CURRICULUM AND DETAILED SYLLABI

FOR

M.TECH DEGREE PROGRAMME

IN

CIVIL ENGINEERING

STRUCTURAL ENGINEERING

SEMESTERS I TO IV

2022 SCHEME

(AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)

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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

M. TECH DEGREE PROGRAMME

IN

STRUCTURAL ENGINEERING

(2022 scheme)

CURRICULUM AND DETAILED SYLLABI

Items	Board of Studies (BoS)	Academic Council (AC)
Date of Approval	05.08.2022	29.08.2022
	28.02.2023	20.03.2023

Head of Department
Chairman, Board of Studies

Dr. JISHA S.V.
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MAR BASELIOS COLLEGE OF ENGINEERING & TECHNOLOGY
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Principal
Chairman, Academic Council

Principal
Mar Baselios College
of Engineering & Technology
Mar Ivanios Vidyanagar, Nalanchira
Thiruvananthapuram-695015

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Vision and Mission of the Institution

Vision:

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

Mission:

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

DEPARTMENT OF CIVIL ENGINEERING

Vision and Mission of the Department

Vision:

To be a Centre of Excellence in Civil Engineering education with a global perspective, creating ethically strong engineers for the service of society.

Mission:

To provide Engineering Education which can create exemplary professional Civil Engineers of high ethics with strong conceptual foundation coupled with practical insight, to serve the industry and community.

DEPARTMENT OF CIVIL ENGINEERING

M.Tech. Structural Engineering

For the students admitted from 2022-23

Scheduling of Courses

i) Knowledge Segments and Credits

Every course of M. Tech Programme is placed in one of the eight categories as listed in Table 1 below. No semester shall have more than six lecture-based courses and two laboratory courses, and/or project courses in the curriculum.

Table 1: Credit distribution and the Knowledge Domains

Sl. No.	Category	Category Code	Number of Courses	Total Credits
1	Discipline core courses	DCC	2	6
2	Programme Core Courses	PCC	3	9
3	Laboratory Courses	LBC	2	2
4	Programme Elective Courses	PEC	4	12
5	Mandatory Credit Course (Research Methodology & IPR)	RM	1	2
6	Industry/Interdisciplinary Elective	IEC	1	3
7	Internship	PR	1	3
8	Mini Project		1	2
9	Project		2	27
10	MOOC	MOOC	1	2
11	Audit course	AC	1	-
Total Mandatory Credits				**68**

*Note: 68 credits have been the requirement for award of degree in all M.Tech Programmes of the College which was approved by the University.

ii) Semester-wise Credit Distribution

Semester	**I**	**II**	**III**	**IV**	**Total Credits**
Credits for Courses	18	18	16	16	**68**

Semester I							
Slot	**Category Code**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
A	DCC	22CE060A	Advanced Numerical Methods and Optimization	3	0	0	3
B	PCC	22CE161A	Advanced Solid Mechanics	3	0	0	3
C	PCC	22CE161B	Advanced Theory and Design of RCC Structures	3	0	0	3
D	PEC	22CE16XX	Programme Elective 1	3	0	0	3
E	PEC	22CE16XX	Programme Elective 2	3	0	0	3
S	RM	22MC061A	Research Methodology & IPR	2	0	0	2
T	LBC	22CE169A	Structural Engineering and Design Lab	0	0	2	1
Total				**17**	**0**	**2**	**18**

Semester II							
Slot	**Category Code**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
A	DCC	22CE060B	Finite Element Methods in Engineering	3	0	0	3
B	PCC	22CE161C	Structural Dynamics	3	0	0	3
C	PEC	22CE16XX	Programme Elective 3	3	0	0	3
D	PEC	22CE16XX	Programme Elective 4	3	0	0	3
E	IEC	22CE16XX	Industry/Interdisciplinary Elective	3	0	0	3
S	PR	22CE167A	Mini Project	0	0	4	2
T	LBC	22CE169B	Structural Dynamics and FEM Lab	0	0	2	1
Total				**15**	**0**	**6**	**18**

Semester III							
Slot	**Category Code**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
A	MOOC		MOOC				2
B	AC	22AC171X	Audit Course	3	0	0	
U	PR	22CE177A	Internship				3
W	PR	22CE178A	Dissertation Phase I Research Project Phase I	0	0	17	11
Total				**6**	**0**	**17**	**16**

Semester IV							
Slot	**Category Code**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
W	PR	22CE178B	Dissertation Phase II Research Project Phase II	0	0	24	16
Total				**0**	**0**	**24**	**16**

ELECTIVE BASKET

Category Code	Course Number	Course Name	L	T	P	Credit
PEC	22CE162A	Earthquake Resistant Design of Structures	3	0	0	3
	22CE162B	Theory of Plates and Shells	3	0	0	3
	22CE162C	Design of Bridges	3	0	0	3
	22CE162D	Aluminium and Steel Structures	3	0	0	3
	22CE162E	Composite Structures	3	0	0	3
	22CE162F	Advanced Prestressed Concrete Design	3	0	0	3

	22CE162G	Stability of Structures	3	0	0	3
	22CE162H	High Rise Structures	3	0	0	3
	22CE162I	Fracture Mechanics	3	0	0	3
	22CE162J	Design of offshore structures	3	0	0	3
	22CE162K	Behaviour of Structural Materials and Instrumentation	3	0	0	3
	22CE162L	Soil Structure Interaction	3	0	0	3
	22CE162M	Structural Reliability	3	0	0	3
	22CE162N	Random Vibration	3	0	0	3
	22CE162O	Structural Health Monitoring	3	0	0	3
	22CE162P	Forensic Engineering and Rehabilitation	3	0	0	3

INTERDISCIPLINARY COURSES

Slot	Category Code	Course Number	Course Name	L	T	P	Credit
E	IEC	22CE165A	Mechanics of composite materials	3	0	0	3
		22CE165B	Random Vibrations	3	0	0	3
		22CE165C	Project Management	3	0	0	3

INDUSTRY ELECTIVE COURSES

Slot	Category Code	Course Number	Course Name	L	T	P	Credit
E	IEC	22CE166A	Wind Analysis of Structure and Cladding Components	3	0	0	3
		22CE166B	Soil Investigation and Design of Substructures	3	0	0	3
		22CE166C	Design of Infrastructure services	3	0	0	3
		22CE166D	Advanced Finite Element Methods	3	0	0	3

DETAILED SYLLABI

STRUCTURAL ENGINEERING

DISCIPLINE CORE COURSES (DCC)

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE060A	Advanced Numerical Methods and Optimisation	DCC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to expose the students to different numerical solutions and to impart the ability to apply mathematics and optimizing techniques for finding solutions to real time problems.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Solve a system of linear and non-linear algebraic equations.	Apply
CO2	Apply interpolation and data smoothening techniques.	Analyse
CO3	Solve ordinary differential equations of boundary value type and partial differential equations.	Apply
CO4	Illustrate the framework of structural optimisation problems.	Analyse
CO5	Apply linear and non-linear programming methods for structural optimisation.	Apply

iii) SYLLABUS

Introduction to numerical methods- errors in numerical methods; System of linear algebraic equations, Systems of non-linear equations - Newton-Raphson method.
Quadratic and Cubic splines, Multiple linear regression; Numerical integration, Ordinary differential equations of the boundary value type - Finite difference solution; Partial differential equations Introduction to structural optimisation; Linear Programming, Duality of linear programming, Non- Linear Programming problems, Formulation of geometric programming.

v) REFERENCES:

1) Akai, T. J., *Applied Numerical Methods for Engineers*, Wiley publishers, 1994
2) Chapra, S. C. and Canale, R. P., *Numerical Methods for Engineers,* Mc Graw Hill, 7th edition, 2015.
3) Grewal, B. S., *Numerical Methods in Engineering and Science*, Khanna Publishers, 11th Edition, 2017.

4) Rao S. S., *Engineering Optimisation – Theory and Practice*, 4th edition, John Wiley & Sons, Inc., 2009.

5) Deb, K., *Optimisation for Engineering Design – Algorithms and examples*, 2nd edition, Prentice Hall, 2013.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to numerical methods**: errors in numerical methods; System of linear algebraic equations- Gauss Elimination, factorization and Gauss Seidel iteration; Eigen Value problems- power method; Systems of non-linear equations - Newton-Raphson method.	**10**
II	**Quadratic and Cubic splines:** Data smoothing by least squares criterion -Non-polynomial models like exponential model and power equation; Multiple linear regression; Numerical integration- Newton – Cotes open quadrature.	**8**
III	**Ordinary differential equations**: Boundary value type - Finite difference solution; Partial differential equations - Parabolic equations - Explicit finite difference method, Crank-Nicholson implicit method; Ellipse equations.	**8**
IV	**Introduction to structural optimization**: Unconstrained and constrained optimization problems - Problem formulation with examples; Linear Programming - Simplex method, Two phase solution, Duality of linear programming.	**9**
V	**Non-Linear Programming problems**: Unconstrained optimisation Techniques-Direct search method, Random search, Uni-variate pattern search, Descent methods. Formulation of geometric programming.	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE060B	Finite Element Methods in Engineering	DCC	3	0	0	3	2022

i) COURSE OBJECTIVES:

This course imparts an understanding of fundamental knowledge and technique of FEM. This course enables the students to develop tools to analyse engineering problems using FEM and typical commercial FEA packages.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Apply the fundamental concept of theory of elasticity and finite element method in developing the equilibrium equations	Apply
CO2	Develop knowledge to find the stresses and strains using the fundamentals of theory of elasticity	Apply
CO3	Analyse the structural members using energy principles	Analyse
CO4	Develop the shape functions of different elements	Apply
CO5	Analyse the stiffness matrix and Nodal load vector for bar beam and CST elements	Analyse
CO6	Apply the isoparametric formulation to determine the stresses of different elements	Apply

iii) SYLLABUS

Fundamentals of theory of elasticity- Equations of equilibrium, Strain-displacement relation, compatibility conditions, constitutive relation; Energy principles- Introduction to weighted residual methods; Evolution of FEM, Review of direct stiffness method, Outline of the FE procedure; Element properties, convergence requirements, equilibrium and compatibility in the solution; Types of finite elements; Shape functions; Development of stiffness matrix and nodal load vector for bar, beam and CST elements, Concept of iso parametric formulation; Computer Implementation of FEM procedure.

iv) REFERENCES

1. Cook, R. D., Malkus, D. S., Plesha, M. E. and Witt, R. J., *Concepts and Applications of Finite Element Analysis*, John Wiley & Sons, 4th Edition, 2001.
2. Krishnamoorthy, C. S., *Finite Element Analysis: Theory and Programming*, Tata McGraw Hill, 2nd edition, 2007.
3. Bathe, K. J., *Finite Element Procedures in Engineering Analysis*, Prentice Hall, 2nd edition, 2009.
4. Zienkiewicz, O. C. and Taylor, R. W., *Finite Element Method*, Elsevier Butterworth-Heinemann, 5th edition, 2005.
5. Chandrupatla, T. R. and Belegundu, A. D., *Introduction to Finite Elements in Engineering*, Pearson Education, 4th edition, 2012.
6. Hutton, D. V., *Fundamentals of Finite Element Analysis*, Tata McGraw Hill, 1st edition, 2004.
7. Mukhopadhyay, M. and Abdul Hamid Sheikh, *Matrix and Finite Element Analyses of Structures*, Ane Books, 1st edition, 2015.
8. Timeshenko, S. P. and Goodier, J. N., *Theory of Elasticity*, Mc-Graw Hill Education Private Ltd., 3rd edition, 2010.

9) Srinath, L. S., *Advanced mechanics of Solids*, Tata McGraw-Hill, 3rd edition, 2010.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of theory of elasticity**- Concept of Stress and Strain, Stress tensor, Stain tensor, Equations of equilibrium, Strain-displacement relation, Compatibility conditions, Constitutive relation **Energy principles**- Principle of virtual work, Principle of stationary potential energy; Variational formulation- Rayleigh-Ritz method	**10**
II	**Introduction to FEM**- Evolution of FEM, Review of direct stiffness method, Outline of the FE procedure; Element properties- Displacement functions, convergence requirements, equilibrium and compatibility in the solution, Development of equilibrium equation	**8**
III	**Types of finite elements**- Development of shape functions for bar and beam, CST, LST; Lagrange and Serendipity elements; Plane stress and plane strain problems. Introduction to axisymmetric elements; Types of 3D	**8**

	elements	
IV	**Development of stiffness matrix-** bar, beam and CST elements **Development of consistent nodal load vector-** bar, beam and CST elements	**10**
V	**Concept of isoparametric formulation**- Line element and Plane bilinear element; Gauss quadrature technique **Computer Implementation of FEM procedure-** Pre-Processing, Solution, Post-Processing, Use of Commercial FEA Software	**9**
	Total hours	**45**

PROGRAM CORE COURSES (PCC)

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE161A	Advanced Solid Mechanics	PCC	3	0	0	3	2022

i) COURSE OBJECTIVES:

This course is intended to expand on the basic principles established in Solid Mechanics and familiarise the students with basic equations of elasticity in 3D. The students are exposed to two dimensional problems in Cartesian and Polar coordinates and different failure criteria which enhances their skill and capability in analysing and solving problems in Civil Engineering.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Apply the concepts, principles and governing equations in the evaluation of stresses and strains of elastic solids in 3D	Apply
CO2	Analyse the transformation of stresses and strains in 3D	Analyse
CO3	Analyse solid mechanics problems using classical methods and energy methods	Analyse
CO4	Apply the different failure criteria's in understanding modes of failure in simple structural systems	Apply
CO5	Apply the concept of elastic behaviour of solids in solving plane stress and plane strain problems using polar coordinates and cartesian coordinates system	Apply

iii) SYLLABUS

Analysis of stress in 3D - Analysis of strain in 3D - Stress Strain relations – Failure theories- Two dimensional problems in Rectangular coordinates - Two dimensional problems in polar coordinates

iv) REFERENCES

1) Timeshanko, S. P. and Goodier, J. N., *Theory of Elasticity*, McGraw Hill Education Private Ltd., 3rd edition, 2010.
2) Boreis, A. P., Schmidt, R. J.,*Advanced Mechanics of Materials*, John Wiley & Sons, 6th edition, 2002.
3) Srinath, L. S., *Advanced Mechanics of Solids*, Tata McGra-Hill, 3rd edition, 2009.

4) Cook, R.D., Young, W.C., *Advanced Mechanics of Materials*, Prentice Hall, 2nd edition, 1999.

5) Sadd, M. H., *Elasticity: Theory, Applications and Numerics*, Academic Press, 3rd edition, 2014.

6) Ameen, M., *Computational Elasticity*, Narosa Publishing House, 2009.

7) Sitharam, T.G. and Govindaraju, L., *Applied Elasticity*, Interline Publishing Pvt. Ltd., 2008.

8) Singh, S., *Experimental Stress Analysis*, Khanna Publisher, 4th edition, 2017.

9) Volterra, E. and Gaines, J. H., *Advanced Strength of Materials*, Prentice Hall Publication, New York, USA, 2000.

10) Wang, C. T., *Applied Elasticity*, McGraw Hill Publication, NY, USA, 2000.

11) Singh, S., *Theory of Elasticity*, Khanna Publisher, 4th edition, 2013.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Analysis of stress in 3D:** Introduction to stress tensor components, Stress Components, Equilibrium Equations, Stress on Oblique Plane through a point, Stress Transformation, Principal Stresses, Stress Invariants, Hydrostatic and Deviatoric Stresses, Octahedral Stresses, Stress Boundary Condition Problem	**9**
II	**Analysis of strain in 3D:** Introduction to Strain tensor – Strain displacement relations for small deformations– Compatibility conditions – Strain transformations– Principal strains – Strain invariants, Octahedral strains, Hydrostatic and deviatoric strains(no derivation required)	**8**
III	**Stress Strain relations**: General Hooke's law and its reduction for isotropic and orthotropic materials, Boundary value problems of elasticity – Displacement, Traction and Mixed types. Navier's Equations, Beltrami-Michell's Equations (no derivation required) Strain Energy Density, Complementary Internal Energy Density, Elasticity and Strain Energy Density, Elasticity and Complementary Internal Energy Density, Saint Venant's principle, Uniqueness of Solution	**9**
IV	**Two dimensional problems in Rectangular coordinates**: Plane stress and plane strain problems - Airy's stress function -Solution by polynomials – Bending of cantilever loaded at	**9**

	free end, Bending of simply supported beam with udl	
V	**Two dimensional problems in polar coordinates**: General equations - Equilibrium equations, Strain displacement relations and Stress strain relations, compatibility relations (no derivation required). Biharmonic equations and Airy's stress functions- Pure bending of curved beams Problems of axisymmetric stress distributions - Thick cylinders - Stress concentration due to circular hole in plates (Kirsch's problem) Modes of failure, yield failure criteria, Maximum Principal Stress Criteria, Maximum Shear stress criteria, Maximum Strain Criteria, Maximum Strain Energy Density Criteria, Von Mises Criteria, Stress Concentration Factor	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE161B	Advanced Theory and Design of RCC Structures	PCC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to expose the students to the basic concepts of design and ductile detailing of reinforced concrete structures. It introduces the design and detailing of special RCC structures. It also provides an introduction to strut and tie model of design. This course also deals with the beam-column joints and the design using suitable software.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Design RCC flexural and compression members and provide their ductile detailing.	Analyse
CO2	Apply the standard procedure to calculate defection and cracking in flexural members	Apply
CO3	Design special RCC members such as pile cap, flat slab, ribbed slab and shear wall	Analyse
CO4	Apply the concept of strut and tie model in the design of corbels, deep beams and beam-column joints	Apply
CO5	EvaluateRCC buildings using any relevant software	Evaluate

iii) SYLLABUS

Basic theory and design philosophies-Advanced theory in Stress-strain characteristics of concrete, Design concepts-Limit state method-Estimation of deflection and control of cracking, -Design of special RC member, Strut and Tie Models- Development, RCC beam – column joints, different types of walls and their applications in structural systems

iv) REFERENCES:

1) Nilson, A. H., Darwin, D. and Dolan, C. W., *Design of Concrete Structures*, Tata Mc-Graw Hill Book Co., New York, 2016.
2) Park, R. and Paulay, T., *Reinforced Concrete Structures*, John Wiley & Sons, New York, 1975.

3) DevadasMenon and UnnikrishnaPillai, S. Reinforced Concrete Design, Tata McGraw Hill Pvt. Ltd., New Delhi, 2017.
4) Jain, A. K., *Reinforced Concrete: Limit State Design*, Nem Chand and Brothers, Roorkee, 2012.
5) Thomas, T. C., *Unified Theory of Reinforced Concrete*, CRC Press, London, 2015.
6) Varghese, P. C, *Advanced of Reinforced Concrete Design*, Prentice Hall of India Pvt Ltd, 2010.
7) IS 456 : 2000 (Reaffirmed 2005), *Plain and Reinforced Concrete Code of Practice*, Bureau of Indian Standards, New Delhi, 2005.
8) SP 16 : 1980, *Design Aids for Reinforced Concrete to IS 456:2000,* Bureau of Indian Standards, New Delhi, 1999
9) IS 13920 : 2016, *Ductile Design and Detailing of Reinforced Concrete Structures subjected to Seismic Forces - Code of Practice*, Bureau of Indian Standards, New Delhi, 2016.
10) BS 8110:1997, *Structural use of concrete — Part 1: Code of practice for design and construction,* British Standard, 1997
11) ACI 318:1995, *Building Code Requirements for Structural Concrete*, American Concrete Institute, MI, 1995
12) EN 1992-1-1 2004: *Design of concrete structures - Part 1-1: General rules and rules for buildings*, Eurocode 2, 2004.
13) ECP 203:2007, *Egyptian Code for Design and Construction of Concrete Structures,* Arab Republic of Eygpt, 2007.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Basic theory and design philosophies**: Advanced theory in stress-strain characteristics of concrete under uniaxial and multi axial states of stress, confined concrete, Effect of cyclic loading on concrete and reinforcing steel, Stress block parameters. **Design and Ductile detailing of structural members**: General principles of ductile detailing, factors that increase ductility, specifications of materials for ductility, design and ductile detailing of flexural and compression members.	**12**
II	**Deflection of reinforced concrete flexural members**: Introduction, Short-term and long-term deflection of flexural members due to imposed loads. **Cracking in concrete members:** Introduction, factors affecting crack width in beams, mechanisms of flexural cracking, calculation of crack width, estimation of crack width in beams as per IS 456:2000, BS 8110:1997, ACI 318:1995, BS EN 1992-1-1 2004, ECP 203:2007.	**7**

III	**Design of special RCC members**: Design of pile cap, flat slab, ribbed slab, shear wall	**12**
IV	**Strut and Tie model and design:** Strut-tie model, identify the regions in various structural components, flow of forces, identify locations and details of reinforcement based on strut and tie models, apply strut and tie model to the design of deep beams, corbels and beam-column joints.	**7**
V	**Joints and Walls Joints:** Beam-column joint modes of failure, and necessary design considerations to address these failure modes; design and detailing of various beam- column joints, describe different types of walls and their applications in structural systems. **Software in design of RCC buildings:** Design of building frames using any relevant design software.	**7**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE161C	Structural Dynamics	PCC	3	0	0	3	2022

i) COURSE OBJECTIVES:

This course deals with free and forced vibration characteristics of single degrees of freedom and multi degree of freedom systems. It also deals with the frequencies and mode shapes of the beam with different end conditions (distributed mass system).

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Model single and multi-degree freedom systems for dynamic analysis and develop equations of motion	Apply
CO 2	Analyse the free and forced vibration characteristics of a single degree of freedom system.	Analyse
CO 3	Analyse the free and forced vibration characteristics of a multi degree of freedom system	Analyse
CO 4	Analyse vibration isolation systems	Analyse
CO 5	Identify the vibration characteristics of distributed parameter systems	Apply

iii) SYLLABUS:

Importance of vibration studies. Systems with single degree of freedom - Free andforced vibration with and without damping - Response to support motion. Multi-degree of freedom systems (Lumped mass) - Evaluation of natural frequencies and mode shapes - Coordinate coupling - Orthogonality of normal modes - Forced vibration analysis of multi-degree of freedom systems - Mode superposition method. Vibration isolation- Distributed mass (continuous) systems - Axial vibration of rods - Flexural vibration of single span beams - Evaluation of frequencies and mode shapes.

iv) REFERENCES:

1) Paz, M., *Structural Dynamics - Theory and Computation*, CBS Publishers and Distributors, 2nd edition, 2004.
2) Mukhopadhyay, M., *Structural Dynamics - Vibrations and Systems*, Ane Books, 2nd edition, 2008.
3) Chopra, A. K., *Dynamics of Structures- Theory and Application to Earthquake Engineering*, Pearson Education, 1st edition, 2001.
4) Clough, R. W. and Penzien, J., *Dynamics of Structures*, McGraw Hill, 2nd edition, 1996.
5) Humar, J., *Dynamics of Structures*, CRC Press, 3rd edition, 2012.
6) Thomson, W. T., *Theory of Vibration with Application*, Pearson Education, 5th edition, 1998.
7) Weaver, W., Timoshenko, S. P. and Young, D. H., *Vibration Problems in Engineering*, John Wiley & Sons, 5th edition, 1992.

v) COURSE PLAN:

Module	Contents	No. of hours
I	Vibration studies and its importance to structural engineering applications – Types of dynamic loading – Systems with single degree of freedom – Elements of a vibratory system – Mathematical model for single degree of freedom systems - Equation of motion. Undamped and damped free vibration of single degree of freedom system. Measurement of damping from free vibration response - Logarithmic decrement	**9**
II	Response of single degree of freedom systems to harmonic loading, Measurement of damping from forced response – Half power band width method. Impulse response function, Response of single degree of freedom systems subjected to impulse, periodic and general loading- Duhamel integral. Single degree freedom subjected to support motion. Vibration isolation –Transmissibility.	**10**
III	Multi-degree of freedom systems – Equation of motion. Shear building concept and models for dynamic analysis – Evaluation of natural frequencies and mode shapes by solution of characteristic equation. Co-ordinate coupling - Orthogonality of normal modes	**10**
IV	Forced vibration analysis of multi-degree of freedom systems - Mode superposition method of analysis. Response of multi degree of freedom systems to support	**9**

	motion. Vibration isolation- Vibration measuring instruments - Methods of vibration control - Tuned mass damper	
V	Distributed mass systems - Axial vibration of rods - Flexural vibration of single span beams - simply supported beam, cantilever beam and fixed beam - Evaluation of frequencies and mode shapes –Variational formulation of the equation of motion – Hamilton's principle - Lagrange's equation.	**7**
	Total hours	**45**

PROGRAM ELECTIVE COURSES (PEC)

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162A	Earthquake Resistant Design of Structures	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

This course imparts the basic concept about seismology and seismic design of structures. This course also deals with different methods for the seismic analysis of buildings.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Apply the basic concept of seismology in developing the response spectra	Apply
CO2	Determine the seismic response of framed RCC structures using different static and dynamic methods	Apply
CO3	Design the masonry structures for earthquake loads	Apply
CO4	Evaluate the seismic response of structure using finite element software package	Evaluate

iii) SYLLABUS

Elements of earthquake engineering;Seismic performance of structures and structural components during earthquakes; Response spectrum, design spectrum; Seismic Design Philosophy; Seismic analysis of RCC buildings- Equivalent static analysis, response spectrum analysis, mode superposition method, Time history analysis, Push over analysis;Seismic protection of structures; Seismic Design of masonry buildings;Analysis and design of building systems to Earthquake Loads (Hands on session using packages like ETABS).

iv) REFERENCES:

1) Duggal, S. K., *Earthquake Resistant Design of Structures*, Oxford University Press, 2nd edition, 2007.
2) Mario Paz, Structural Dynamics - *Theory and Computations*, CBS Publishers, 6th edition, 2018.
3) PankajAgarwal and Manish Shrikhande, *Earthquake Resistant Design of Structures*, Prentice Hall, 5th edition, 2009.
4) Jai Krishna, A. R., Chandrasekharan, A. R. and Brijesh Chandra, *Elements of Earthquake Engineering*, South Asian Publishers, 2nd edition, 2001.
5) Anil, K. Chopra, *Dynamics of Structures*, Pearson Education, 5th edition, 2007.

6) Clough and Penzien, *Dynamics of Structures*, McGraw Hill, 4th edition, 2008.
7) IS 1893 (Part 1) : 2016, *Criteria for Earthquake Resistant Design of Structures*, Bureau of Indian Standards, New Delhi, 2016.
8) IS 4326: 2013, *Earthquake Resistant Design and Construction of Buildings - Code of Practice*, Bureau of Indian Standards, New Delhi, 2013.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Earthquake seismology** – Causes of earthquake, Plate tectonics, Earthquake fault sources, Seismic waves, Elastic rebound theory, Quantification of earthquake, Intensity and magnitudes, Earthquake source models.	**7**
II	**Basic Concepts**: Seismic performance of structures and structural components during earthquakes; Ground motion parameters; Response spectrum, design spectrum; Seismic design philosophy, capacity design;	**9**
III	**Seismic Analysis of RCC Buildings**: Equivalent static analysis, response spectrum analysis, mode superposition method; Time history analysis. Push over analysis - Introduction - Modern concepts **Seismic Protection of Structures**: Basic elements of seismic isolation; Seismic dampers - Types of Dampers	**10**
IV	**Seismic Design of Masonry Buildings:** Box Action and Provision of Bands, Restoration and Strengthening Methods.	**9**
V	**Computer Aided Analysis and Design** Computer Analysis and design of Building systems to Earthquake Loads – Hands on session using packages like ETABS.	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162B	Theory of Plates and Shells	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES

Goal of this course is to impart an understanding on various thin walled structures in the form of plates and shells suitable for their use in various structural systems. It develops an ability to study the behaviour of the plates and shells with variable geometry under the action of different types of loads. An ability to apply these concepts in structures is also developed.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Analyse the deformations developed in different plates subjected to various loading and support conditions	Analyse
CO2	Analyse the deformations developed in different shells subjected to various loading conditions	Analyse
CO3	Apply the concepts of classical plate theory in analysing special forms of plates and shells	Apply

iii) SYLLABUS

Introduction to plates, Pure bending of plates, Deflections of laterally loaded plates, Simply supported rectangular plates, Classical Plate theory, Circular plates, Annular plates, Introduction to shells, General theories of cylindrical shells, Theory of folded plates, Special forms of shells

iv) REFERENCES

1) Timoshenko, S.P. and Krieger, S. W., *Theory of Plates and Shells*, Tata McGraw Hill, 2nd edition, 2017.
2) Chandrashekhara, K., *Theory of Shells*, Universities (India) Press Ltd., 2009.
3) Ramaswamy, G. S., *Design and Construction of Concrete Shell Roofs*, CBS Publishers, 2nd edition, 2018.
4) Kelkar, V. S. and Sewell, R.T., *Fundamentals of the Analysis and Design of Shell Structures*, Prentice Hall Inc., 2014.
5) Varadan, T. K. and Bhaskar, K., *Analysis of Plates – Theory and Problems*, Narosa Publishing Co., 2016.
6) Reddy, J. N., *Theory and Analysis of Plates and Shells*, Taylor and Francis, 2nd edition, 2012.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to plates:** Classification of plates – thin, thick plates; Assumptions in the theory of thin plates - Differential equation to bending of long rectangular plates to a cylindrical surface, isotropic and anisotropic plates. **Pure bending of plates:** Relation between slope and curvature, bending moments and curvature; Particular cases of pure bending.	**9**
II	**Deflections of laterally loaded plates:** Differential equation for small deflections in laterally loaded plates **Simply supported rectangular plates:** Solution by Navier's method and Levy's method **Classical Plate theory:** Orthotropic plates, layered plates; Mindlin's plate theory.	**9**
III	**Circular plates:** Differential equations for symmetrical bending of circular plates - uniformly loaded circular plates with simply supported and fixed edges. **Annular plates:** Plates subjected to uniform moments and shear forces along the boundaries.	**9**
IV	**Introduction to shells:** Classifications, Membrane theory of shells, application to spherical, conical and cylindrical shells, Deformation of shells without bending - definitions and notations; shells in the form of a surface of revolution and loaded symmetrically with respect to their axis.	**9**
V	**Theory of folded plates**: Concepts, Classification of folded plates, Aspects of reinforced concrete folded plates **Special forms of shells:** Hyperbolic shells, hyperbolic paraboloid shells and Conoids; applications of these inn structures.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162C	Design of Bridges	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

This course is to expose the students to the fundamentals of design of bridges by imparting knowledge on the various methods of analysis of loads acting on different types of bridge structures using IRC codes.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Analyse the deck slab based on various support conditions.	Analyse
CO2	Design RC deck slab, T-beam and slab, single vent box girder and balanced cantilever bridges by the standard procedures in IRC codes.	Analyse
CO3	Design prestressed concrete bridges.	Analyse
CO4	Analyse the behaviour of substructure, foundation and bearings of bridges.	Analyse

iii) SYLLABUS:

Introduction to Bridge Engineering: types of bridges, forces and design criteria, IRC loads, Bridge Deck Analysis- Design of RCC deck slab, T-beam and slab, box girder, balanced cantilever bridge, Analysis and design of Prestressed concrete bridge, Design of substructure and foundation, bearings

iv) REFERENCES:

1) Victor, D. J., *Essentials of Bridge Engineering*, 6th Edition, Oxford, IBH publishing Co., Ltd, 201.
2) Jagadish, T.R. and Jayaram, M.A., *Design of Bridge Structures*, 6th edition, 2009.
3) Raju, N. K., *Prestressed Concrete Bridges*, CBS Publishers & Distributors,Mc-GrawHill Education, 6th edition, 2018.
4) Raju, N. K., *Design of Bridges*, Oxford and IBH Publishing Co., Ltd., 5th edition, 2019.
5) Baker, R. M. and Puckett, J. A., *Design of Highway Bridges an LRFD Approach*, Wiley Publications, 4th edition, 2021.
6) Vazirani, V.N. Ratvani, M.M. and Aswani, M.G., *Design of Concrete Bridges*, Khanna Publishers, 5th edition, 2006.
7) IRC: 6-2017, *Standard Specifications and Code of Practice for Road Bridges, Section-II Loads and Load Combinations (Seventh Revision),* Indian Road Congress, New Delhi, 2017.

8) IRC: 22-2015, *Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (Limit States Design) (Third Revision),* Indian Road Congress, New Delhi, 2015.
9) IRC: 112-2011, *Code of Practice for Concrete Road Bridges*, Indian Road Congress, New Delhi, 2011.
10) IRC: 78-2014, *Standard Specifications and Code of Practice for Road Bridges, Section VII-Foundations and Substructures*, Indian Road Congress, New Delhi, 2014.
11) IRC: 83, 2018, Part II, *Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings (Elastomeric Bearings),* Indian Road Congress, New Delhi, Second Revision, 2018.
12) IS 456-2000, (Reaffirmed 2005), *Plain and Reinforced Concrete Code of Practice*, Bureau of Indian Standards, New Delhi, 2005.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Bridge Engineering:** Components on bridge structures, Planning of bridges - Bridge types and selection criteria - Geometric design considerations - Highway bridge loads as per IRC codes - Load combinations **Bridge Deck Analysis:** Simplified deck analysis and load distribution methods (Pigeaud, Courbon, Morrice-Little, Hendry- Jaegar methods)	**9**
II	**R. C. Bridges:** Design of R. C bridge decks-slab bridges- Straight and skew slab bridges - Design of T beam bridges	**9**
III	**Other Bridges:** Introduction - continuous girder bridges, rigid frame bridges, arch bridges, suspension bridges and cable stayed bridges **Box girder bridges**: Design of box girder (Single cell only) **Balanced Cantilever Bridge:** Design of Balanced cantilever bridge	**9**
IV	**Pre-stressed Concrete Bridges**: Design of single span bridges- Introduction to various forms - Slab bridges-girder bridges- box girder	**9**
V	**Substructure:** parts of substructures, types of substructures, Loads acting on substructures, Design of pier and pier cap, Design of different types of foundation – Open & well foundation **Bearings:** Forces, types - Design of elastomeric bearings- expansion joints	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162D	Aluminium and Steel Structures	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

To help the students develop an ability to perform analysis and design of steel members and their connections. It enables students to identify steel structural members based on their behaviour. An expertise to professional and contemporary issues in advanced steel design is also acquired.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Design various types of connections in steel structures	Analyse
CO2	Design crane and gantry girders and outline the layout and roof system of industrial buildings	Analyse
CO3	Design light gauge steel structures	Analyse
CO4	Design aluminium structures	Analyse

iii) SYLLABUS:

Design Philosophies, Connections, Beam to column connections, Splices, Industrial buildings and gantry girders, Steel-Concrete Composite structures, Light gauge steel structures and aluminum structures.

iv) REFERENCES:

1) Dayaratnam, P., *Design of Steel Structures*, S. Chand Publishing, 1stedition, 2015.
2) Subramanian, N., *Design of Steel Structures*, Oxford University Press, 2015.
3) Ramchandra, Gehlot, V.,*Design of Steel Structures 2*, Scientific publishers, 19th edition, 2016.
4) Duggal, S.K., *Design of Steel Structures*, McGraw Hill Education; 3rd edition, 2017.
5) Wie-Wen, Y., *Cold-Formed Steel Structures*, John Wiley & Sons, 4thedition, 2019.
6) Johnson, R.P., *Composite Structures in Steel and Concrete*, Blackwell Scientific Publications, UK, 2nd edition, 2008.
7) IS 800: 2007, *General Construction in Steel – Code of Practice*, Bureau of Indian Standards, New Delhi, Third Revision, 2007.
8) IS 801 : 1975 (Reaffirmed 2010), *Code of Practice for use of Cold formed Light gauge Steel Structural members in General Building Construction*, Bureau of Indian Standards, New Delhi, First Revision, 2010.
9) IS 8147: 1976 (Reaffirmed 2006), *Code of Practice for use of Aluminium alloys in Structures*, Bureau of Indian Standards, New Delhi, First Revision, 2006.
10) IS 811 : 1987 (Reaffirmed 2004), *Specification for Cold Formed Light Gauge Structural Steel Sections*, Bureau of Indian Standards, New Delhi, Second Revision, 2004.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Design Philosophies:** Existing methods, Introduction to Limit State Design. **Connections:** - Classification (Simple, Rigid, Semi rigid), Beam to Column and Beam to Beam connections , web angle and end plate connections; defects in connections	9
II	**Beam to column connections:** Seat angle, stiffened beam seat connection; lug angles and shear lag **Splices:** Need for splices, Beam and column splices, bolted and welded splices; Prying force.	9
III	**Column Bases:** Design of slab base and gusseted base; eccentrically loaded base plate **Special connections:** Connections from column base to footings - anchor bolts and shear connectors	9
IV	**Industrial buildings:** Layout, Roof System, Design of crane and gantry girders **Steel-Concrete Composite structures:** Composite behaviour, Connections for composite action, composite sections under positive and negative bending (concepts only)	9
V	**Light gauge steel structures:** Types of sections, basic terminology; Form factor; Design of tension, compression members and beams, local and post buckling of thin sections **Aluminium Structures**: Introduction, Stress-strain relationship, Permissible stresses; Design of Aluminium members – Tension members, Compression members and Beams	9
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162E	Composite Structures	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to expose the students to the concepts of composite materials that are finding immense application in the field of aerospace, automobile and civil engineering presently due to its outstanding material capability. It deals with the fundamentals of composite materials for designing composite structures in various fields.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Choose different composites based on their application and manufacturing processes	Apply
CO2	Examine the models, failure and stress/strain criteria of different types of lamina	Apply
CO3	Examine the micro mechanical behaviour of composite laminates	Apply
CO4	Examine the strength and failure analysis of laminates	Apply
CO5	Deduce the governing equations to solve the deflection of composite beams and plates	Analyse

iii) SYLLABUS

Introduction to composites, Composite Fundamentals, Structural applications of Composite Materials, Manufacturing Processes. Mechanics of Composite Lamina, Failure theories. Micro Mechanical Behaviour of Composite Laminates - Classical Lamination Theory, stress- strain variation, In-plane forces, bending and twisting moments, special cases of laminate stiffness. Laminate strength analysis procedure, Failure envelopes, Free-Edge Inter laminar Effects, Analysis of free edge inter-laminar stresses, Effects of stacking sequence- Bending and Buckling of Laminated Beams and Plates.

iv) REFERENCES:

1) Reddy, J. N, *Mechanics of Laminated Composite Plates: Theory and Analysis*, CRC Press, 2nd edition, 2003.
2) Ronald F. Gibson, *Principles of Composite Material Mechanics* ,CRC Press, 4thedition, 2016.
3) Jones M. Roberts, *Mechanics of Composite Materials*, Taylor and Francis, 2nd edition, 1999.
4) Calcote, L. R., *Analysis of Laminated Composite Structures*, Van Nostrand, 1stedition, 1969.

5) Vinson, J. R. And Chou, T. W., *Composite materials and their use in Structures*, Applied Science Publications Ltd., London, 1975.

6) Agarwal,B. D. And Broutman, L. J., *Analysis and performance of Fibre composites*, Wiley, 3rdedition, 1990.

7) Ever J. Barbero, *Introduction to Composite Materials Design*, CRC Press, 2nd edition, 2014**.**

v) COURSEPLAN

Module	Contents	No. of hours
I	**Composite Fundamentals:** Definition of composites - constituents-Classification of composites –Structural applications of Composite Materials – Manufacturing Processes. Review of Basic Mechanics of Materials Equations and Linear Elasticity in 3D and 2-D plane stress and plane strain	**8**
II	**Lamina Stress-Strain Relationships:** Number of elastic constants and reduction from 81 to 2 for different materials. Stress-Strain relations for a uni-directional and orthotropic lamina Effective Moduli of a continuous fibre-reinforced lamina: Models based on mechanics of materials and theory of elasticity - Failure of Continuous Fibre-reinforced orthotropic Lamina - Maximum stress/strain criteria, Tsai-Hill and Tsai-Wu criterion.	**8**
III	**Micro-mechanical behaviour of composite laminates:** Classical Lamination Theory, stress-strain variation, In- plane forces, bending and twisting moments, special cases of laminate stiffness.	**9**
IV	**Analysis of Laminates:** Laminate strength analysis procedure – Failure envelopes – Progressive failure Analysis. Free-Edge Inter laminar Effects – Analysis of free edge inter laminar stresses-Effects of stacking sequence-Hygro-thermal effects on material properties inlaminates.	**10**
V	**Bending of Laminated Beams and Plates:** Governing equations and boundary conditions - Solution techniques - deflection of composite beams and plates under transverse loads for different boundary conditions	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162F	Advanced Prestressed Concrete Design	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to make students familiar with the concepts and design of typical pre- stressed concrete structural elements and to have knowledge about the provisions in the code of practice.

ii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO1	Analyse determinate and indeterminate prestressed concrete section	Analyse
CO2	Examine the loss of pretensioning, post tensioning and transfer of prestress in the pretensioned concretemembers.	Apply
CO3	Design the prestressed concrete members for flexure, shear, torsion by the concept of limit state method	Analyse
CO4	Calculate the short term and long term deflection of prestressed concrete members as per IS code	Apply
CO5	Design prestressed concrete liquid retaining structures and pipes.	Analyse

iii) SYLLABUS

Basic concept and principles of pre-stressed concrete systems, Analysis for flexure, Loss Of pre-stress, Design philosophy and design for flexure, shear and torsion, Codal provisions, Calculation of deflection (short & long term), Design of PSC slabs, Design of compression members, prestressing of statically indeterminate structures, Transfer of prestress, Design of End block.

iv) REFERENCES:

1) Dayaratnam, P., *Prestressed Concrete Structures*, Oxford & IBH Publishing Co., 7^{th}edition, 2017.
2) Krishna, R.N., *Prestressed Concrete*, Tata McGraw Hill Publishing Company Ltd., New Delhi, 6^{th}edition ,2018.
3) Lin, T.Y. and Ned H.B., *Design of Prestressed Concrete Structures*, John Wiley and sons, New York, 3^{rd}edition, 2010.
4) Praveen, N., *Prestressed Concrete Design*, Pearson Education India, Delhi, 1^{st}edition, 2013.
5) IS 1343 – 2012 (Reaffirmed 2012), *Pre-stressed Concrete Code of Practice*, Bureau of

Indian Standards, 2012.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction:** Principles – advantages – materials for prestressed concrete - definition of Type I, Type II and Type III structures – requirements. **Methods of prestressing**– pre-tensioning and post- tensioning – anchorage systems. **Analysis**: Assumptions – Analysis of Prestress – Resultant Stresses at a section –Thrust Line – Concept of load balancing – Stresses in tendons – Cracking Moment. **Loss of Prestress**- Stages of losses, Types of losses in pre-tensioning and post-tensioning due to Elastic shortening, Shrinkage, Creep, Relaxation, Anchorage Slip, Friction - Concept of reduction factor.	**10**
II	**Design for flexure**: Philosophy - limit states - concepts - collapse and serviceability - service load - basic requirements - stress range approach - Lin's approach - Magnel's approach - cable layouts. **Design for shear:** Shear and principal stresses - limit state shearing resistance of cracked and uncracked sections - design of shear reinforcement by limit state approach. **Design for torsion:** Behaviour under torsion - modes of failure - design for combined torsion, shear and bending as per IS 1343: 2012.	**10**
III	**Deflection:** Deflection - short- and long-term deflection of uncracked and cracked members as per IS 1343: 2012 Design and analysis of post and pre-tensioned PSC slabs. **Prestressing of statically indeterminate structures:** Advantages, Effect, Method of achieving continuity, Primary, Secondary and Resultant moments, Pressure line, Concept of Linear transformation, Guyon's theorem, Concordant cable profile.	**8**

IV	**Design of Compression members** (Concepts only, no design expected): - Design of compression members with and without flexure, its application in the design of Piles, Flag masts and similar structures. **Tanks and pipes:** Circular prestressing in liquid retaining tanks - analysis for stresses - design of tank wall. PSC pipes - types - design of non-cylinder pipes (Codal provisions only).	**8**
V	**Transfer of prestress**: Transmission of prestressingforce by bond in pretensioned members - Transmission length - Factors affecting transmission length - check for transmission length - transverse tensile stresses Anchorage zone stresses in post-tensioned members - Magnel's method - Calculation of bearing stress and bursting tensile forces - code provisions - Reinforcement in anchorage zone.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162G	Stability of Structures	PEC	3	0	0	3	2022

i) COURSEOBJECTIVES:

Goal of this course is to expose the students to buckling phenomenon that occurs in the structures like columns, beam-columns, frames, plates and shells which helps them to understand the stability of various structures.

ii) COURSEOUTCOMES:

After the completion of the course the student will be able to:

CO1	Examine the stability of columns using deformation theories.	Apply
CO2	Examine the behaviour of imperfect columns.	Apply
CO3	Apply energy methods for calculating the critical load of columns and plates	Apply
CO4	Examine the buckling of built-up columns, beams, beam-columns and frames.	Apply
CO5	Determine the torsional buckling of columns and the lateral buckling of beams	Apply

iii) SYLLABUS

BucklingofColumns-MethodsofNeutralEquilibrium,LargeDeformationTheoryforColumns, Energy method for calculating critical loads, Buckling of Beam Columns, TorsionalBuckling,BucklingofFrames,StabilityofaframebyMatrixAnalysis,BucklingofPlates, Instability of shells

iv) REFERENCES:

1) Timoshenko, S. P. And Gere, J. M., *Theory of Elastic Stability,* Dover Publications, 2nd edition, 2009.
2) Chajes, A., *Principles of Structural Stability Theory*, Prentice Hall Inc., 1974.
3) Iyenger, N. G. R., *Structural Stability of columns and plates*, Affiliated East West Press Pvt. Ltd., 1990.
4) Allen, H. G. And Bulson, P. S., *Background to Buckling*, Mc-Graw Hill Book Co., 1980.
5) Galambos, T. V., *Structural Members and Frames*, Dover Publications Inc., 1st edition, 2016.
6) Galambos, T. V. And Surovek, A. E., *Structural Stability of Steel: Concepts and Applications for Structural Engineers*, Wiley, 1st edition, 2008.

v) COURSEPLAN

Module	Contents	No. of hours
I	**Buckling of Columns:** Introduction-Concepts of Stability-Methods of Neutral Equilibrium - Euler Column - Eigen Value Problem – Axially Loaded Column - Effective Length Concept and Design Curve. Large Deformation Theory for Columns.	9
II	**Behaviour of Imperfect Columns:** Initially bent column-Eccentrically Loaded Column. Inelastic Buckling of Columns-Double Modulus Theory-Tangent Modulus Theory. Energy method for calculating critical loads: Rayleigh Ritz Method-Galerkin Method	9
III	**Buckling of Built-up Columns:** Non-prismatic members-Effect of shear on critical Loads. **Beams and Beam Columns:** Introduction - Beam Column with Concentrated and Distributed Loads - Effect of Axial Load on Bending Stiffness. Design of Beam Columns-Interaction Formula.	9
IV	**Buckling of Frames:** Introduction-Modes of Buckling-Critical Load using Neutral Equilibrium Methods. Stability of a frame by Matrix Analysis. **Torsional Buckling:** Torsional and Torsional-Flexural Buckling of Columns, Lateral Buckling of Beams. Continuous beams with axial load.	9
V	**Buckling of Plates:** Differential Equation of Plate Buckling-Critical Load of a plate uniformly compressed in one direction. Tension field behaviour in Plate Girder Webs - Post-buckling behaviour of axially compressed plates. Instability of shells.	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162H	High Rise Structures	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES

Goal of this course is to impart knowledge in fundamental and latest concepts of high rise structures and structural systems. It also deals with various techniques in the analysis and design of tallstructures subjected to wind.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Design tall structures subjected to different loading conditions.	Analyse
CO2	Design foundations of RCC chimney as per the standards.	Analyse
CO3	Apply the concept of wind loads to estimate its effects on tall structures.	Apply
CO4	Evaluate the performance of tall structures designed using relevant software.	Evaluate

iii) SYLLABUS

Tall structures, Structural systems, design considerations of Transmission tower, Cooling towers, RCC Chimney and its foundations, effects of wind on tall structures, application of software in analysis and design of high rise structures.

iv) REFERENCES:

1) Bryan, S. and Alex, C., *Tall Building Structures*, Wiley, 1st edition, 1991.
2) Manohar, S. N., *Tall Chimneys-Design and Construction*, Tata McGraw-Hill, 1st edition, 2008.
3) Murthy, S. S. and Santhakumar, A. R., *Transmission Line Structures*, McGraw-Hill, 3rd edition, 2010.
4) Relevant IS codes (IS 4998 (Part 1): 1992 (Reaffirmed 2012), IS 6533 (Part 2): 1989 (Reaffirmed 2003), IS 6533 (Part 2): 1989 (Reaffirmed 2003)), Bureau of Indian Standards, New Delhi.
5) Raju, K. N., *Advanced Reinforced Concrete Design*, University Press, 4th edition, 2007.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Tall Buildings:** Structural Concept, Configurations, Need for tall structures **Structural systems:** Various structural systems, Rigid frame	9

	Structures, Braced frames, Infilled frames, Shear walls, Coupled shear walls, Wall frame structures, Tubular structures, core structures, outrigger braced structures, Design of any two structural system.	
II	**Transmission towers:** Configuration, bracing system, design of a tower for vertical, transverse and longitudinal loads.	**9**
III	**Cooling towers:** Types, components, design forces, analysis and design of a typical cooling tower.	**9**
IV	**RCC Chimney and its foundation:**, Types of chimneys, elastic design concept and limit state design concept, design of RCC chimney based on these concepts, foundations for chimneys, design of raft and pile foundations.	**9**
V	**Wind on tall structures:** Static and dynamic effects of wind, wind load analysis, structural design considerations, analysis of wind on tall structures. **Software for analysis:** Analysis and design of a tall structure using STAAD.Pro/ETABS	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162I	Fracture Mechanics	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to expose the students to Significance of fracture mechanics and enhance their problem-solving skills. It introduces Linear Elastic Fracture Mechanics, Elastic Plastic Fracture Mechanics, Experimental and Modelling tools and Numerical Simulation of plain concrete fracture experiments.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Solve fracture parameters by applying the concepts of linear elastic fracture mechanics	Analyse
CO 2	Solve fracture parameters by applying the concepts of elastic plastic fracture mechanics	Analyse
CO 3	Identify the experimental and modelling tools associated with fracture processes of concrete and non-metals	Apply
CO 4	Examine crack propagation using Computational Fracture Mechanics	Apply

iii) SYLLABUS

Significance of fracture mechanics, Griffith energy balance approach, Irwin's modification to the Griffith theory, Stress intensity approach, Cack tip plasticity, Fracture toughness, sub-critical crack growth, Linear Elastic Fracture Mechanics (LEFM), Cack Tip Plasticity, LEFM Testing, Plane strain and plane stress fracture toughness testing, Elastic Plastic Fracture Mechanics (EPFM), Fatigue Cack Growth, Sustained Load Fracture, Experimental and Modelling tools, Numerical Simulation of plain concrete fracture experiments.

iv) (a) TEXT BOOKS

1) Anderson, T.L, *Fracture Mechanics Fundamentals and Applications*, CRC Press, 4th edition, 2017.
2) Broek, D., *Elementary Engineering Fracture Mechanics*, MartinusNijhoff Publishers, 2nd edition, 1986.
3) Mier, J. G. M., *Fracture Processes of ConcreteAssessment of Material Parameters for Fracture Models*, CRC Press, 1st edition, 2017.

b) REFERENCES:

1) Janssen, M., Zuidema, J. and Wanhill, R., *Fracture Mechanics*, CRC Press, 2nd edition, 2004.
2) Broek, D. The Practical Use of Fracture Mechanics – Kluwer Academic Publishers, 1989.
3) Hellan, D., *Introduction to Fracture Mechanics*, McGraw-Hill Inc. US, 1984.

4) Kumar, P., *Elements of Fracture Mechanics*, McGraw-Hill Education Private Limited, 2014.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction**, Significance of fracture mechanics, Griffith energy balance approach, Relations for practical use, Irwin's modification to the Griffith theory, Stress intensity approach, Crack tip plasticity, Fracture toughness, sub-critical crack growth, Influence of material behaviour, I, II & III modes, Mixed mode problems. **Linear Elastic Fracture Mechanics (LEFM),** Elastic stress field approach, Mode I elastic stress field equations, Stress intensity factors (SIF),Energy Release Rate	**9**
II	**Crack Tip Plasticity,** Irwin plastic zone size, Shape of plastic zone, State of stress in the crack tip region, Influence of stress state on fracture behaviour, Slow stable crack growth and R-curve concept, Description of crack resistance. Determination of R-curves, , Practical use of fracture toughness and R-curve data.	**9**
III	**Elastic Plastic Fracture Mechanics (EPFM),** Development of EPFM, J-integral, Crack opening displacement (COD) approach, COD design curve, Relation between J and COD, Tearingmodulus concept, Fatigue Crack Growth: - Description of fatigue crack growth using stress intensity factor, Effects of stress ratio and crack tip plasticity – crack closure,	**9**
IV	**Fracture Processes of Concrete:** Cracking in concrete and concrete structures, Mechanical behaviour of Concrete in compression. tension, shear and multiaxial state of stress **Experimental and Modelling tools,** Load- versus displacement-controlled testing. Importance of boundary Conditions, Specimen selection, Need for standard testing, Fictitious crack model, Lattice model **Fracture mechanics for structural analysis**, Analysis of bond-slip between steel and concrete, Analysis of anchor pull-out, Evaluation of brittleness of structures	**11**
V	**Computational Fracture Mechanics** The Finite Element Method. The Boundary Integral Equation Method. Mesh Design. Linear Elastic Convergence Study, Analysis of Growing Cracks Conventional Finite Elements, Special Crack Tip Elements, Quarter Point Eight Node Isoparametric Elements. **Fracture Mechanisms in Nonmetals** Fracture Toughness of Fiber Reinforced Brittle Matrix Composites Crack	**7**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162J	Design of Offshore Structures	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to make students familiar with the concepts and design of offshore structures and to have knowledge about the provisions in the code of practice.

ii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO 1	Examine the basic tasks regarding dimensioning and structural design of offshore structures.	Apply
CO 2	Estimate the maximum forces on an offshore structure due to operational loads and conduct static and dynamic analyses of fixed platforms.	Apply
CO 3	Design jacket platforms, tubular joints and concrete gravity platforms.	Analyse
CO 4	Estimate the resistance of platforms against fatigue and accidental loads.	Apply
CO 5	Examine the corrosion mechanism and its preventive methods	Apply

iii) SYLLABUS

Offshore structures – types-conceptual development - Basics of wave motion-wave theories-wave kinematics-random waves-wave spectrum-wave breaking - Loads on offshore structures-operational Loads - environmental loads – Morison equation- Wave forces on large structures-Linear diffraction theory - materials-allowable stresses-design methods and code provisions of API and, DNV- Principles of static and dynamic analysis of jacket platforms- Analytical modeling of jacket platforms- Design principles of Concrete offshore platforms-Jack up platforms -Compliant platforms- Tension Leg Platforms and Spar platforms- -Design of tubular members and joints – simple design problems- Fatigue analysis- Submarine pipelines-design procedure-thickness calculations.

iv) REFERENCES:

1) Chakrabarti S.K., *Hydrodynamics of Offshore Structures*, WIT Press Publications, 2001.
2) Chandrasekaran, S., *Dynamic Analysis and Design of Ocean Structures*, Springer, 2019.
3) DNV-RP-C203- *Fatigue Design of Offshore Steel Structures*, 2019.
4) DNV-RP-C204- *Design Against Accidental Loads,* 2019.
5) DNV-RP-B101-*Corrosion Protection of Floating Protection and Storage Units*, 2015.

6) API RP 2A. *Planning, Designing and Constructing Fixed Offshore Platforms*, API. 2014.
7) Gerwick, B.C., Jr.,*Construction of Marine and Offshore Structures*, CRC Press, Florida, 2007.
8) Clauss, G, Lehmann, E.andOstergaard, C., *Offshore Structures*, Vol. 1 & 2, Springer-Verlag, 1994.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Types of offshore structures and their conceptual development**- Fixed, Compliant, Floating-Analytical models for offshore structures- Behaviour under static and dynamic loads- Materials and construction of jacket and gravity platforms **Statutory regulations**- Allowable stresses- Design methods and Code Provisions- Design specification of API, DNV, Lloyd's and other Classification Societies.	8
II	**Environmental loads**- Wind, wave, current and ice loads- Calculation based on maximum base shear and overturning moments- Design wave height and spectral definition- Morison's Equation-Maximum wave force on offshore structure- Concept of return waves- Principles of static and dynamic analyses of fixed platforms **Use of approximate methods**- Principles of WSD and LRFD- Allowable stresses and partial safety factors- Design of structural elements.	11
III	**Introduction to tubular members**- Slenderness effect- Column buckling-Tubular joints- Possible modes of failure, Eccentric connections and offset connections-Cylindrical and rectangular structural members- Inplane and multi plane connections- Parameters of inplane tubular joints- Kuang's formulae **Elastic stress distribution**- Punching shear stress- Overlapping braces- Stress concentration- Chord collapse and ring stiffener spacing- Stiffened tubes- External hydrostatic pressure- Fatigue of tubular joints- Fatigue behaviour- S-N curves- Palmgren-Miner cumulative damage rule- Design of tubular joints as per API Code.	11
IV	**Design against accidental loads- Fire, Blast and Collision**- Behaviour of steel at elevated temperature-Fire rating for Hydrocarbon fire- Design of structures for high temperature-Blast mitigation-Blast walls- Collision of boats and energy absorption.	8
V	**Corrosion**- Corrosion mechanism- Types of corrosion- Offshore structure corrosion zones- Biological corrosion- Preventive measures of corrosion- Principles of cathode protection systems- Sacrificial anode method and impressed current method- Online corrosion monitoring- Corrosion fatigue.	7
	Total hours.	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162K	Behaviour of Structural Material and Instrumentation	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to familiarize the students regarding the estimation of properties of the materials used in concrete. The course also aims to expose the students to different types ofconcrete, their mix design and evaluation of strength of concrete by destructive and non-destructive methods.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Examine the suitability of materials used for preparing RCC	Apply
CO 2	Examine the different types of concretes and their properties	Apply
CO 3	Apply the codal provisions to design concrete mix	Apply
CO 4	Choose different retrofitting techniques based on the type of damage	Apply
CO 5	Apply different NDT techniques to determine the quality of concrete.	Apply
CO 6	Examine the load, strain and displacement using different instrumentation systems	Apply

iii) SYLLABUS

Components of concrete, special concrete, mix design of various types of concrete, properties of hardened concrete, durability test, non-destructive testing, instrumentation and testing of reinforced concrete members.

iv) REFERENCES:

1) Nevile, A. M., *Properties of Concrete*, Pearson, 5th edition, 2011.
2) Mehta, P. K. and Monteiro, P. J. M., *Concrete: Microstructure, Properties and Materials,* McGraw Hill, 4th edition, 2006.
3) Santhakumar, A. R., *Concrete Technology*, Oxford University Press, 2nd edition, 2018.
4) Zongjin, L., *Advanced Concrete Technology,* John Wiley and Sons, Inc., Hoboken, New Jersey, 2011.
5) Krishnaraju, N., *Design of Concrete Mixes*, CBS Publishers, 4th edition, 2010.
6) Prasad, J., Nair, C. G. K., *Non-Destructive Test and Evaluation of Materials*, Mc-Graw Hill, 2nd edition, 2011.

7) Jan, G .M. V. M., *Fracture Processes of Concrete: Assessment of Material Parameters for Fracture Models,* CRP Press, 1997.
8) IS 10262: 2019, *Concrete Mix Proportioning – Guidelines*, Bureau of Indian Standards, New Delhi, India, 2019.
9) IS 1489 (Part 1): 2015, *Specification for Portland Pozzolana Cement*, Bureau of Indian Standards, New Delhi, 2015.
10) IS 383: 2016, *Specification for Coarse and Fine Aggregates from Natural Sources for Concrete (Third revision)*, Bureau of Indian Standards, New Delhi,2016.
11) IS 2386 (Part III) : 1963, *Methods of Test for Aggregates for Concrete - Specific Gravity, Density, Voids, Absorption and Bulking,* Bureau of Indian Standards, New Delhi,1963.
12) IS 516 – 1959, *Method of Tests for Strength of Concrete*, Bureau of Indian Standards, New Delhi,1959.
13) IS 456: 2000 (Reaffirmed 2005), *Plain and Reinforced Concrete Code of Practice*, Bureau of Indian Standards, New Delhi, 2005.
14) IS 2770 (Part I) : 1967 (Reaffirmed 2007), *Methods of Testing Bond in Reinforced Concrete*, Bureau of Indian Standards, New Delhi,1967.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Concrete Components**: Cement – Bogue's Compounds, Hydration Process, Types of Cement. Aggregates – Gradation Charts, effects on properties of concrete, Combined Aggregate, Alkali Silica Reaction. Interface between aggregates and cement matrix, Interface properties: strength and fracture energy. Admixtures – Chemical and Mineral Admixtures. Fresh Concrete, Segregation and bleeding. Steel: Types, stress strain curve – mild steel and tor steel, young's modulus **Properties of hardened concrete:** Microstructure of hardened concrete – Aggregate phase, hydrated cement paste, interfacial transition zone. Strength of concrete, behaviour of concrete under various stress states, stress strain behaviour – cyclic load, Dimensional stability of concrete – Elastic behaviour, shrinkage and creep. Test on bond strength between steel and concrete	**9**
II	**Durability of concrete**: Durability concept; factors affecting, reinforcement corrosion; fire resistance; frost damage; sulphate attack; alkali silica reaction; concrete in sea water, statistical quality control, acceptance criteria as per BIS code. **Special concretes** – Fibre reinforced concrete, High strength concrete, High performance concrete, Ultra High performance concrete, Self-compacting concrete, Geo polymer concrete, Lightweight concrete, Polymer concrete	**9**
III	**Proportioning of concrete mixtures:** Factors considered in the design of mix, IS method of mix design, Mix design of special concrete - High performance concrete - Self compacting concrete **Retrofitting techniques** – Need for retrofitting, retrofitting of structural members i.e., column and beams by Jacketing	**9**

	technique, Externally bonding(ERB) technique, near surface mounted (NSM) technique, External post- tensioning, Section enlargement, ferrocement.	
IV	**Non-destructive testing of concrete**: Surface Hardness, Ultrasonic pulse velocity, Penetration resistance, Pull-out test, chemical testing for chloride and carbonation- core cutting - measuring reinforcement cover. Scanning Electron Microscopy, X-Ray Microanalysis of Concretes, Interpretation of concrete deterioration from SEM/EDXA, Techniques for Corrosion Investigation in Reinforced Concrete	**9**
V	**Measurement of Strain**: Strain Gauge Characteristics- - Strain gauge types, circuits - Strain Gauge rosettes. **Force transducers**: Load cells - different types-tension, compression, shear beam, bending. **Measurement of displacement**: Linear variable differential transformer – principle and working. **RC Members - Testing and instrumentation:** Test on RC beams for flexure, shear and torsion, compression test on RC columns, test on beam column joints – cyclic and reverse cyclic.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162L	Soil Structure Interaction	PEC	3	0	0	3	2022

i) COURSE OBECTIVES:

The goal of this course is to render the effects of soil flexibility in the response of the structure. It introduces the analysis of the structure with soil structure interaction effects to obtain the realistic response

ii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO 1	Analyse the beams founded on elastic foundation using the basic concepts of soil-structure interaction	Analyse
CO 2	Analyse the plates founded on elastic foundation using the basic concepts of soil-structure interaction	Analyse
CO 3	Analyse single pile and pile group	Analyse
CO 4	Determine the load deflection behaviour for laterally loaded piles	Apply

iii) SYLLABUS

Soil-Foundation Interaction - Soil response model - Elasto-plastic behaviour, Beams on Elastic Foundations- Analysis of beams of finite and infinite length -Time dependent behaviour, Plates on Elastic medium-thin and thick plates, Elastic analysis of piles- Analysis of pile groups, Interaction analysis, Load deflection prediction for laterally loaded piles.

iv) REFERENCES

1) Selvadurai, A. P. S., *Elastic Analysis of Soil-Foundation Interaction*, Elsevier, 2013.
2) Poulos, H. G. and Davis, E. H., *Pile Foundation Analysis and Design*, John Wiley,1980.
3) Reese, L.C., *Single Piles and Pile Groups under Lateral Loading*, Taylor & Francis, 2nd edition, 2011.
4) Kurian, N. P., *Design of Foundation System- Principles & Practices*, Narosa Publishing, 3rd edition, 2006
5) ACI 336.2R-88 (Reapproved 2002), Suggested Analysis and Design Procedures for combined footings and Mats, American Concrete Institute.
6) Swami Saran, *Analysis & Design of Substructures*, Oxford & IBH Publishing Co. Pvt. Ltd., 2nd Edition, 2019.

v) COURSE PLAN

Module	Contents	No. of hours
I	**General soil-structure interaction problems:** Contact pressures and soil-structure interaction for shallow foundations, concept of sub grade modulus, effects/parameters influencing subgrade modulus. Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models	**9**
II	**Beam on Elastic Foundation:** Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness, Time-dependent response.	**8**
III	**Plate on Elastic Medium:** Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.	**8**
IV	**Elastic Analysis of Pile:** Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.	**10**
V	**Laterally Loaded Pile:** Load deflection prediction for laterally loaded piles, Sub-grade reaction and elastic analysis, Interaction analysis.	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162M	Structural Reliability	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

This course aims to introduce the basics of the structural reliability analysis procedures and to familiarize students with the applications of probability analysis and reliability techniques in structural engineering.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Apply probability theories, random variables, and random processes for quantifying uncertainties mathematically.	Apply
CO 2	Apply probabilistic analysis and properties of material to determine allowable stresses based on specified reliability	Apply
CO 3	Apply Monte Carlo simulations for reliability analysis of structural elements	Apply
CO 4	Analyse structural systems using reliability methods and codal provisions	Analyse

iii) SYLLABUS

Fundamentals of probability theory, resistance distributions and parameters, probabilistic analysis for loads, basic structural reliability, level 2 reliability methods, Monte Carlo study of structural safety, reliability of structural system, reliability-based design.

iv) REFERENCES

1) Nowak, A. S. and Collins, K. R., *Reliability of Structures*, CRC Press, London, 2nd edition,2013.
2) Melchers, R. E., *Structural Reliability Analysis and Prediction*, John Wiley & Sons, 3rdedition, 2018.
3) R. Ranganathan, *Reliability Analysis and Design of Structures*, Tata McGraw Hill, 2006.
4) Ang, A. H. S. and Tang, W. H., *Probability Concepts in Engineering Planning and Design*, Volume 1-Basic Principles, John Wiley & Sons, New York, 1st edition, 1975.
5) Benjamin, J. R. and Cornell, C. A., *Probability, Statistics and Decision for Engineers*, McGraw-Hill, 1st edition

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of Probability theory:** Concepts of Structural safety, design method, basic statistics and probability data reductions. Histograms, sample correlation, Random variables, functions of random variables, moments and expectation, discrete and continuous variables, common probability distributions.	9
II	**Resistance distributions and parameters:** Introduction, Statistics ofproperties of concrete, steel and other building materials, statistics of dimensional variations, characterization of variables, allowable stresses based on specified reliability. **Probabilistic analysis** for live load, gravity load and wind load.	9
III	**Basic structural reliability:** Introduction, computation of structural reliability, reliability analysis of simple elements. **Level 2 Reliability methods:** Introduction, basic variables and failure surface, first order second moment methods (FOSM).	9
IV	**Monte Carlo study of structural safety:** General, Monte Carlo method, applications. **Reliability of Structural system:** Introduction, system reliability, modelling of structural systems, bounds of system reliability, reliability analysis of frames.	9
V	**Reliability based design:** Introduction, resistance factors of design, safety checking formats and code calibrations, IS Code provisions, introduction to stochastic process.	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162N	Random Vibration	PEC	3	0	0	3	2022

i) COURSE OBJECTIVE:

This course aims to introduce students the statistical concepts in vibration analysis and understand the behaviour of systems subjected to random vibrations.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Apply the concept of probability theory and random process to solve random vibration problems.	Apply
CO 2	Analyse the solution of random vibration through spectral and stochastic functions.	Analyse
CO 3	Analyse the response of linear continuous system of random vibration.	Analyse
CO 4	Apply the concept of nonlinear random vibration for practical application.	Apply

iii) SYLLABUS

Basic concepts in Probability Theory, Random process, spectral density functions, Properties ofvarious random processes, Random vibration, response of linear SDOF, MDOF and continuous systems, Basics of nonlinear random vibration.

iv) REFERENCES

1) Newland, D. E., *An Introduction to Random Vibrations, Spectral & Wavelet Analysis*, Dover Publications2012
2) Preumont, A., *Random Vibration and Spectral Analysis*, Springer Netherlands, 2013
3) Lin, Y. K., *Probabilistic Structural Dynamics Advanced Theory and Applications*, McGrawHill, 2004
4) Cho, T. W. S., *Nonlinear Random Vibration*, Taylor and Francis, 2014
5) Lalanne, C., *Random Vibration*, CRC Press. 2019.
6) Wirsching, P. H, Paez, T. L. and Ortiz, H., *Random Vibration*, Dover Publications.2006
7) Ibrahim, R. A., *Parametric Random Vibration*, Dover Publications, 2008

v) COURSE PLAN

Module	Contents	No. of hours
I	**Probability Theory** - Random variables, Probability distribution and density functions - Expected value mean, variance, conditional probability, characteristic functions, Chebyshev inequality, functions of random variable.	9
II	**Random process** - concepts of stationary and ergodicity–non stationary process - auto and cross correlation and covariance functions - Mean square limit, differentiability and integrability	9
III	**Spectral decomposition, power spectral and cross spectral density functions -**Wiener Khintchine relation. Properties of Guassian, Poisson and Markov process. Broad band and narrow band random process - white noise.	9
IV	**Random vibration** - response of linear SDOF and MDOF systems to stationary and non-stationary random excitation. Response of continuous systems - normal mode method.	9
V	**Nonlinear random vibration** - Markov vector – equivalent linearization and perturbation methods - Level crossing, peak and envelope statistics - First excursion and fatigue failures - Applications.	9
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162O	Structural Health Monitoring	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to make students familiar with the concepts and design of typical pre-stressed concrete structural elements and to have knowledge about the provisions in the code of practice.

ii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO 1	Examine the finite element and structural modelling for assessing failure of structures	Apply
CO 2	Compare the different systems and sensors for health monitoring of structures	Analyse
CO 3	Apply different techniques for health monitoring of structures	Apply
CO 4	Analyse and interpret health monitoring data	Analyse
CO 5	Evaluate the structural health through case studies.	Evaluate

iii) SYLLABUS

Review of Structural Modelling and Finite Element Models - Review of Signals, Systems and Data Acquisition Systems - Sensors for Health Monitoring Systems - Health Monitoring/Diagnostic Techniques- Health Monitoring/Diagnostic Techniques -Integrated Health Monitoring Systems - Information Technology for Health Monitoring -Project Based Health Monitoring Techniques

iv) REFERENCES:

1) Philip, W., *Industrial sensors and applications for condition monitoring*, Mechanical Engineering Publications, 1994.
2) Armer, G.S.T., *Monitoring and assessment of structures*, CRS Press, 2019.
3) Wu, Z.S., *Structured health monitoring and intelligent infrastructure*, Proceedings of the First International Conference SHMII-01, Tokyo, Japan, 13-15 November 2003 Volumes 1 and 2, CRC Press/Balkema, 2003.
4) Piersol, A.G. and Paez, T. L., *Harris' Shock and Vibration,* Handbook, McGraw-Hill, 2009.
5) Rao, J.S., *Vibratory condition monitoring of machines*, Narosa Publishing House, 2000.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Review of Structural Modelling and Finite Element Models:** Modelling for damage and collapse behaviour of structures, finite element modelling, theoretical prediction of structural failures.	9
II	**Review of Signals, Systems and Data Acquisition Systems:** Frequency and time domain representation of systems, Fourier/Laplace transforms, modelling from frequency response measurements, D/A and A/D converters, programming methods for data acquisition systems. **Sensors for Health Monitoring Systems:** Acoustic emission sensors, ultrasonic sensors, piezo-ceramic sensors and actuators, fibre optic sensors and laser shearography techniques, imaging techniques.	10
III	**Health Monitoring/Diagnostic Techniques:** Vibration signature analysis, modal analysis, neural network-based classification techniques. **Integrated Health Monitoring Systems:** Intelligent Health Monitoring Techniques, Neural network classification techniques, extraction of features from measurements, training and simulation techniques, connectionist algorithms for anomaly detection, multiple damage detection, and case studies.	10
IV	**Information Technology for Health Monitoring:** Information gathering, signal analysis, information storage, archival, retrieval, security; wireless communication, telemetry, real time remote monitoring, network protocols, data analysis and interpretation.	8
V	**Project Based Health Monitoring Techniques:** Health monitoring techniques based on case studies, practical aspects of testing large bridges for structural assessment, optimal placement of sensors, structural integrity of aging multi-storey buildings, condition monitoring of other types of structures.	8
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE162P	Forensic Engineering	PEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to equip the students to identify reasons of distress in structures and suggest repair/ remedial measures.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Examine the causes of failure of structures	Apply
CO 2	Examine the level of distress of structures	Apply
CO 3	Examine the effect of various environmental problems and natural hazards for the strengthening of structures	Apply
CO 4	Examine the different repair and retrofitting techniques for structures	Apply

iii) SYLLABUS

Failure of Structures, review of the construction theory, performance problems. Causes of deterioration in concrete and steel structures. Diagnosis and Assessment of Distress, Visual inspection, non-destructive tests. Fibre optic method for prediction of structural weakness. Effect of Environmental Problems and Natural Hazards. Methods of repair of concrete and steel structures. Modern Techniques of Retrofitting, Case studies.

iv) REFERENCES:

1) Raikar, R. N., *Learning from Failures – Deficiencies in Design, Construction and Service,* R&D Centre (SDCPL), Raikar Bhavan, 2002.
2) Dovkaminetzky, *Design and Construction Failures*, Galgotia Publication, New Delhi, 2001.
3) Raina, V. K., *Bridge Rehabilitation*, Shroff Publications, New Delhi, 2006.
4) Feld, J. and Carper, K. L., *Construction Failures*, Wiley Europe, 2008.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Failure of Structures**: Review of the construction theory –	**9**

	performance problems – responsibility and accountability – case studies – learning from failures – causes of distress in structural members – design and material deficiencies – over loading. Causes of deterioration in concrete and steel structures. Preventive measures, maintenance.	
II	**Diagnosis and Assessment of Distress**: Visual inspection – non-destructive tests – ultrasonic pulse velocity method – rebound hammer technique – ASTM classifications – pullout tests – Bremor test – Windsor probe test – crack detection techniques – case studies – single and multistorey buildings – Fibre optic method for prediction of structural weakness.	**9**
III	**Environmental Problems and Natural Hazards**: Effect of corrosive, chemical and marine environment – pollution and carbonation problems – durability of RCC structures – damage due to earthquakes, flood and fire - strengthening of buildings – provisions of BIS 1893 and 4326	**9**
IV	Modern Techniques of repair, rehabilitation and retrofitting of RCC and steel structures. Structural first aid after a disaster – guniting - jacketing – use of chemicals in repair – application of polymers. Ferrocement and fiber concrete as rehabilitation materials	**9**
V	Rust eliminators and polymer coating for rebars - foamed concrete - mortar repair for cracks - shoring and underpinning - strengthening by pre-stressing. Case studies – bridges - water tanks – cooling towers – heritage buildings – high rise buildings. Introduction and case studies on Environmental Forensics and Geotechnical Forensics.	**9**
	Total hours	**45**

RESEARCH METHODOLOGY & IPR (RM)

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22MC061A	Research Methodology & IPR	RM	2	0	0	2	2022

i) COURSE OBJECTIVES:

This course is intended to prepare the M. Tech students to carry out their dissertation/ research project work effectively, with a research bias. The student will be able to formulate a viable research problem, do a critical analysis of publications in the area of research, and identify a research method suitable for the work. The student will achieve the capability to write a technical paper based on his/her dissertation/ research project.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Explain research ethics, Citation, Impact factor and Plagiarism	Apply
CO2	Formulate a research problem, make a suitable research design, and identify the data collection methods	Apply
CO3	Analyse the collected data	Analyse
CO4	Explain the role of IPR and Patent law in fostering research work, leading to creation of improved products, thus supporting economic growth and social benefits	Apply
CO5	Develop a technical paper for publication	Apply

iii) SYLLABUS:

Introduction to Research Methodology- motivation for research, types of research, ethical issues. Identifying a research area and collecting related literature. Research problem- scope- objectives, literature review, identifying research gaps, and formulate the research problem. Research design and methods, data collection and analysis.Copy right – royalty - IPR and patent law.Process of patenting and development, Procedure for grant of patents.Copy left- open access, citation, plagiarism, iImpact factor.Writing a technical paper.

iv) REFERENCES:

1) Stuart Melville and Wayne Goddard, *Research methodology: an introduction for science & engineering students.*
2) Ranjit Kumar, 2nd Edition, *Research Methodology: A Step by Step Guide for beginners*.
3) Ramappa T.*, Intellectual Property Rights Under WTO*, S. Chand, 2008.

4) Robert P. Merges, Peter S. Menell, Mark A. Lemley, *Intellectual Property in New Technological Age*, 2016.
5) Mayall, *Industrial Design*, McGraw Hill, 1992. Niebel, "Product Design", McGraw Hill, 1974.

v) Course Plan:

Module	Contents	Hours
I	**Introduction to Research Methodology:** Motivation towards research, Types of research. Professional ethics in research: Ethical issues, ethical committees. Identification of major conferences and important journals in a chosen area of interest. Collection of at least 10 published papers on a research problem in the chosen area.	6
II	**Defining and formulating the research problem:** Literature Survey, Analysing the collected papers to understand how the authors haveidentified the research gaps, arrived at their objectives, and formulated their research problem. Understanding how their research work is different from the previous works in the chosen area.	6
III	**Research design and methods**: Analyzing the collected papers to understand how the authors have formulated the research methods, both analytical methods and experimental methods. Data Collection and analysis: Analyzing the collected papers to understand the methods of data collection, data processing,analysis strategies, and tools used for analyzing the data.	6
IV	**Copy right** - royalty - Intellectual property rights and patent law – Process of Patenting and Development, Procedure for grant of patents. **Reproduction of published material:** Copy left- Open access, Citation and acknowledgement. Plagiarism, Impact factor.	6
V	**Technical writing** - Structure and components of a typical technical paper, abstract and conclusion, illustrations and tables, bibliography, referencing and footnotes. Writing a technical paper – based on the identified research problem, and using the collected papers, Literature survey, Problem formulation, and Research design, and a hypothetical result.	6
	Total hours	**30**

INTERDISCIPLINARY COURSES (IEC)

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE165A	Mechanics of Composite Materials	IEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

To make students familiar with different structural composites, behaviour and uses, the concepts of analysis and design of composite structural elements

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Develop knowledge about composite materials, advantage over their conventional counterparts and their specific use in engineering structures	Apply
CO2	Examine various types of structural composite elements	Analyse
CO3	Distinguish the behaviour of composite materials	Analyse
CO4	Examine structural components made of composite materials under various loads	Analyse

iii) SYLLABUS

Composite materials – types, comparison of strength, Composite beams - elastic behaviour of composite beams, serviceability limits - basic design considerations - design of composite beams, composite floors - analysis for internal forces and moments, composite columns - reinforced steel-composite column design, combined compression and uniaxial bending, continuous beams and slab - design strategies distribution.

iv) REFERENCES:

1. FRP Composite Structures - Theory, Fundamentals, and Design By Hota V. S., GangaRao, Woraphot Prachasaree, (2021)
2. Composite Structures of Steel and Concrete: Beams, Slabs, Columns and Frames for Buildings BY R.P. JOHNSON, Wiley-Blackwell; 4th edition (16 November 2018)
3. Mechanics Of Composite Materials by Autar K. Kaw: Taylor and Francis, (2006)

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction, Types of composite materials, Lamina and Laminate, Matrix and Fibre, Fibre-reinforced Composites, Comparison of strengths between bulk material and fibres Composite beams - Elastic behaviour of composite beams - No interaction case - Full interaction case	**9**
II	Shear connectors - Characteristics of shear connectors - Ultimate load behavior. Serviceability limits - Basic design considerations. Design of composite beams.	**9**
III	Composite floors:- Structural elements - Profiled sheet decking - Bending resistance - Serviceability criteria -Analysis for internal forces and moments.	**8**
IV	Composite columns:- Materials - Structural steel - Concrete- Reinforced steel - Composite column design - Fire resistance.	**9**
V	Combined compression and uniaxial bending Continuous beams and slab - hogging moment regions of composite beams -Vertical shear and moment - Shear interaction - Global analysis of continuous beams - Design strategies	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE165B	Random Vibrations	IEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

This course imparts an understanding of statistical concepts in vibration analysis. This course enables the students to find the response of structural systems subjected to random vibrations.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Apply the basic concept of probability theory, randomvariables and its extension to stochastic processes for determining the response of structural systems subjected to random vibrations	Apply
CO2	Analyse linear SDOF system subjected to random vibration	Analyse
CO3	Analyse linear MDOF system subjected to random vibration	Analyse
CO4	Identify the stochastic behaviour of linear continuous system subjected to random vibration	Apply
CO5	Analyse the nonlinear systems subjected to random excitation	Analyse

iii) SYLLABUS

Basic concepts in probability theory, random process, spectral density functions, Properties of various random processes, Random vibration - response of linear SDOF, MDOF and continuous systems, Basics of nonlinear random vibration.

iv) REFERENCES:

1. Newland, D. E., *An Introduction to Random Vibrations, Spectral & Wavelet Analysis*, Dover Publications, 3rd Edition, 2012.
2. Preumont, A., *Random Vibration and Spectral Analysis*, Springer, 1st Edition, 2013.
3. Lin, Y. K., *Probabilistic Structural Dynamics Advanced Theory and Applications*, McGraw Hill, 1st Edition, 2004.
4. Cho, T. W. S., *Nonlinear Random Vibration*, Taylor and Francis, 2nd Edition 2014.
5. Lalanne, C., *Random Vibration*, CRC Press, 1st Edition, 2020.

6. Wirsching, P. H, Paez, T. L. and Ortiz, H., *Random Vibration*, Dover Publications, 3rd Edition, 2014.
7. Ibrahim, R. A., *Parametric Random Vibration*, Dover Publications, 1st Edition, 2007.
8. Nigam, N. C., *Introduction to Random Vibration*, MIT Press, 1st Edition, 1983.
9. Nigam, N. C. and Narayanan, S., *Applications of random vibration*, Narosa, 1st Edition, 1994.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Probability Theory -** Random variables, Probability distribution and density functions. **Random process -** Concepts of stationary and ergodicity– nonstationary process - auto and cross correlation and covariance functions - Mean square limit, differentiability and integrability.	**9**
II	Spectral analysis, Wiener-Khintchine equation. Properties of Guassian, Poisson and Markov process. Broad band and narrow band random process- white noise.	**9**
III	**Stochastic Response of Linear SDOF Systems-** Level crossing, peak, first passage time and other characteristics of the response of SDOF Systems.	**9**
IV	**Stochastic Response of Linear MDOF Systems.** **Stochastic Response of Linear Continuous System-** Normal mode method.	**9**
V	**Response of Non-linear Systems to Random Excitation-** Equivalent linearization, Perturbation and Markov Vector Methods. Fatigue damage of structure due to random loads.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE165C	Project Management	IEC	3	0	0	3	2022

i) COURSE OVERVIEW:

Goal of this course is to make students familiar with the concepts of construction planning, Scheduling procedures and techniques, Cost control monitoring and accounting, Quality control and safety during constructions organization and use of project information

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the relationships among activities and coding system	Understand
CO 2	Apply method of crashing in scheduling of activities	Apply
CO 3	Explain different cost control monitoring techniques and accounting methods	Understand
CO 4	Explain quality control and safety during constructions	Understand
CO 5	Explain different data management system	Understand

iii) SYLLABUS

Construction planning- Scheduling procedures and techniques- Cost control monitoring and accounting- Quality control and safety during constructions organization and use of project information

iv) REFERENCES

1) Chittkara, K,K. Construction Project Management, Planning Scheduling and Control, Tata McGraw-Hill Publising Company, New Delhi,2012.
2) Calin M Popescu, Chotchai Charoenngam, Project Planning, Scheduling and control in construction: An encyclopaedia of terms application, Wiley, New York, 1995.
3) Chris Hendrickson and Tung Au, Project management FOR CONSTRUCTION Fundamental concepts for owners, Engineers, Architects and Builders, Prentice Hall, Pittsburg 2000.
4) Wills, E, M., Scheduling Construction Projects, John Wiley & Sons,2000.
5) Halpin, D,W., Financila and Cost Concepts for construction Management, John Wiley & Sons, Newyork,2014.

vi) COURSE PLAN

Module	Contents	No. of hours
I	CONSTRUCTION PLANNING Basic concept in the development of construction Plans- Choice of technology and construction method- defining work task- defining precedence relationships among activities- estimating activity duration- estimating resource requirements for work activities- Coding Systems.	**9**
II	SCHEDULING PROCEDURES AND TECHNIQUES Construction schedules- critical Path Method- Scheduling Calculations- Float Presenting Project Schedules- Scheduling of Activity –on Node and with leads, Lags and Windows- Scheduling with Recourse constraints and precedence- Uses of advanced scheduling techniques- Scheduling with uncertain duration- Calculations for Monte Carlo Schedule Simulation- Crashing a Time/Cost Trade-offs- Improving the scheduling Process.	**9**
III	COST CONTROL MONITORING AND ACCOUNTING The cost Control Problem- The Project Budget- Forecasting for Activity cost control- Financial Accounting Systems and cost accounts- Control of project cash flows Schedule control- Schedule and budget updates- Relating cost and schedule information.	**9**
IV	QUALITY CONTROL AND SAFETY DURING CONSTRUCTIONS Quality and safety concerns in construction- Organizing for quality and safety- Work and material specification- Total Quality Control- Quality control by statistical methods- Statistical quality control with sampling by attributes- statistical quality control with sampling by variables- Safety	**9**
V	ORGANIZATION AND USE OF PROJECT INFORMATION Types of Project Information- accuracy and use of information- Computerized Organization and Use of Information- Organization information in databases- Relational mode of Databases- Other conceptual made of databases- Centralized data management system- Databases and applications programs- Information transfer and flow.	**9**
	Total hours	**45**

INDUSTRY ELECTIVE COURSES (IEC)

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE166A	Wind Analysis on Structures, Cladding and Glazing Components	IEC	3	0	0	3	2022

i) COURSE OVERVIEW:

Goal of this course is to familiarise the student with the effects of wind loading in buildings and other structures such as bridges, steel transmission line towers and cooling towers. The concepts learned will help them to analyse the structure for the given wind force condition as per the codal provisions. It also enables the students to undertake sustained learning on wind tunnel testing.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the characteristics of wind and Bluff body aerodynamics.	Apply
CO 2	Make use of static and dynamic wind effects on structures	Apply
CO 3	Explain the effect of wind on building structures, cladding and glazing.	Apply
CO 4	Analyse the structures, claddings and glazing subjected to wind load	Analyse
CO 5	Explain the role of wind tunnel testing on structures	Apply

iii) SYLLABUS

Nature of wind storm, Design wind speed, Atmospheric boundary layer and Wind turbulence. Basic Bluff body aerodynamics, Wind effects on Low Buildings, Wind effects on Tall Buildings, Design forces on multi-storey buildings, towers, cladding and roof trusses, Wind load calculation on special structures such as cooling towers, rail/road bridges and tall chimneys, Role of Wind Tunnel, Modelling, Tornado effects.

iv) TEXT BOOKS

1) Holmes, J. D., Wind loading of structures, CRC Press, 4th edition, 2022.
2) Sachs, P., Wind Forces in Engineering, Pergamon Press, New York, 2nd edition, 2013.
3) Simiu, Emil; Yeo, DongHun, Wind effects on Structures- Modern Structural Design for Wind, John Wiley & Sons, 4th Edition, 2019

4) Lawson, T. V., Wind Effects on Buildings, Vols. I and II, Applied Science and Publishers,
London, 1993.
5) Devenport, A. G., Wind Loads on Structures, Division of Building Research, Ottowa, 1990.

REFERENCES

1) Scruton, C. P., An introduction to wind effects on structures (Vol. 3), Oxford University Press, 1981.
2) Sachs, P., Wind forces in engineering, Elsevier, 2013.
3) Dyrbye, C. and Hansen, S. O., Wind loads on structures, John Wiley & Sons, 1996.
4) Simiu E and Miyata T, Design of buildings and bridges for wind: a practical guide for ASCE-
7 standard users and designers of special structures, 1st edition, Wiley, 2006.
5) Simiu, E. and Scanlan, R. H., Wind effects on structures: An Introduction to wind engineering, Wiley, 1996.
6) IS 875 (Part 3): 2015 - Design Loads (Other than Earthquake) for Buildings and Structures -
Code of Practice - Wind Loads (Third Revision), Bureau of Indian Standards, New Delhi.
7) AS 1288-2006: Glass in buildings- selection and installation, Australian Standard.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction: Characteristics of wind, Nature of wind storm, types of winds, Extreme wind conditions, Design wind speed, Atmospheric boundary layer and Wind turbulence. Basic Bluff body aerodynamics: Flow around bluff bodies, Pressure & force coefficients flow around flat plates, Walls, Prismatic shapes	**9**
II	Static wind effects-drag coefficient, lift coefficient. Dynamic wind effects - along wind load, across wind load, flutter, galloping, buffeting. Interference effects (concept only) – Rigid structure – Aeroelastic structure (concept only)	**9**
III	Effect on typical structures: Wind effects on roof and cladding, Wind effects on Low rise buildings: Low buildings with different roof shapes and multi-span buildings. Wind effects on tall buildings: Along wind effects, Across wind effects and vortex shedding. Wind effect on	**9**

	chimneys, towers, bridges and structural glazing.	
IV	Wind load calculations as per IS 875 (Part 3) - Application to design: Design forces on multi-storey buildings, towers, cladding and roof trusses. Wind load calculation on special structures such as cooling towers, rail/road bridges, tall chimneys and structural glazing.	**9**
V	Wind Tunnel: Role of Wind Tunnel-Flow simulation, Modelling, Flow measurement, Pressure measurement, Deformation measurement. Basic considerations, Tornado effects.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE166B	Soil Investigation and Design of Substructures	IEC	3	0	0	3	2022

i) COURSE OVERVIEW

Goal of this course is to expose the students to design of various types of foundation, slope failures and site investigation techniques.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Develop the design of shallow foundations, deep foundations and subgrade.	Apply
CO 2	Apply the standard procedure to calculate pile capacity.	Apply
CO 3	Apply the concept of slope stability to interpret slope failure.	Apply
CO 4	Examine the soil characteristics to identify suitable ground Improvement techniques.	Analyse
CO 5	identify the various parameters for foundation design from site investigation data.	Apply

iii) SYLLABUS

Introduction to shallow foundation, Limit State Design of reinforced concrete in foundations; design of subgrade using CBR method. Design of Pile foundations. Analysis of slope stability. Selection of Ground Improvement Techniques based on soil characteristics. Interpretation of site investigation data.

iv) REFERENCES

1) Das, B. M., and Sivakugan, N., "Principles of Foundation Engineering", Cengage Learning Inc, 7th Edition, 2019.
2) Terzaghi, K., Theoretical Soil Mechanics, John Wiley & Sons, 1943
3) Moseley, M. P. and K. Krisch, Ground Improvement, Taylor and Francis, 2006.
4) Coduto, D. P., "Foundation Design Principles and Practices", Pearson, Indian edition, 2nd edition, 2012.
5) Hausmann, M. R., "Engineering Principles of Ground Modification", McGraw Hill, 1989.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to shallow foundation, types; bearing capacity factors - effect of foundation shape, eccentricity and inclination of load, influence of water table; Introduction to Limit State Design of reinforced concrete in foundations; Soil pressure for structural design; structural design of spread footings, isolated footings, combined footings, strap footing and strip footings. Introduction to shallow foundation, types; bearing capacity factors - effect of foundation shape, eccentricity and inclination of load, influence of water table; Design of Raft Foundation. Introduction to Limit State Design of reinforced concrete in foundations; Soil pressure for structural design; structural design of spread footings, isolated footings, combined footings, strap footing and strip footings. Brief introduction to design of subgrade using CBR methods. Determination of soil modulus.	9
II	Introduction to Pile foundation, types; Estimation of pile capacity of single pile; Calculation of settlement for single piles by elastic method. Estimation of pile capacity of group piles; Spacing criteria; efficiency of group piles. Stress on underlying soil strata, structural design of pile foundation and its components – pile cap, pile shoes, pile to pile cap connection. Introduction to Under-reamed pile foundation, Piled Raft Foundation – Advantages and necessity Pile Load Test, interpretation of values and field application.	9
III	Introduction and types; natural slopes and engineered slopes; slope failure – types, factors; Concept of slope stability, factors to be considered for analysis - site topography, ground water, seismicity, effect of ground water. Infinite slope analysis in dry sand, c-φ soil with seepage; Planar surface analysis, Circular surface analysis – friction circle method, method of slices, Limit equilibrium method Introduction to Geotechnical Forensic Investigation of Slope Failure, measures to prevent slope failure.	9
IV	Introduction – need; Types of insitu densification – vibrofloataion, compaction pile, vibro-compaction piles,	9

	dynamic compaction Types of drains, design of vertical drains, construction techniques. Grouting techniques, types, desirable characteristics, properties of treated ground; Brief introduction to Soil stabilization on various soil types, geosynthetics and soil reinforcement. Introduction to stone columns and encased stone columns	
V	Exploration and Field Investigation Principles of exploration, planning of investigation programmes, preliminary investigation, methods of exploration, geophysical methods, sampling and samplers; Standard Penetration Test, corrections, Correlation of SPT value with Atterberg's limit, shear strength and relative density. Brief introduction to SCPT, DCPT, Pressure meter and Plate Load Test, Correlations. Laboratory Testing of samples procured from site investigation; Site investigation report writing;	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE166C	Design of Infrastructure Services	IEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

Goal of this course is to expose the students to the analysis and design of retaining structures and bridges.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Apply IRC standards for the design of retaining walls, culverts, bridges, substructure and foundation.	Apply
CO2	Assess the hydraulic and clearance parameters for bridges.	Evaluate
CO3	Apply 2D frame analysis and grillage analysis for the analysis and design of RCC box culverts and girder bridges.	Apply
CO4	Examine the effect of soil structure interaction, construction sequences and secondary effects on bridges.	Analyze
CO5	Estimate the bearing capacity of shallow and deep foundations resting on different types of soil.	Evaluate
CO6	Develop a program to perform the analysis and design of retaining walls as per IRC provisions.	Apply

Note: CO3 and CO6 may be assessed through project work.

iii) SYLLABUS

Analysis and design of retaining wall, hydraulic calculation for bridges, analysis and design of sub structure, Design of RCC box type structures based on 2D frame analysis, Grillage analysis and design of girder bridges, Introduction to continuous and integral bridges, Seismic design and detailing, safe bearing capacity calculation, design principle of retaining structures.

iv) REFERENCES:

1) Mosley, B., Reinforced concrete design, Red Globe Press, 7th edition, 2012.

2) Surana, C.S. and Agrawal, R., Grillage Analogy in Bridge Deck Analysis, Narosa Publishing House, 2001.

3) Hambly, E. C., Bridge deck behaviour, Taylor and Francis Group, 2nd edition, 2019.

4) Bowles, J. E., Foundation Analysis and Design, McGraw-Hill Education, 5th edition, 2001.

5) IRC:5-2015, Standard Specifications and Code of Practices for Road Bridges – Section-I General Features of Design, Indian Roads Congress, New Delhi, 2015.

6) IRC SP 13:2004, Guidelines for The Design of Small Bridges and Culverts, Indian Roads Congress, New Delhi, 2004.

7) IRC 78:2014, Standard Specifications and Code of Practice for Road Bridges, Section-VII Foundations and Substructures, Indian Roads Congress, New Delhi, 2014.

8) IRC 112:2020, Code of Practice for Concrete Road Bridges, Indian Roads Congress, New Delhi, 2020.

9) IRC 6:2017, Standard Specifications and Code of Practice for Road Bridges, Section-II, Loads and Load Combinations, Indian Roads Congress, New Delhi, 2017.

10) IRC: SP:116-2018, Guidelines for Design and Installation of Gabion Structures, Indian Roads Congress, New Delhi, 2018.

11) IRC: SP: 66-2016, Guidelines for Design of Continuous Bridges, Indian Roads Congress, New Delhi, 2016.

12) IRC: SP: 102-2014, Guidelines for Design and Construction of Reinforced Soil Walls, Indian Roads Congress, New Delhi, 2014

13) IRC: SP:115-2018, Guidelines for Design of Integral Bridges, Indian Roads Congress, New Delhi, 2018

14) Flood reports, Central Water Commission, Government of India.

iv) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to behavior of retaining wall, loads acting on retaining walls as per IRC provisions, analysis and design of retaining wall, stress check and check for crack width as per IRC standards. Developing excel worksheet for the analysis and design of retaining walls.	**9**
II	Hydraulic calculation of bridges as per IRC, discharge calculation using catchment area method, area velocity method, hand synthetic unit hydrograph method; Afflux and scour depth calculation	**9**
III	Analysis and design of RCC box culverts and girder bridges	**9**

	based on 2D frame analysis and grillage using any software package. Soil structure interaction, construction sequences, secondary effects due to creep and shrinkage, temperature effects. Eigen stresses due to non-linear temperature distribution over the section. Introduction to continuous and integral bridges	
IV	Analysis and design of substructure and foundation – abutments, pier, open foundation and pile foundation. Developing excel worksheet for the plotting the interaction curve and determining the moment of resistance of circular and rectangular columns.	**9**
V	Introduction to seismic design and ductile detailing of substructure and foundations. Safe bearing capacity calculation for open foundation resting on sandy soil and clayey soil. Pile capacity calculation – end bearing, friction pile. Design principles for retaining structures such as reinforced earth wall, gabion wall, soil nailing.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE166D	Advanced Finite Element Methods	IEC	3	0	0	3	2022

i) COURSE OBJECTIVES:

To expose the students to apply Finite Element (FE) Modelling knowledge to real life structural engineering applications, predicting behaviour of structural elements and implementing computational facilities and FE formulation to industry and research.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Identify advanced FEM and application of such knowledge to real life Structural Engineering applications.	Apply
CO2	Examine behaviour of plates and shells through FE modeling and analysis.	Analyse
CO3	Examine dynamic behaviour of different elements through FE modeling and analysis	Analyse
CO4	Examine buckling behaviour of different elements through FE modeling and analysis	Analyse
CO5	Solve for errors, elemental mapping and its integration, eigen values and vectors in FE modeling.	Apply
CO6	Apply the concept of FEM to non-linear problems and fracture mechanics	Apply

iii) SYLLABUS

Review of Finite Element Method - Two dimensional Finite Element Analysis – introduction, Application of three dimensional equations for two dimensional analysis – Axisymmetric elements and its applications - Finite Element Analysis of Plates and Shells - Dynamic Analysis using Finite Element Method - Buckling analysis - Error analysis in Finite Element Method - Numerical Integration - Eigenvalue and vectors in FEM - Introduction to non-linear FE Modelling and FEM in fracture mechanics.

iv) REFERENCES:

1. A textbook of finite element analysis formulation and programming by D K Maharaj, Dreamtech Press (1 January 2019)
2. Introduction to finite element method by J N Reddy, McGraw-Hill Education, Fourth edition, 2019
3. Fundamentals Of Finite Element Analysis by David V. Hutton Publisher: Tata Mcgraw Hill Education Private Limited, Paperback, 1st July 2017
4. Finite Element Analysis Theory and Application with ANSYS by Saeed Moaveni Publisher: Pearson, third edition (2011)
5. Finite element analysis: Theory and programming by C Krishnamoorthy, Second edition (2001) Tata McGraw Hill Education

v) COURSE PLAN

Module	Contents	No. of hours
I	Review of Finite Element Method. Two dimensional Finite Element Analysis: Introduction, Application of three dimensional equations for two dimensional analysis. Axisymmetric/solid of revolution elements - Stiffness matrix derivation, Applications of axisymmetric elements - Solution of pressure vessel.	**9**
II	Finite Element Analysis of Plates and Shells: Introduction, Review of plate theories, Kirchhoff plate elements and Mindlin plate elements, Formulation of triangular and rectangular elements for plate bending analysis. Introduction to analysis of shells, General three and four node elements, Curved isoperimetric elements.	**10**
III	Dynamic Analysis using Finite Element Method: Introduction, Governing Equations, Mass matrices - lumped, consistent and coupled damping, Free vibration analysis of spring mass system - a bar and a beam, Modal participation and effective mass computation, Forced vibration - Harmonic response analysis.	**10**
IV	Buckling analysis - Bifurcation buckling, Stress stiffness matrix for a bar and a beam, Calculation of buckling	**8**

	loads. Error analysis in Finite Element Method - Sources of error, Discretisation of error, Mesh Revision Methods Brief description to numerical integration - One and two dimensional integration	
V	Eigen values and eigen vectors - General eigen value problems, Solution algorithms Introduction to non-linear finite element method, Direct substitution method and Newton-Raphson method Finite element method in fracture mechanics.	**8**
	Total hours	**45**

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LABORATORY COURSE (LBC)

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE169A	Structural Engineering and Design Lab	LBC	0	0	2	1	2022

i) COURSE OBJECTIVES:

Goal of this course is to familiarize the students with experimental evaluation of properties of materials used in concrete and to study the behaviour of concrete members. The students will be exposed to the instruments for measurement of strain, deflection, operations of UTM, hydraulic loading systems, force measuring devices etc. The course also aims to familiarize the students with software packages for analysis, design and detailing of reinforced concrete structures.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Decide the suitability of materials used for preparing a concrete mix.	Evaluate
CO 2	Apply the IS method of mix design to develop a concrete mix.	Apply
CO 3	Evaluate the hardened properties and quality of concrete mix using destructive and non-destructive testing methods.	Evaluate
CO 4	Assess the modes of failure and bond strength between concrete and reinforcement bars.	Evaluate
CO 5	Assess the failure modes and behaviour of reinforced concrete and prestressed concrete members	Evaluate
CO 6	Apply software tools in the analysis and design of structural elements and framed structures subjected to gravity loads.	Apply

iii) SYLLABUS:

- Design of concrete mix – 4 sessions
- Hardened property of concrete – 1 session
- Durability test and NDT – 1 session
- Bond strength test – 1 session
- Test on RC members – 3 sessions
- Design of RCC members – 1 session
- Design of RCC structures – 4 sessions

iv) REFERENCES:

1) Relevant IS codes (IS 10262: 2019, IS 1489 (Part 1): 2015, IS 383: 2016, IS 2386 (Part III): 1963, IS 516 – 1959, IS 456-2000 (Reaffirmed 2005), IS 2770 (Part I): 1967 (Reaffirmed 2007), Bureau of Indian Standards, New Delhi.
2) Reference Manual of the Relevant Software.

v) COURSE PLAN

Module	Contents	No. of hours
I	Develop a concrete mix which is suitable for structural applications a) Test on materials b) Mix design c) Fresh property d) Test for compressive strength	**8**
II	Evaluate the tensile and flexural strength of developed mix and relate it with the compressive strength a) Test for flexural strength b) Test for split tensile strength c) Test for modulus of elasticity	**2**
III	Evaluate the quality of concrete using durability and non-destructive testing methods a) RCPT test b) Rebound hammer test c) Ultrasonic pulse velocity test	**2**
IV	Determine the modes of failure and bond strength between concrete and reinforcement bars a) Test on 8 mm and 16 mm diameter bars	**2**
V	Study the modes of failure and behaviour of reinforced concrete members prepared using the developed mix a) Test on reinforced concrete beam b) Test on prestressed concrete beam c) Test on reinforced concrete column	**6**
VI	Analysis and design of RCC elements with different support conditions using any software package a) Continuous Beams b) Rigid Joint Frames c) Pin Joint Frames	**2**
VII	Analysis and design of multistoreyed buildings using any software package	**8**
	Total hours	**30**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE169B	Structural Dynamics and FEM Lab	LBC	0	0	2	2	2022

i) COURSE OBJECTIVES:

Goal of this course is to study the dynamic response of structures and to understand the concept of amplification, liquefaction and soil structure interaction of structures. The course is also intended to familiarize the students with the various finite element software packages available for structural applications.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Investigate the dynamic response of structures subjected to harmonic and non-harmonic base motion.	Apply
CO 2	Investigate the effectiveness of vibration isolation system and vibration absorber.	Apply
CO 3	Analyse the dynamic response of a four storied building frame with and without an open ground floor.	Analyse
CO 4	Analyse the vibration of single and two span beams.	Analyse
CO 5	Demonstrate seismic parameters, response and soil structure interaction of structures.	Analyse
CO 6	Apply software tools to analyse of plates	Apply
CO 7	Explain the fundamentals of MATLAB	Apply

iii) SYLLABUS

- Dynamics of a single storied building frame with planar asymmetry subjected to harmonic base motion - 1 session
- Dynamics of a three storied building frame with and without planar asymmetry subjected to periodic (non-harmonic) base motion - 1 session
- Vibration isolation of a secondary system - 1 session
- Dynamics of a vibration absorber - 1 session
- Dynamics of a four storied building frame with and without an open ground floor - 1 session
- Dynamics of a single and two span beams - 1 session

- Earthquake induced waves in rectangular water tanks, Dynamics of free standing rigid bodies under base motion, Seismic wave amplification, liquefaction and soil structure interaction (Demonstration only) - 1 session
- Introduction to finite element software packages - 1 session
- Stress analysis of plates: Circular plate, Rectangular plate, Rectangular plate with a circular hole - 4 sessions
- Introduction to MATLAB and study of basic matrix operations using MATLAB - 2 sessions

iv) REFERENCES

1) Mario, Paz, *Structural Dynamics – Theory and Computation*, CBS Publishers and Distributors, 2004.
2) Mukhopadhyay, M., *Structural Dynamics - Vibrations and Systems*, Ane Books, 2nd edition, 2008.
3) Anil, K. Chopra, *Dynamics of Structures- Theory and Application to Earthquake Engineering*, Pearson Education, 1st edition, 2001.
4) IS 1893 (Part 1): 2016, *Criteria for Earthquake Resistant Design of Structures*, Bureau of Indian Standards, New Delhi, 2016.
5) Reference manual of the relevant software.

v) COURSE PLAN

Module	Contents	No. of hours
I	Dynamics of a single storied building frame with planar asymmetry subjected to harmonic base motion	**2**
II	Dynamics of a three storied building frame with and without planar asymmetry subjected to periodic (non-harmonic) base motion	**2**
III	Vibration isolation of a secondary system	**2**
IV	Dynamics of a vibration absorber	**2**
V	Dynamics of a four storied building frame with and without an open ground floor	**2**
VI	Dynamics of a single and two span beams	**2**
VII	a) Earthquake induced waves in rectangular water tanks (Demonstration only) b) Dynamics of free standing rigid bodies under base motion (Demonstration only). c) Seismic wave amplification, liquefaction and soil structure interaction (Demonstration only)	**2**

VIII	Introduction to finite element software packages	**2**
IX	Stress analysis of plates: Circular plate, Rectangular plate, Rectangular plate with a circular hole	**10**
X	Introduction to MATLAB and study of basic matrix operations using MATLAB	**4**
	Total hours	**30**

MINI PROJECT (PR)

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22CE167A	Mini Project	PR	0	0	4	2	2022

vi) COURSE OBJECTIVES:

Goal of this course is to enable students to take up small problems in their field of study as mini project and collect the recent publications related to the topic and present the observations and findings related to the project work.

vii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Identify new promising directions of various cutting edge technologies.	Apply
CO 2	Organize information after a detailed study of research papers associated to the area of interest.	Apply
CO 3	Develop effective written and oral communication.	Apply
CO 4	Identify potential research areas in the field of their study	Apply
CO 5	Formulate and propose a plan for creating a solution for the research plan identified.	Create
CO 6	Analyse and interpret data to provide valid conclusions.	Analyse

viii)APPROACH:

- Mini project ensures preparedness of students to undertake Dissertation/ Research projects.
- Students should identify a **topic** of interest in consultation with PG Programme Coordinator that **should lead** to their Dissertation/ Research project.
- Students shall make a presentation for 20-25 minutes based on the detailed study on the project and submit a report of the study.
- The progress of the mini project is evaluated based on three reviews - two interim reviews and a final review. The first review will focus on the topic, objectives, methodology, design and expected results. The second review will focus on the progress of work. The final review will be based on the outcomes of the project work.
- A report is required to be submitted before the final review.

ASSESSMENT PATTERN

(2022 SCHEME)

(i) CORE COURSES

Evaluation shall include application, analysis and design-based questions (for both continuous internal evaluation and end semester examination).

Continuous Internal Evaluation (CIE)	**:**	**40 marks**
Micro project/ Course based project	:	20 marks
Course based task/ Seminar/ Quiz	:	10 marks
Continuous assessment Test (CAT), 1 No.	:	10 marks

(CAT shall include minimum 80% of the syllabus)
The project shall be done individually. Group projects not permitted.

End Semester Examination (ESE)	**:**	**60 marks**

End Semester Examination (ESE) Pattern:

The ESE shall be conducted by the CoE. The examination will be for 150 minutes.

The question paper will have two parts; Part A and Part B.

Part A contain 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students are required to answer all questions.

Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module, of which student are required to answer any five. Each question shall carry 7 marks.

(ii) ELECTIVE COURSES

Evaluation shall include application, analysis and design-based questions (for both continuous internal evaluation and end semester examination).

Continuous Internal Evaluation (CIE)	**:**	**40 marks**
Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred)	:	15 marks
Course based task/ Seminar/Data collection and interpretation	:	15 marks

Continuous assessment Test (CAT), 1 No.	:	10 marks
(CAT shall include minimum 80% of the syllabus)		
End Semester Examination (ESE)	**:**	**60 marks**

End Semester Examination (ESE) Pattern:

The ESE will be conducted by the CoE. The examination will be for 150 minutes.

The question paper will have two parts; Part A and Part B.

Part A will contain 5 questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students are required to answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module, of which student are required to answer any five. Each question shall carry 7 marks.

(iii) RESEARCH METHODOLOGY & IPR/AUDIT COURSE

Continuous Internal Evaluation (CIE)	**:**	**40 marks**
Course based task	:	15 marks
Seminar/ Quiz	:	15 marks
Continuous assessment Test (CAT), 1 No.	:	10 marks
(CAT shall include minimum 80% of the syllabus)		
End Semester Examination (ESE)	**:**	**60 marks**

End Semester Examination (ESE) Pattern:

The ESE will be conducted by the CoE. The examination will be for 150 minutes.

The question paper will contain 7 questions, with minimum one question from each module, of which students are required to answer any five. Each question shall carry 12 marks.

(iv) MINI PROJECT

The Mini project will have Continuous Internal Assessment for a total of 100 marks.

Interim evaluations	**:**	**40 marks**
First evaluation	:	20 marks
Second evaluation	:	20 marks
Final evaluation	**:**	**60 marks**
Evaluation by a Committee	:	30 marks
Report	:	10 marks
Supervisor/ Guide	:	20 marks

Note:

- The committee will evaluate the demonstration of functionality/ specifications, clarity of presentation, oral examination, and knowledge on the project work.
- The committee will evaluate the technical content, and adequacy of references.
- Permitted plagiarism level is not more than 25%.

(v) LABORATORY COURSES

The laboratory courses will be having only Continuous Internal Assessment (CIA) for 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Continuous Internal Assessment (CIA)	**:**	**100 marks**
Practical Records/Output	:	40 marks
Regular Class Viva	:	20 marks
Final Test	:	40 marks

(vi) INTERNSHIP

Internship for the M.Tech students is accepted as a matter of policy in ensuring the immersive learning by the students. Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined timescales. An internship may be compensated or non-compensated by the organization providing the internship. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectives and the activities of the internship program are clearly defined and understood. The internship offers the students an opportunity to

(i) Gain hands-on industrial or organizational exposure

(ii) Integrate the knowledge and skills acquired through the coursework

(iii) Interact with professionals and other interns, and

(iv) Improve their presentation, writing, and communication skills.

Internship often acts as a gateway for final placement for many students.

A student shall opt for carrying out the Internship at an Industry/ Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/ decided by the students on their own after getting approval from the respective PG Programme Coordinator. Every student shall be assigned an internship Supervisor/ Guide at the beginning of the Internship. The training shall be related to their specialization and must be carried out immediately after the second semester ESE, for duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Objectives

- Exposure to the industrial environment, which cannot be simulated in the class room and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical/ managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

Benefits of Internship

Benefits to Students

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career option to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.

- Makes a valuable addition to their resume that enhances their candidacy for higher education/ placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a fulltime position.

Benefits to the Institute

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/ students.
- Improvement in teaching learning process.

Benefits to the Industry

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.
- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

Types of Internships

- Industry Internship with/ without Stipend
- Government / PSU Internship (BARC/ Railway/ ISRO etc.)
- Internship with prominent education/ Research Institutes
- Internship with Incubation centers/ Start-ups

Guidelines

- All the students need to go for internship for minimum duration of 6 weeks and a maximum duration of 8 weeks.

- Students can take up mini projects, assignments, case studies, and so on by discussing it with authority from the host organization/ industry concerned and can work on it during the internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from the industry.
- Student should follow all ethical practices and Standard operating procedure (SOP) of industry.
- Students have to take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from the College on a weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
  - ✓ Report of work done
  - ✓ Internship certificate
  - ✓ Feedback from employer/ internship mentor
  - ✓ Proof of Stipend received (if applicable).

Total Marks 100: The marks awarded for the Internship will be on the basis of

(i) Evaluation done by the Industry
(ii) Student's diary/ Daily log
(iii) Internship Report and
(iv) Comprehensive Viva Voce.

Continuous Internal Evaluation: 50 marks

Student's diary/ Daily Log: 25 Marks
Evaluation done by the Industry: 25 Marks

Student's Diary/ Daily Log: 25 marks

The main purpose of writing Student's Diary/ Daily Log is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary

- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

The format of Student's Diary/ Daily Log

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

Day	Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc.
1	
2	
3	

Signature of Industry supervisor Signature of Head/ HR Manager

Office Seal

The format of Student's attendance Sheet

Name of the Organization/ Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	

Signature of Industry supervisor   Signature of Head/ HR Manager

Office Seal

Note:

- Student’s Diary/ Daily log shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark ‘P’.
- Holidays should be marked in red ink in the attendance column. Absence should be marked as ‘A’ in red ink.

Evaluation done by the Industry: 25 marks

Format for Supervisor Evaluation of Intern

Student Name :   Date:

Supervisor Name :   Designation:

Company/ Organization :

Internship Address:

Dates of Internship: From__________________ To________________________

Please evaluate intern by indicating the frequency with which you observed the following parameters

Parameters/ Marks	Needs improvement (0 – 0.25 marks)	Satisfactory (0.25 – 0.5 marks)	Good (0.75 marks)	Excellent (1 mark)
Behavior				
Performs in a dependable manner				
Cooperates with coworkers and supervisor				
Shows interest in work				
Learns quickly				
Shows initiative				
Produces high quality work				
Accepts responsibility				
Accepts criticism				
Demonstrates organizational skills				
Uses technical knowledge and expertise				
Shows good judgment				
Demonstrates creativity/ originality				
Analyzes problems effectively				
Is self reliant				
Communicates well				
Writes effectively				
Has a professional attitude				
Gives professional appearance				
Is punctual				
Uses time effectively				

Overall performance of student Intern (Tick one):

Needs improvement (0 - 0.50 mark) Satisfactory (0.50 – 1.0 mark)
Good (1.5 mark) Excellent (2.0 mark)

Additional comments, if any (2 marks) :

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

End Semester Evaluation (External Evaluation): 50 Marks

Internship Report: 25 Marks

Comprehensive Viva Voce: 25 Marks

Internship Report: 25 marks

After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty mentor. The student may contact Industry Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Student's Diary/ Daily log will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the diary. The training report should be signed by the Internship supervisor, PG Programme Coordinator and Faculty Mentor.

The Internship report will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course.

Comprehensive Viva Voce: 25 marks

Viva Voce will be done by a committee comprising Faculty mentor, PG Programme Coordinator and an external expert (from Industry or research/ academic Institute). This committee will be evaluating the internship report also.

(vii) INDUSTRY BASED ELECTIVES/ INTERDISCIPLINARY ELECTIVES

Engineering students frequently aspire to work in areas and domains that are key topics in the industry. There are concerns by recruiters that skill sets of engineering students did not match with the Industry requirements, especially in the field of latest topics.

Interdisciplinary knowledge is critical for connecting students with current industry trends, where multitasking is the norm. Interdisciplinary knowledge aids in the bridge buildingprocess between academic institutions and industry. It aids students in expanding their

knowledge and innovating by allowing them to create something new. While core engineering courses provide students with a strong foundation, evolving technology necessitates new methods and approaches to progress, prosperity, and the inculcation of problem-solving techniques. Other courses' knowledge, on the other hand, can assist them to deal with any scenario more effectively. Interdisciplinary courses may be one approach to address such needs, as they can aid in the enhancement of engineering education andthe integration of desirable specialized subjects into the current engineering education system. This will enable students to fulfill the current industry demands. Students with multidisciplinary knowledge and projects are more likely to be placed in top industries, according to the placement trend. The future of developing engineers will be influenced by their understanding of emerging technology and interdisciplinary approaches.

Rapid technological advancements and the onset of the fourth industrial revolution have resulted in a massive revival in the way engineering works in the industry. Projects necessitate the integration of knowledge and abilities from a diverse variety of engineering specialties, with the barriers between them becoming increasingly blurred.

Students can choose courses offered by other departments/ Industries that cover a wide range of highly relevant topics such as artificial intelligence, internet of things, big data, automation, and other software or other relatable courses. In the case of Industry based electives the course shall handled by the expert in the industry and the faculty in the college.

Assessment pattern for Interdisciplinary electives:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications: 15 marks
(minimum 10 publications shall be referred)

Course based task/ Seminar/ Data collection and interpretation: 15 marks

Continuous assessment Test (CAT), 1 No: 10 marks
(CAT shall include three modules, approximately 60% of the syllabus)

End Semester Examination: 60 marks

The ESE will be conducted by the CoE. The examination will be for 150 minutes.

The question paper will have two parts; Part A and Part B.

Part A will contain 5 questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative

evaluation), with minimum one question from each module of which student are required to answer any five. Each question shall carry 7 marks.

Assessment pattern for Industry based electives:

Continuous Internal Evaluation: 40 marks

The continuous internal evaluation will be done jointly by the expert in the Industry and the faculty in the college.

Micro project/ Course based project: 20 marks
(The project shall be done individually. Group projects not permitted)

Course based task/Seminar/Quiz: 10 marks

Continuous assessment Test (CAT), 1 No: 10 marks
(CAT shall include three modules, approximately 60% of the syllabus)

End Semester Examination: 60 marks

The ESE will be conducted by the CoE. The examination will be for 150 minutes.

The question paper shall be prepared jointly by the expert in the industry and the faculty in the college. The question paper will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question shall carry 12 marks.

The first valuation of the answer scripts shall be done by the expert in the Industry handling the course, and the second valuation shall be done by the faculty in the college. In the situation when the expert in the Industry is not available for first valuation, the college shall appoint an expert for this valuation.

(viii) MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/ NPTEL/ SWAYAM/ NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/ offline end semester examination. The students can do the MOOC according to their convenience starting from first semester, but shall complete it by fourth semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/ stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/ elective course in the concerned discipline.

A certificate of successful completion of the MOOC course (as per the evaluation pattern of the respective agency conducting the MOOC) is to be duly produced for verification. Two credits will be awarded to all students whoever successfully completes the MOOC course.

(ix) DISSERTATION/ RESEARCH PROJECT

Research Project:

Students selected for track 2 shall carry out their Research project only in the college, under the guidance of a supervisor assigned by the DLAC.

Dissertation:

All categories of students in track 1 are to carry out the Dissertation in the college or can work either in any CSIR/ industrial R&D organization/ any other reputed Institute which have facilities for dissertation work in the area proposed.

Dissertation outside the Institute:

For doing Dissertation outside the college, the following conditions are to be met:

- They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
- The student has to get prior approval from Dean (PGSR), on recommendation from the concerned DLAC.
- Students availing this facility should continue as regular students of the College.
- Facilities required for doing the dissertation shall be available in the Organization/ Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/ Industry shall be submitted by the student along with the application).
- The student should have an external as well as an internal supervisor. The internal supervisor shall belong to the college and the external supervisor shall be a Scientist or Engineer from the Institution/ Industry/ R&D organization with which the student is associated for doing the Dissertation work. The external supervisor shall be with a minimum Post graduate degree in the related area.
- The course work in the 3rd semester is to be completed as per the curriculum requirements:
    - (i) MOOC can be completed as per the norms specified in thiscurriculum.
    - (ii) Audit course is to be carried out either in the College or by self-learning. However, for self-learning students, all assessments shall be carried out in the college as in the case of regular students.
- The student has to furnish his/her monthly progress as well as attendance report signed by the external supervisor and submit the same to the concerned Internal supervisor.
- The external supervisor is to be preferably present (online/ offline) during all stages of evaluation of the Dissertation.

Internship leading to Dissertation:

The students who, after completion of 6 to 8 weeks internship at some reputed organization, are allowed to continue their work as dissertation for the third and fourth semester can do so only after getting approval from Dean (PGSR) on recommendation from the concerned DLAC. Such students shall make a brief presentation regarding the work they

propose to carry out before the DLAC for a detailed scrutiny and to resolve its suitability for accepting it as an M.Tech Dissertation. These students will be continuing as regular students of the college in third semester for carrying out all academic requirements as per the curriculum/ regulation. However, they will be permitted to complete their Dissertationin the Industry/ Organization (where they have successfully completed their internship) during fourth semester.

Dissertation as part of Employment:

Students may be permitted to discontinue the programme and take up a job, provided they have successfully completed all the courses till the second semester (FE status students are not permitted) prescribed in the approved curriculum. The dissertation work can be done during a later period either in the organization where they work if it has R & D facility, or in the College. Such students should submit application with details (copy of employment offer, plan of completion of their project etc.) to the Dean (PGSR) through the HoD for approval. When the students are planning to do the Dissertation work in the organization with R & D facility where they are employed, they shall submit a separate application with the following details:

- Name of R&D Organization/Industry
- Name and designation of an external supervisor from the proposed Organization/Industry (Scientists or Engineers with a minimum post graduate degree in the related area) and his/her profile with consent
- Name and designation of a faculty member of the College as internal supervisor along with his/her consent
- Letter from the competent authority from the Organization/ Industry granting permission to do the Dissertation
- Details of the proposed work along with the work plan

DLAC will scrutinize the proposal and forward to Dean (PGSR) for approval.

When students are doing dissertation work along with the job in the organization (with R & D facility) where they are employed, the dissertation work shall be completed in foursemesters normally (two semesters of dissertation work along with the job may be considered as equivalent to one semester of dissertation work at the college). Extensions may be granted based on requests from the student and recommendation of the supervisors such that he/she will complete the M. Tech programme within four years from the date of admission as per the regulation. Method of assessment and grading of the Dissertation will be the same as in the case of regular students.

The course work in the 3rd semester for such students is to be completed as per the curriculum requirements

(i) MOOC can be completed as per the norms specified in this curriculum.

(ii) Audit course is to be carried out either in the College or by self-learning. However, for self-learning students, all assessments shall be carried out in the college as in the case of regular students.

Marks distribution:

Phase I:	**Total marks:**	**100**
	Continuous Internal Evaluation:	100 marks
Phase II:	**Total marks: 200**	
	Continuous Internal Evaluation:	100 marks
	End Semester Examination:	100 marks

Final report of Dissertation/ Research Project:

Students must submit the final report of Dissertation/ Research project on or before the specified deadline. If the report is not submitted on or before the specified deadline, an extension of time up to a maximum of 30 days may be given for the submission of the report with due approval obtained from the HoD.

If a student fails to submit the final report of Dissertation/ Research project on or before the specified deadline/ extended deadline, he/ she is deemed to have failed in Project work and shall re-register for the same in the immediate next semester.

If a student does not appear for the ESE/ fails in the ESE, he/ she is deemed to have failed in Dissertation/ Research Project Phase II and shall have to re-register for the same in the immediate next semester.

(x) TEACHING ASSISTANCESHIP (TA)

All M.Tech students irrespective of their category of admission, shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of the course, enhance communication skills, obtain a hands-on experience in handling the experiments in the laboratory and improve peer interactions.

The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve asa mentor for students, and act as the course web-master. TAs may be required to attend the instructor's lecture regularly. A TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities. Students who are doing their dissertation work outside the college are not required to do TA work during their second year.

Handling a tutorial session:

(i) Meet the teacher concerned and understand the responsibilities well in advance, attend the lectures of the course for which the student is a tutor, work out the solutions for all the tutorial problems himself/herself, approach the teacher if he/she finds any discrepancy or if he/she needs help in solving the tutorial problems, use reference text books, be innovative and express everything in English only.

(ii) Try to lead the students to the correct solutions by providing appropriate hints rather than solving the entire problem by themselves, encourage questions from the students, lead the group to a discussion based on their questions, plan to ask them some questions, be friendly and open with the students, simultaneously being firm with them.

(iii) Keep track of the progress of each student in the assigned group, give a periodic feedback to the student about his/her progress, issue warnings if the student is consistently under-performing, report to the faculty if TA finds that a particular student is consistently underperforming, pay special attention to slow-learners and be open to the feedback and comments from the students and faculty.

(iv) After the tutorial session TA may be required to grade the tutorials/assignments/tests. Make sure that TA work out the solutions to the questions own their own, and compare it with the answer key, think and work out possible alternate solutions to the same question, understand the marking scheme from the teacher prior to the evaluation.

(v) Consult the teacher and make sure that there is no partiality to any student/ students while grading. They will follow basic ethics in this regard.

Handling a laboratory Session:

(i) Meet the faculty – in- charge a few days in advance of the actual lab class and get the details of the experiment, get clarifications from him/her regarding all aspects of the experiment and the expectations, prepare by reading about the theoretical background of the experiment, know the physical concepts involved in the experiment, go to the laboratory and check out the condition of the equipment/instrumentation, perform the laboratory experiment at least once one or two days before the actual laboratory class, familiarize with safety/ security aspects of the experiment / equipment/laboratory, prepare an instruction sheet for the experiment in consultation with the faculty, and keep sufficient copies ready for distribution to students for their reference.

(ii) Verify condition of the equipment/set up about 30 minutes before the students arrive in the class and be ready with the hand outs, make brief introductory remarks about the experiment, its importance, its relevance to the theory they have studied in the class, ask the students suitable questions to know there level of preparation for the experiment, discuss how to interpret results, ask them comment on the results.

(iii) Correct/evaluate/grade the submitted reports after receiving suitable instructions from the faculty in charge, continue to interact with students if they have any clarifications regarding any aspect of the laboratory session, includingof course grading, Carefully observe instrument and human safety in laboratory class, Preparing simple questions for short oral quizzing during explanation of experiments enables active participation of students, facilitate attention, provides feedback and formative assessment.

MOOC

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

(Autonomous)

Mar Ivanios Vidyanagar,Nalanchira, Thiruvananthapuram, Kerala

Department of Civil Engineering

M.Tech. in Structural Engineering (2022 scheme)

LIST OF COURSES (MOOC)

Sl.No.	Course Name	Duration	Organizing/Coordinating Institute	Faculty handling the sessions
1	Dynamics of Structures	12 Weeks	IITB	Prof. Manish Kumar
2	Plates and Shells	12 Weeks	IITG	Prof. Sudip Talukdar
3	Finite Element Method and Computational Structural Dynamics	12 Weeks	IITR	Prof. Manish Shrikhande
4	Maintenance and Repair of Concrete Structures	12 Weeks	IITM	Prof. Radhakrishna G. Pillai
5	Soil Structure Interaction	12 Weeks	IITKGP	Prof. Koushik Deb
6	FEM & Constitutive Modelling in Geomechanics	12 Weeks	IITM	Prof. K Rajagopal
7	Development and Applications of Special Concretes	8 Weeks	IITK	Prof. Sudhir Misra
8	Safety in Construction	8 Weeks	IITD	Prof. J. Uma Maheswari

AUDIT COURSES

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

(Autonomous)

Mar Ivanios Vidyanagar,Nalanchira, Thiruvananthapuram, Kerala

Department of Civil Engineering

M.Tech. in Structural Engineering (2022 scheme)

LIST OF AUDIT COURSES

Sl. No.	Name of Course
1.	English for Research Paper Writing
2.	Business Communication and Presentation Skills
3.	Universal Human Values
4.	Pedagogy Studies
5.	Stress Management by Yoga
6.	Personality Development through Life Enlightenment Skills
7.	Cost Management of Engineering Projects
8.	Operations Research
9.	Composite Materials
10.	Energy from Waste
11.	Entrepreneurship Development
12	Principles of Automation