT IV

Materials for Offshore Applications : Introduction - Factors Affecting Materials selection, Classification of Materials; Structural Steel; Topside Materials- Materials Applications, Materials for Seawater Systems, Materials for Process Piping and Equipment; Material for HPHT Applications- Limitations of Materials for HPHT Application; Advanced Composite Materials; Elastomers; Corrosion Control; Material Reliability and Monitoring; Fracture Control.

Suggested Readings

1. Baris, S, and Tettenborn, A, "*Offshore Contracts and Liabilities (Maritime and Transport Law Library)",* 2014.
2. Chakrabarti, SS, Chakrabarti, SK, "*Hydrodynamics of Offshore Structures",* 2003.
3. Chakrabarti, SK, "*Handbook of Offshore Engineering* (Vol.1 & 2)", Elsevier Publishers, 2005
4. El-Reedy, MA, "*Offshore Structures: Design", Construction and Maintenance*, 2012.
5. Graff, "*Introduction to Offshore Structures: Design, Fabrication, Installation.",* 1981.
6. Offshore Technology Conference Volumes, O.C. Zienkiewicz, R., Wlewis and K.G. Stagg, '*Numerical Methods in offshore Engineering'*, Wiley Interscience Publication, 1978.

MT CE 214: EARTH RETAINING STRUCTURES
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credits
3	1	-	4

Course Outcomes:

CO1: Determine the earth pressure on the retaining wall.
CO2: Analyse the distribution of earth pressure on sheet piles and Coffer Dam.
CO3: Design of earth retaining walls.

UNIT- I

Review of Earth pressure: Introduction, different types and their coefficients, earth pressure as a stability problems, classical theories of earth pressure –Rankine's and Coulomb's theories for active and passive earth pressure, Computation of lateral earth pressure in homogeneous and layered soils in various ground conditions, graphical solutions for Coulomb's theory in active and passive conditions.

UNIT- II

Retaining wall: Types, material, method of construction, nature of forces acting, type of failures of retaining walls, comparison of different earth pressure theories and application in retaining wall. Stability analysis and design aspects, application of theory of elasticity in analysis of earth pressure distribution.

UNIT- III

Sheet Pile and Cofferdam: Type, material, method of construction, distribution of earth pressure and related approximation. Sheet Pile Structures – Types of Sheet piles, cantilever sheet piles in sands and clays, anchored sheet piles – free earth and fixed earth support methods, – types of cofferdam, suitability, merits and demerits – Design of single – wall cofferdams and their stability aspects distinction between Sheet Pile and Retaining wall.

UNIT- IV

Earth Dams: Classification, features of an earth dam, seepage control in embankments and foundations, stability analysis: introduction to analysis based on general failure surfaces, method of slices, use of stability charts, stability of earth dams during different stages - steady seepage, rapid drawdown, end of construction, slope protection, filters, embankment construction materials and construction, quality control, grouting techniques.

Suggested Books

1. Arora, KR, "*Soil Mechanics and Foundation Engineering",* Standard Publishers, 2009.
2. Bowles, J E, "*Foundation Analysis & Design*", McGraw-Hill Companies, 2017.
3. Chris, RI, Clayton, Rick I. Woods, Andrew J. Bond, Jarbas Milititsky, "*Earth Pressure and Earth Retaining Structures*", CRC Press,2013.
4. Das, BM, "*Principles of Foundation Engineering*", Nelson Engineering, 2004.
5. Coduto, DP, "*Foundation Design Principles and Practices*", Pearson, Indian edition, Phi Learning, 2014.
6. *"Earth and Rock-Fill Dams: General Design and Construction Considerations"* by United States Army Corps of Engineers, University Press of the Pacific,2004.

MT CE 215: ADVANCED NUMERICAL ANALYSIS
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credits
3	1	-	4

Course Outcomes:

CO1: Understand the advanced mathematical computation.

CO2: Analyse the different numerical problems by numerical techniques.

UNIT- I

Error analysis, significant digits, inherent errors, numerical errors, absolute and relative error, error propagation, conditioning & stability.

UNIT- II

Solution of linear simultaneous equations, direct and iterative algorithms based on Gauss elimination, Gauss Jordan method, Gauss Seidel method

Numerical solution to non-linear system of equations, bisection method, false position method, Newton-Raphson method, Secant method, fixed point method

UNIT- III

Interpolation formulae, Polynomial forms, linear interpolation, lagrange interpolation polynomial, Newton interpolation polynomial, forward and backward differences

Numerical differentiation by forward difference quotient. Central difference quotient, Richardson extrapolation and numerical integration by Trapezoidal rule, Simpson's 1/3 rule, Romberg integration, Gaussian integration

UNIT- IV

Numerical solution of ordinary differential equations by Taylor series method, Euler's method, Runge-kutta method, Picard's method, Heun's method, polygon Method.

Suggested Books:

1. Akai, TJ, *"Numerical Methods"*, John Wiley & Sons lnc, Singapore,1994.
2. Baron, ML, Salvadori, MG, "Numerical Methods in Engineering" PHI Pvt.Ltd.1963.
3. Shastry, SS, *"Introductory Method of Numerical Analysis*", PHI Pvt.Ltd.,1997
4. Saxena, HC, "Finite Differences and Numerical Analysis", S.Chand& Co.Delhi,2001.

MT CE 216: GEOTECHNICAL EARTHQUAKE ENGINEERING
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	-	4

Course Outcome

CO1: Understand the concept of seismic wave propagation and dynamic soil properties.
CO2: Design of earth retaining walls for seismic load.
CO3: Infer the liquefaction phenomenon and its effects.
CO4: Learn the concept of landslides and slope stability.

UNIT I

Introduction: Background and lessons learnt from damages in past earthquakes.
Wave Propagation: Waves in semi-infinite media – one, two- and three-dimensional wave propagation; Attenuation of stress waves – material and radiation damping; Dispersion, waves in a layered medium.
Dynamic Soil Properties: Stress & strain conditions, concept of stress path; Measurement of seismic response of soil at low and high strain, using laboratory tests; Cyclic triaxial, cyclic direct simple shear, resonant column, shaking table, centrifuge and using field tests - standard penetration test, plate load test, block vibration test, SASW/MASW tests, cross bore hole; Evaluation of damping and elastic coefficients; Stress-strain behavior of cyclically loaded soils; Effect of strain level on the dynamic soil properties; Equivalent linear and cyclic nonlinear models; Static and dynamic characteristics of soils.

UNIT II

Liquefaction: Introduction, pore pressure, liquefaction related phenomena – flow liquefaction and cyclic mobility, factors affecting liquefaction, liquefaction of cohesionless soils and sensitive clays, liquefaction susceptibility; State Criteria –CVR line, SSL, FLS; Evaluation of liquefaction potential: characterization of earthquake loading and liquefaction resistance, cyclic stress ratio, Seed and Idriss method; Effects of liquefaction.

UNIT III

Ground Response Analysis: Introduction, one, two and three dimensional analyses; Equivalent and nonlinear finite element approaches; Introduction to soil-structure interaction.
Earth Pressure: Active and passive earth pressures; Terzaghi's passive wedge theory, numerical methods, earth pressure measurements.; Seismic design of retaining walls: types, modes of failures, static pressure, seismic response (including M-O Method), seismic displacement, design considerations.

UNIT IV

Seismic Slope Stability: Types of earthquake induced landslides; Evaluation of slope stability – stability analysis with dynamic loading, friction circle method, effective and total stress methods of analysis, factor of safety, yield acceleration, damage potential, displacement analysis, effect of saturated and submerged conditions.

Suggested Readings:

1. Day Robert, W, "*Geotechnical Earthquake Engineering Handbook"*, McGraw-Hill. 2001
2. Kameshwara, Rao, NSV, "*Dynamic Soil Tests & Applications"*, Wheeler Publications. 2000
3. Kramer, SL, "*Geotechnical-Earthquake Engineering"*, Pearson Education – Indian Low Price Edition. 2004
4. Prakash, S, "*Soil Dynamics"*, McGraw Hill Book Company. 1981
5. Ranjan, G.and Rao ASR, "*Basic and Applied Soil Mechanics"*, New Age Int. Ltd. 2000
6. Saran, S, "*Soil Dynamics & Machine Foundation"*, Galgotia Publication. 2006

MT CE 217: ANALYSIS AND DESIGN OF TUNNELS
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	--	4

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

CO1. Classify different rock mass and parameters associated with them.

CO2. Demonstrate the understanding of design approach and support methods for tunnels.

CO3. Relate different excavation techniques with sub-strata.

CO4. Understand the concepts of tunneling in soft ground.

UNIT –I

Introduction: Historical review of the development of tunnelling, its advantages and disadvantages.

Classification and Characterization : Classification and Characterization of Rock and Rock Mass, determination of Ground Types, determination of mechanical and hydraulic rock parameters, objectives and methods.

UNIT-II

Geotechnical Design and Tunnel Layout: Introduction to structured design approach, Identification of influencing factors. Analysis of ground behaviour, using closed form solutions and numerical simulations, Support methods, effects and characteristics of supports, Assignment of excavation and support methods to characteristic geotechnical situations, Analysis of system behaviour; estimation of stresses and deformation, structural design of shotcrete linings, Special measures in soft soils, for tunnels with high overburden, and tunnels below the groundwater table.

UNIT –III

Conventional and Mechanical Excavation Techniques including basics in TBM : Excavation Methods, Excavation by Drilling and Blasting, Mechanized excavation Techniques, Excavation of large and deep tunnels and Caverns, Methods of Sinking Shafts.

Design of Tunnels: Determination of appropriate location, size, shape and alignment, Assessment of behavior of tunneling media - deformation modulus and support pressure measurement, instrumentation and monitoring of rockmass performance, application of numerical modelling in space design, earthquake effects on tunnels, design of underground space in rocks with the help of field data.

UNIT – IV

Soft ground tunnelling : Design considerations, lining type, short term and long-term behavior, subsidence, instrumentation and monitoring, case study.

Case studies of planning and design : Metro, highway tunnel, underground station, storage of oil & gas, food, Water/sewage treatment plants, immersed tunnels.

Suggested Readings

1. Heidelberg, VB, Lunardi, P, "Design and construction of tunnels", Springer, 2008.
2. Jimeno, Carcedo, Jimeno, "*Drilling and blasting of rocks"*.
3. Whittaker, BN, Frith, RC, "*Tunnelling: Design, Stability and Construction Books*" IMM publication, 1990

4. Whittaker, and Frith, "*Planning design and construction of tunnels"*.

MT CE 218: ADVANCED STEEL STRUCTURES DESIGN
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
3	1	--	4

Course Outcomes:

CO1: Understand the concepts and practical knowledge of modern Civil Engineering techniques for design of steel structures.
CO2: Understand the concepts of plastic analysis and design.
CO3: Analysis and design of elevated circular tanks.
CO4: Analysis and design of light gauge steel.

Unit I

Planning of industrial structures, Design of braced and unbraced industrial portals in steel, Design of gantry girder, Design of single and multi bay industrial sheds in steel. Design of tie rods, sag rods, grit angles.

Unit II

Transmission Line Towers, Analysis by Tension Coefficients, Member Selection; Steel Tanks and Stacks, Different Configurations and components of Elevated Circular Tanks.

Unit III

Plastic Design, Plastic Hinge, Plastic Collapse Load, Plastic Analysis of Frames; Wind Loads on Industrial Buildings, Design of Purlins, Braced and Unbraced Section.

Unit IV

Machine foundations, Design of foundations for impact and rotary and reciprocating type machines. Analysis and design of Virendeel Girders. Design in Light Gauge Steel; Aluminum Structures; Residual Stresses

Suggested readings:

1. Arya, AS and Ajmani JL, "*Design of Steel Structures*" Nem Chand & Bros., Roorkee, 1996.
2. Dayaratnam, P, "*Design of Steel Structures*" Wheeler Publishers, Allahabad, 1996
3. Neal, BG, "*Plastic Analysis of Structures*" Chapman Hall, London, 1977
4. Raz, SA, "*Structural Design in Steel*", New Age International Publishers, New Delhi, 2002.

MT CE 301: DISSERTATION PHASE-I
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
-	-	--	10

Every student will carry out dissertation under the supervision of a Supervisor(s). The topic shall be approved by a Committee constituted by the Head of the concerned Department. Every student will be required to present two seminar talks, first at the beginning of the Dissertation (Phase-I) to present the scope of the work and to finalize the topic, and second towards the end of the semester, presenting the work carried out by him/her in the semester. The committee constituted will screen both the presentations so as to award the grades. A student scoring 'F' grade (Fail) shall have to improve this grade before continuing his/her Dissertation in the 4th semester failing which he/she shall have to repeat the Dissertation (Phase-I) next time in the next semester.

MT CE 302: RESEARCH METHODOLOGY
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
4	2	--	6

Course Outcomes:

CO1: Understand research problem, meaning and design.
CO2: Apply the computer tools in research.
CO3: Understanding of research ethics.

UNIT –I

Introduction of Research Methodology: Concept of research and its applications: characteristics features, objectives, scope, reliability and validity of research, Scientific process: Meaning and Definition, Steps involved in research process, a brief history of scientific process.

Formulation of research problem: Objectives of research problem. Research Design-Meaning, Need and features of good research design, defining problem, preparing research design analysis and interpretation of data, Basic Principles of Experimental Techniques.

UNIT II

Scientific Methodology: Meaning, Scope, Primary sources of literature survey- journal, patents etc. Secondary sources of literature survey - books, reference books, text books. Paper Writing and preparation of Dissertation: Basic concepts of paper writing - Steps of paper writing, Methods of presentation, Precautions in preparing the research Dissertation – Concepts of bibliography and annexure, Discussion of results, Drawing conclusions, Giving suggestion and recommendation of concerned persons.

UNIT III

Computer Applications: a. Spreadsheet tool: Introduction to spread-sheet applications, features & functions, using formulae & functions, data storing, features for statistical data analysis, generating charts/graphs & other features. Tools: Microsoft Excel, Open office and similar or other advanced tools b. Presentation tool: Introduction to presentation tool, features & functions, creating presentations, customising presentation. [Tools used: Microsoft Power point, Open Office or any other tool]

UNIT IV

Measurement Scales and Evaluation: Concepts of Measurement Scales; Primary Levels of Measurement; Classification of Measurement Scales; Validity and Reliability Analysis
Scholarly Writing Characteristics of Scholarly Writing; Standard Guidelines; Critical Reviews; Research Proposals; Research Reports; Thesis/Dissertations; Research Papers; Impact Factor of Journals; Citation and Acknowledgement; Plagiarism and Self-Plagiarism; Reproducibility and Accountability

Suggested Readings:

1. Bowen, W. G. and Rudenstine, N. L. *In pursuit of the Ph.D*. Princeton University Press, 1992.
2. Davis, G. B. and Parker, C. A. *Writing the Doctoral Dissertation: A Systematic Approach.* 3rd Edition, Barron's Educational Series, 2012.
3. Gash, S. *Effective Literature Searching for Research*. 2nd Revised ed., Gower, 1989
4. Kothari, C. R. and Garg, G. *Research Methodology: Methods and Techniques.* 4th Multi-Colour Edition, New Age International Publishers, 2019.

5. Kumar, R. *Research Methodology: A Step-by-step Guide for Beginners.* 4th ed., Sage Publications, 2014.
6. Lester, J. D. and Lester, J. D. Jr., *Writing Research Papers: A Complete Guide*. 15th ed., Longman, 2014.

MT CE 401: DISSERTATION PHASE-II
M. TECH (CIVIL) STRUCTURAL ENGINEERING

L	T	P	Credit
-	-	--	30

The Dissertation Phase-1 will be continued as Dissertation Phase-II in 4th Semester. The award of the grades shall be done by an internal Committee constituted by the Head of the Department. This assessment shall be based on presentation (s), report, etc. before this committee. In case a student scores 'F' grade, failing which he/ she will not be allowed to submit the dissertation. At the end of the semester, every student will be required to submit three bound copies of his/her Master's dissertation of the office of the concerned Department. Out of these, one copy will be kept for department record & one copy shall be for the supervisor. A copy of the dissertation will be sent to the external examiner by mail by the concerned department, after his/her appointment and intimation from the university. Dissertation will be evaluated by a committee of examiners consisting of the Head of the Department, dissertation supervisor(s) and one external examiner. There shall be no requirement of a separate evaluation report on the Master Dissertation from the external examiner. The external examiner shall be appointed by the University from a panel of examiners submitted by the respective Supervisor to the HoD. The student shall defend his/her dissertation through presentation before this committee and the committee will award the grades. Student scoring 'F' grade in the exam shall have to resubmit his /her Dissertation after making all correction / improvements and this dissertation shall be evaluated as above.