M.E. DEGREE (STRUCTURAL ENGINEERING) PROGRAMME

CURRICULUM AND DETAILED SYLLABI

FOR

FIRST SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2026-27 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
M.E. Degree Programme

COURSES OF STUDY
(For the candidates admitted from 2026-27 onwards)

FIRST SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
26PAKA0	Applied Engineering Mathematics	FC	2	1	-	3
26PACA0	Analysis and Design of Reinforced Concrete Structures	PCC	3	-	-	3
26PACB0	Theory of Elasticity and Plasticity	PCC	2	1	-	3
26PAPXX	Program Elective Course - 1	PEC	3	-	-	3
26PAPXX	Program Elective Course - 2	PEC	3	-	-	3
THEORY CUM PRACTICAL						
26PACC0	Structural Dynamics	PCC	2	-	2	3
PRACTICAL						
26PACD0	Structural Engineering Laboratory	PCC	-	-	4	2
VALUE ADDED COURSES						
26XXXXX	VAC - 1	VAC				-
		Total				**20**

FC : Foundation Course
PCC : Programme Core Courses
PEC : Programme Elective Courses
VAC : Value Added Courses

L : Lecture
T : Tutorial
P : Practical

Note:
1 Lecture Period/week is equivalent to 1 credit
1 Tutorial Period/week is equivalent to 1 credit
1 Practical Period/week is equivalent to 0.5 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
M.E. Degree Programme

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2026-27 onwards)

FIRST SEMESTER

S.No	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	26PAKA0	Applied Engineering Mathematics	3	40	60	100	27	50
2	26PACA0	Analysis and Design of Reinforced Concrete Structures	3	40	60	100	27	50
3	26PACB0	Theory of Elasticity and Plasticity	3	40	60	100	27	50
4	26PAPXX	Program Elective Course - 1	3	40	60	100	27	50
5	26PAPXX	Program Elective Course - 2	3	40	60	100	27	50
THEORY CUM PRACTICAL								
6	26PACC0	Structural Dynamics	3 (Terminal Exam Type : Theory)	50	50	100	22.5	50
PRACTICAL								
7	26PACD0	Structural Engineering Laboratory	3	60	40	100	18	50

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E. DEGREE PROGRAMMES

CREDIT DISTRIBUTION

(For the students admitted from the Academic Year 2026-27 onwards)

Sl. No.	Category	Credits
A.	Foundation Course (FC)	03
B.	Program Core Courses (PCC)	22
C.	Program Elective Courses (PEC)	18
D.	Research Methodology and IPR course (RMC)	03
E.	Employability Enhancement Course (EEC)	27
F.	Value Added Courses (VAC) (Non-Credit and not included in CGPA) (04 credits)	-
	Minimum Credits to be earned for the award of the Degree	73
		From A to E and the successful completion of F

M.E. STRUCTURAL ENGINEERING SCHEDULING OF COURSES FOR STUDENTS JOINED FROM ACADEMIC YEAR 2026-27 ONWARDS											
Sem	Theory						Theory cum Practical	Practical	Value Added Courses	Employability Enhancement Courses	Credit
	1	2	3	4	5	6	7	8			
I	26PAKA0 Applied Engineering Mathematics (FC-3)	26PACA0 Analysis and Design of Reinforced Concrete Structures (PCC-3)	26PACB0 Theory of Elasticity and Plasticity (PCC-3)	PEC-1 (PEC-3)	PEC-2 (PEC-3)		26PACC0 Structural Dynamics (PCC-3)	26PACD0 Structural Engineering Laboratory (PCC-2)	VAC 1 (2 credits)		20
II	26PACE0 Structural Steel design (PCC-3)	26PACF0 Design of Foundation and Substructure (PCC-3)	PEC-3 (PEC-3)			Research Methodology and IPR Course (3 Credits)	26PACG0 Finite Element Analysis of Structures (PCC-3)	26PACF0 STAAD Pro Laboratory (PCC-2)	VAC -2 (2 credits)	Mini Project (3 credits)	20
III	PEC-4 (PEC-3)	PEC-5 (PEC-3)	PEC-6 (PEC-3)							Project-I (9 credits)	18
IV										Project-II (15 Credits)	15
											73

Passed in Board of Studies Meeting held on 23.05.2026

Approved in 71st Academic Council Meeting on 27.06.2026

26PAKA0	APPLIED ENGINEERING MATHEMATICS	Category*	L	T	P	Credit
		FC	2	1	0	3

Preamble

By exploring Fourier transforms via advanced mathematical techniques lead to analyze discrete signals and complex physical systems. Partial differential equations extend to wave propagation and heat diffusion phenomena. Calculus of variations introduces foundational principles for optimizing dynamic engineered system behaviours and statistical hypothesis testing equips with techniques for data-driven decision-making.

Prerequisite

- Nil

Course Outcomes

After the successful completion of the course, students will be able to:

No.	Course Outcome	TPS Level	CO Weightage	SDG addressed	SDG Level
CO1	Apply Fourier transform techniques and properties to solve continuous signal problems.	TPS3	20%	SDG4	2
CO2	Compute the discrete Fourier transform for given numerical sequences.	TPS3	10%	SDG4	2
CO3	Solve standard wave, heat conduction, and Laplace differential equations.	TPS3	20%	SDG4	2
CO4	Apply Euler's equation and variational methods to optimize engineering functionals.	TPS3	20%	SDG4	2
CO5	Conduct one-sample z-tests and t-tests to evaluate hypotheses about a population mean and population proportion.	TPS3	15%	SDG4	2
CO6	Conduct two-sample z-tests, t-tests, and F-tests to evaluate hypotheses about difference between population means, proportions, and variances.	TPS3	15%	SDG4	2

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	S	L	-	-	-	-	-	-	-	-	L	-
CO2	S	S	L	-	-	-	-	-	-	-	-	L	-
CO3	S	S	L	-	-	-	-	-	-	-	-	L	-
CO4	S	S	L	-	-	-	-	-	-	-	-	L	-
CO5	S	S	L	-	-	-	-	-	-	-	-	L	-
CO6	S	S	L	-	-	-	-	-	-	-	-	L	-

S - Strong; M - Medium; L – Low

Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	40%	40%	-	-	20%
CO2	20%	20%	-	-	10%
CO3	40%	40%	-	-	20%
CO4	-	-	40%	40%	20%
CO5	-	-	30%	30%	15%
CO6	-	-	30%	30%	15%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Syllabus

Module 1:
Fourier Transform: The Fourier Transform – Properties of Fourier transform – Transforms of the step and impulse functions.
Module 2:
The Fourier transform in discrete time: A Fourier transform for sequences – The discrete Fourier transform.
Module 3:
Partial Differential Equations: Solution of the Wave Equation – Solution of the Heat-conduction (Diffusion) Equation –Solution of the Laplace Equation.
Module 4:
Calculus of Variations: Euler's Equation – Solutions of Euler's equation – Several Dependent Variables – Functionals Involving Higher Order Derivatives – Rayleigh Ritz Method.
Module 5:
Testing of Hypothesis – One Sample: Hypotheses and Test Procedures – z tests for Hypotheses about a Population Mean – The One Sample t test – Tests Concerning a Population Proportion.
Module 6:
Testing of Hypothesis – Two Sample: z Tests and Confidence Intervals for a Difference between Two Population Means – The Two-Sample t Test and Confidence Interval – Inferences Concerning a Difference between Population Proportions – Inferences Concerning Two Population Variances.

Learning Resources
Text Book

1. Glyn James, Phil Dyke, "Advanced Modern Engineering Mathematics", 5th Edition, Pearson Education Limited, 2018.
   Module 1: 8.2, 8.3, 8.5
   Module 2: 8.6.2, 8.6.3
   Module 3: 9.3.1 to 9.3.3; 9.4.1, 9.4.2, 9.5.1
2. B.S. Grewel, "Higher Engineering Mathematics", 42nd edition, Kannna Publishers, 2017.
   Module 4: 35.3, 35.4, 35.7, 35.8, 35.9
3. Jay. L. Devore., "Probability and Statistics for Engineering and the Sciences", 9th Edition, Cengage Learning, 2014.
   Module 5: 8. 1 – 8.4
   Module 6: 9.1, 9.2, 9.4, 9.5

Reference Books & Web resources

1. Erwin Kreyszig, "Advanced Engineering Mathematics",10th edition, Wiley, 2017.
2. L. Elsgolc, "Differential equations and the calculus of variations", MIR publishers, 2003.
3. R.E. Walpole, R.H. Myers, S.L. Myers and K. Ye, "Probability & Statistics for Engineers & Scientists", Ninth Edition, Prentice Hall, 2024.

Course Contents and Lecture Schedule

Module No	Topics	No of Periods
1	**Fourier Transform**	
1.1	The Fourier Transform - The Fourier integral	1
1.2	The Fourier Transform pair, The continuous Fourier spectra	1
	Tutorial	1
1.3	Properties of Fourier Transform	1
1.4	Transforms of the step and Impulse function	1
	Tutorial	1
2	**The Fourier transform in discrete time**	
2.1	A Fourier Transform for sequences	1
2.2	The discrete Fourier transform	1
	Tutorial	1
3	**Partial Differential Equations**	
3.1	Solution of the wave equation - D'Alembert solution and characteristics	1
3.2	Separated Solutions, Laplace Solutions	1
	Tutorial	1
3.3	Solution of the heat-conduction (diffusion) equation - Separation method	1
3.4	Laplace transform method	1
	Tutorial	1
3.5	Solution of the Laplace equation – Separated solutions	2
	Tutorial	1
4	**Calculus of Variations**	
4.1	Euler's Equation, Solutions of Euler's equation	1
4.2	Several dependent variables	1
	Tutorial	1
4.3	Functionals involving higher order derivatives	1
4.4	Rayleigh Ritz Method	1
	Tutorial	1
5	**Testing of Hypothesis – One Sample**	
5.1	Hypotheses and test procedures	1
5.2	z tests for hypotheses about a population mean	1
	Tutorial	1
5.3	The one sample t test	1
5.4	Tests concerning a population proportion	1
	Tutorial	1
6	**Testing of Hypothesis – Two Sample**	
6.1	z Tests and Confidence Intervals for a Difference Between Two Population Means	1
6.2	The Two-Sample t Test and Confidence Interval	1
	Tutorial	1
6.3	Inferences Concerning a Difference Between Population Proportions	1
6.4	Inferences Concerning Two Population Variances	1
	Tutorial	1
	Total Periods	**36**

Course Designer(s):

1. Dr. K. Saravanakumar, Assistant Professor, Department of Mathematics kskmat@tce.edu
2. Dr. P. Jeyadurga, Assistant Professor, Department of Mathematics pjdmat@tce.edu
3. Dr. A. Muneesh Kumar, Assistant Professor, Department of Mathematics amkmat@tce.edu

26PACA0	ANALYSIS AND DESIGN OF REINFORCED CONCRETE STRUCTURES

Category	L	T	P	Credit
PCC	3	0	0	3

Preamble

This course provides an advanced understanding of the behaviour, analysis, serviceability and design of various reinforced concrete structural elements. The course also offers the modern analytical approaches for the design of special reinforced concrete elements including flat slabs, corbels, deep beams and spandrel beams. In addition, ductile detailing provisions for RC members are introduced to promote safe and efficient structural design practices in accordance with codal provisions.

Prerequisite

Structural Mechanics

Design of Reinforced Concrete Structures

Course Outcomes

After the successful completion of the course, students will be able to:

No.	Course Outcome	TPS Level	CO Weightage	SDG addressed	SDG Level
CO1	Design the beams under combined shear and torsion and estimation of deflections and crack width as per IS code provisions.	3	20	9	3
CO2	Analyse and design slender reinforced concrete columns and deep beams using codal provisions and strut-and-tie concepts.	3	15	9	3
CO3	Design special reinforced concrete elements such as concrete corbels and spandrel (edge) beams.	3	15	9	3
CO4	Apply moment redistribution concepts and analyse continuous beams.	3	15	9	3
CO5	Analyse and design advanced slab systems including flat slabs, slabs with openings, ribbed slabs and grid slabs	3	20	11	3
CO6	Apply ductility concepts and perform ductile detailing of reinforced concrete beams, columns and frame members	3	15	11	3

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2
CO1	S	M	L	-	M	L	-	M	M	L	L	M	L
CO2	S	M	L	-	M	L	-	M	M	L	L	M	L
CO 3	S	M	L	-	M	L	-	M	M	L	L	M	L
CO 4	S	M	L	-	M	L	-	M	M	L	L	M	L
CO 5	S	M	L	-	M	L	-	M	M	L	L	M	L
CO 6	S	M	L	-	S	L	-	S	M	M	L	M	S

Assessment Pattern

CO	CAT 1	Assignment 1	CAT 2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	**40**	**40**	**-**	**-**	**20**
CO2	**30**	**30**	**-**	**-**	**15**
CO3	**30**	**30**	**-**	**-**	**15**
CO4	**-**	**-**	**30**	**30**	**15**
CO5	**-**	**-**	**40**	**40**	**20**
CO6	**-**	**-**	**30**	**30**	**15**
Total	**100**	**100**	**100**	**100**	**100**

Syllabus

Module1:

Main topic 1 – Serviceability of Reinforced Concrete Members

Review of basic concepts, behaviour and design of RC members under flexure combined shear and torsion, modes of failure, Estimation of short/long-term deflections, crack width-factors affecting crack width-Estimation of crack width as per IS code.

Module 2:

Main topic 2 – Design of Special Reinforced Concrete Elements

Behaviour and design of slender columns, Introduction to strut and tie method, design of deep beams, design of concrete corbels, design of spandrel (edge) beams.

Module 3:

Main topic 3 – Redistribution of moments

Moment redistribution in beams, Advantages and limitations of Moment Redistribution, Baker's method of limit state analysis of continuous beam.

Module 4:

Main topic - Advanced Slab systems

Yield line analysis of slabs - Virtual work method and Equilibrium method, Flat slabs, slabs with openings, Ribbed slab (Voided slab), Grid slab

Module 5:

Main topic - Ductile Detailing of Reinforced Concrete Structures

Concept of ductility, Specifications of materials for ductility, ductile detailing of beams, columns and frame members with axial load and moment as per IS code, Introduction to reinforcement couplers.

Learning Resources

Text Book

1. N. Subramanian, Design of Reinforced Concrete Structures, Oxford University Press, New Delhi, 2014.
2. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design (Fourth Edition), Tata Mc Graw Hill Publishing Company Ltd., New Delhi, 2021.
3. Arthur H.Nilson, George Winter, Design of Concrete Structures, 11th Edition, McGraw Hill Book Co., New York, 2009.
4. P. C. Varghese, Advanced Reinforced Concrete Design, India, PHI Learning, 2009.
5. Krishna Raju, N., "Advanced Reinforced Concrete Design", CBS Publishers and Distributers, 2008

IS Codes

1. IS 456:2000 Plain and Reinforced Concrete – Code of Practice 2021.
2. SP 16:1980 Design Aids for Reinforced Concrete to IS 456:1978
3. IS 13920:2016: Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces - Code of Practice (First Revision).

Reference Books & Web resources

4. N. Krishna Raju and R.N. Pranesh, Reinforced Concrete Design IS 456-2000, Principles and practice, New Age International (P) Ltd Publishers, New Delhi, 2018.
5. Advanced Reinforced Concrete Design, NPTEL course materials https://nptel.ac.in/courses/105106224
6. Park and Paulay T, "Reinforced concrete Structures", John Wiley and Sons, New York, 2009.
7. S.N. Sinha, Reinforced Concrete Design, Tata McGraw-Hill, New Delhi, 2017.

Course Contents and Lecture Schedule

Module No	Topics	No of Periods	Course Outcome
1. Serviceability of Reinforced Concrete Members			
1.1	Review of basic concepts, Modes of failure in flexural members	1	CO1
1.2	Behaviour and design of RC members under flexure combined shear and torsion	2	CO1
1.3	Estimation of short/long-term deflections	2	CO1
1.4	Crack width-factors affecting crack width and Estimation of crack width as per IS code	2	CO1
2. Design of Special Reinforced Concrete Elements			
2.1	Behaviour and design of slender columns	2	CO2
2.2	Introduction to strut and tie method	1	CO2
2.3	Design of deep beams	2	CO3
2.4	Design of concrete corbels	1	CO3
2.5	Design of spandrel (edge) beams	2	CO3
3. Redistribution of moments			
3.1	Introduction to Moment – Rotation	1	CO4

	Characteristics		
3.2	Advantages and limitations of Moment Redistribution	2	CO4
3.3	Baker's method of limit state analysis of continuous beam.	2	CO4
4.Advanced Slab systems			
4.1	Yield line analysis of slabs - Virtual work method and Equilibrium method	1	CO5
4.2	Design of slab using yield line analysis	2	CO5
4.3	Design of flat slabs	2	CO5
4.4	Design of slabs with openings	1	CO5
4.5	Design of Ribbed slab (Voided slab)	2	CO5
4.6	Design of Grid slab	2	CO5
5.Ductile Detailing of Reinforced Concrete Structures			
5.1	Concept of ductility, Specifications of materials for ductility,	1	CO6
5.2	Design and ductile detailing of beams	2	CO6
5.3	Design and ductile detailing of columns and frame members with axial load and moment as per IS code,	2	CO6
5.4	Introduction to reinforcement couplers	1	CO6
	Total Periods	36	

Course Designer(s):

Dr. V Ganga, Assistant Professor, Civil Engineering vgaciv@tce.edu

26PACB0	THEORY OF ELASTICITY AND PLASTICITY

Category*	L	T	P	Credit
PCC	2	1	0	3

Preamble

Theory of Elasticity and Plasticity addresses the behaviour of engineering materials subjected to elastic and plastic deformation under complex loading conditions. The course develops analytical approaches for stress and strain analysis in Cartesian and polar coordinate systems, torsion of structural members, energy theorems, and yield criteria used in advanced structural and mechanical applications. The course supports the analysis and design of resilient structural systems and forms a foundation for advanced studies in solid mechanics, computational mechanics, and structural engineering.

Prerequisite

Engineering Mechanics
Strength of Materials
Engineering Mathematics

Course Outcomes

After the successful completion of the course, students will be able to:

No.	Course Outcome	TPS Level	CO Weightage	SDG addressed	SDG Level
CO1	Apply equilibrium, compatibility, and stress–strain relationships in two-dimensional and three-dimensional elastic systems using Cartesian and polar coordinates.	3	18%	NC	1
CO2	Analyse Airy stress functions and elasticity solutions for plane stress and plane strain problems in engineering systems.	4	18%	NC	1
CO3	Apply elasticity solutions for thick cylinders and stress concentration problems in safe and sustainable infrastructure systems.	3	18%	NC	1
CO4	Apply torsional theories for circular, non-circular, thin-walled, and multicellular sections using St. Venant and Prandtl approaches.	3	18%	NC	1
CO5	Demonstrate energy theorems and virtual work principles to determine deformation and strain energy in elastic systems	3	14%	NC	1
CO6	Apply yielding criteria and plastic stress–strain relationships for engineering materials under tension, compression, bending, and torsion.	3	14%	NC	1

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	M	L	S	-	S	-	-	-	-	-
CO2.	S	M	L	L	-	-	-	-	-	-	-
CO3.	S	M	L	-	M	-	-	-	L	-	-

CO4.	S	M	L	-	-	-	-	-	-	M	-
CO5.	S	M	L	S	-	S	-	-	-	-	-
CO6	S	M	L	M	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	**% of Marks**	**% of Marks**	**% of Marks**	**% of Marks**
CO1	**40**	**40**			**20**
CO2	**20**	**20**			**14**
CO3	**40**	**40**			**18**
CO4			**60**	**60**	**20**
CO5			20	20	14
CO6			**20**	**20**	**14**
Total	**100**	**100**	**100**	**100**	**100**

Syllabus

Module 1: Analysis of Stress and Strain

Stress and strain analysis in two-dimensional and three-dimensional systems – Equilibrium equations in Cartesian and polar coordinate systems – Compatibility equations – Stress and strain transformation – Principal stresses and strains – Generalized Hooke's law – Mohr circle representation – Engineering applications and numerical problems.

Module 2: Two Dimensional Elasticity Problems

Plane stress and plane strain conditions – Airy stress functions in Cartesian and polar coordinates – Application of Airy stress functions – Thick cylinders under internal and external pressure – Shrink fits and force fits – Stress concentration in plates with circular holes – Boussinesq equation and wedge problems.

Module 3: Torsion of Structural Members

Torsion of circular and non-circular sections – Torsion of prismatic bars using St. Venant's approach – Prandtl stress function approach – Torsion of hollow and thin-walled sections – Membrane analogy – Open and closed thin-walled sections – Multicellular sections – Numerical applications.

Module 4: Energy Theorems

Strain energy in two-dimensional and three-dimensional systems – Complementary energy theorem – Principle of virtual work – Principle of virtual displacement – Reciprocal theorem – Engesser theorem – Castigliano theorem – Rayleigh Ritz method – Engineering applications.

Module 5: Plasticity

Fundamental assumptions of plasticity – Yield criteria for metals – Plastic stress–strain relations – Strain hardening – Tresca yield criterion – Von Mises yield criterion – Applications in tension, compression, bending, and torsion problems.

Learning Resources

Text Book

1. Sadhu Singh, "Theory of Elasticity", Khanna Publishers, Fourth Edition, 2021.

   Egor P. Popov, "Engineering Mechanics of Solids", Prentice Hall India, Second Edition, 2020.

Reference Books & Web resources

1. Timoshenko S. and Goodier J.N., "Theory of Elasticity", McGraw Hill Education, Third Edition, 2019.
2. Wang C.T., "Applied Elasticity", McGraw Hill Education, 2018.
3. Mendelson A., "Plasticity Theory and Application", Krieger Publishing, 2020.
4. Chakrabarty J., "Theory of Plasticity", Butterworth-Heinemann, Third Edition, 2021.
5. NPTEL Web Course: Advanced Solid Mechanics by IIT Madras.
6. MIT OpenCourseWare: Elasticity and Plasticity in Structural Systems.

Course Contents and Lecture Schedule

Module No	Topics	No. of Periods
1	Stress and strain analysis in 2D and 3D systems	2
	Equilibrium equations in Cartesian and polar coordinates	2
	Compatibility equations and generalized Hooke’s law	2
	Principal stresses, strains, and Mohr circle problems	2
	Numerical applications	1
2	Plane stress and plane strain problems	2
	Airy stress functions in Cartesian coordinates	2
	Airy stress functions in polar coordinates	1
	Thick cylinders, shrink fits, and force fits	2
	Stress concentration and wedge problems	2
3	Torsion of circular and non-circular sections	2
	St. Venant and Prandtl approaches	2
	Hollow and thin-walled sections	2
	Membrane analogy and multicellular sections	2
	Numerical applications	1
4	Strain energy concepts and complementary energy theorem	2
	Principle of virtual work and reciprocal theorem	2
	Engesser theorem and Castigliano theorem	2
	Rayleigh Ritz method and applications	2
5	Introduction to plasticity and yield criteria	2
	Plastic stress–strain relations and strain hardening	2

Module No	Topics	No. of Periods
	Tresca and Von Mises criteria with problems	2
	Applications in tension, bending, compression, and torsion	2
	Total Periods	36

Course Designer(s):

Dr.S.Arulmary, Professor, Civil Engineering samciv@tce.edu
Dr.R.Sankaranarayanan, Assistant Professor, Civil Engineering rsciv@tce.edu

<table>
<tr><td rowspan="2">26PACC0</td><td rowspan="2">STRUCTURAL DYNAMICS</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>TE</td></tr>
<tr><td>PCC</td><td>2</td><td>0</td><td>2</td><td>3</td><td>TCP-T</td></tr>
</table>

1. Preamble

This course develops analytical understanding of the dynamic behaviour of structures — covering free and forced vibration of SDOF systems, seismic design using Elastic and Design Response Spectra as per IS 1893 (Part 1), and MDOF system analysis through Eigenvalue solutions and mode superposition methods.

2. Prerequisite

Fundamentals of Engineering Mechanics, Strength of Materials, Structural Analysis, Mathematics

3. Course Outcomes

On the successful completion of the course, students will be able to

No.	Course Outcome	TPS Level	CO Weightage	SDG Addressed	SDG Level
CO1	Explain the principles of structural dynamics and examine the free vibration response of undamped and damped SDOF systems.	TPS4	25	SDG 4, SDG 9	1
CO2	Examine the dynamic response of SDOF systems subjected to harmonic, periodic and impulse loads	TPS4	25	SDG 4, SDG 9	1
CO3	Describe the mathematical background of Elastic Response Spectra and apply Design Response Spectra.	TPS3	20	SDG 9, SDG 11	1
CO4	Examine the dynamic behaviour of MDOF systems, orthogonality conditions, mode superposition and differentiate the free and forced vibration response.	TPS4	30	SDG 4, SDG 9, SDG 11	1

4. Mapping with Program Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	M	M	L	L	-	-	-	L	-	L	S	L
CO2	S	S	M	M	L	-	-	-	L	-	L	S	L
CO3	S	M	S	M	L	-	L	-	L	L	L	S	M
CO4	S	S	S	M	S	-	L	L	L	-	L	S	M

S-Strong, M-Medium, L-Low

5. Assessment Pattern:

<table>
<tr><td rowspan="3">CO</td><td colspan="2">Theory</td><td colspan="2">Practical</td><td rowspan="2">Terminal Exam</td></tr>
<tr><td>CAT1</td><td>CAT2</td><td>OCR/ Continuous Assessment</td><td>Model Test CO-wise</td></tr>
<tr><td>% of Marks</td><td>% of Marks</td><td>% of Marks</td><td>% of Marks</td><td>% of Marks</td></tr>
<tr><td>CO1</td><td>50</td><td></td><td rowspan="4">75</td><td rowspan="4">25</td><td>25</td></tr>
<tr><td>CO2</td><td>50</td><td></td><td>25</td></tr>
<tr><td>CO3</td><td></td><td>50</td><td>20</td></tr>
<tr><td>CO4</td><td></td><td>50</td><td>30</td></tr>
<tr><td>Total</td><td>100</td><td>100</td><td>75</td><td>25</td><td>100</td></tr>
</table>

6. Assessment Pattern: Practical Component

Type of Assessment	Component	Marks	Remarks
Continuous Assessment	Pre-lab, In-lab, Post-lab	75	Conducted throughout the semester
Model Test	CO-wise (Cognitive, Psychomotor, Affective)	25	Rubrics covering all Domains of learning
Total Internal Marks		**100**	
End Semester Examination	CO-wise (Cognitive, Psychomotor, Affective)	100	Rubrics covering all Domains of learning

7. Syllabus

Module 1: Free Vibration of SDOF Systems
Understand the principles of structural dynamics, formulate equations of motion, and analyse single-degree-of-freedom (SDOF) systems under free vibration — Dynamic loads vs static loads — D'Alembert's principle — mass, damping, stiffness — Free vibration of undamped and damped SDOF systems — natural frequency — logarithmic decrement
Module 2:Forced Vibration of SDOF Systems
Forced vibration — harmonic, periodic – undamped and damped – Dynamic amplification factor. Periodic loads – Fourier series - undamped and damped system. Impulse – Duhamel Integral – Undamped and damped system
Module 3: Response Spectra and Seismic Design
Elastic Response Spectra - Mathematical Background - Elastic Response Spectra - Displacement Response Spectra - Velocity Response Spectra - Acceleration Response Spectra - Fourier Amplitude Spectra - Design Response Spectra - Tripartite Graph - Elastic Design Tripartite Spectra -Indian Code:1893 Part-1 -Design Spectrum
Module 4: MDOF Systems
Multi-degree of Freedom Systems – Introduction - Spring Mass Model: MDOF System. Two-degree of Freedom Systems - Undamped Free Vibrations -Undamped Forced Vibrations Damped Forced Vibrations. - Holtzer Method - Dynamic Equilibrium Condition: MDOF System: Elastic Force (Spring Force), Damping Force, Inertia Force - Undamped Free Vibration Analysis Solution of Eigenvalue Problem - Rayleigh's Quotient - Orthogonality Condition of Modes Normalization of Modes
Transformation of Eigenvalue Problem to Standard Form -Normal Coordinates. Uncoupled Equations of Motion - Solution of Undamped Free Vibration Analysis. Response Spectrum Analysis - Member Forces - Modal Mass - Mode Superposition, Closely Spaced Modes, Minimum Number of Modes - Rayleigh Damping

8. Learning Resources
8.1 Text Book

1. Anil K. Chopra, "Dynamics of Structures: Theory and Applications to Earthquake Engineering", Prentice Hall, Englewood Cliffs, New Jersy, Second Edition, 2001.
2. Berg. Glen v., "Elements of Structure Dynamics" 'Prentice Hall Englewood Cliffs, New Jersy. 1989.
3. Cheng, F.Y., "Matrix Analysis of Structure Dynamics, Marcel Dekker, New York, 2001.
4. Clough, R.W.and Penzien,J., " Dynamics of Structure", McGraw-Hill,inc., New York, 1993.
5. W.C, Rubinstein.M.F,"Dynamic of Structure", Prentice Hall of India Pvt Ltd.New Delhi.
6. Manicka Selvam K., "Elementary Structural Dynamics", Dhanpatrai and sons, New Delhi,2001.
7. Mario Paz, "Structural Dynamics: Theory and Computation", CBS Publications, New Delhi, 1994.

8.2 Reference Books & web resources

1) William Thomson, "Theory of Vibration and its applications", George Allen Pub.
2) Grover.G.K, "Mechanical vibrations", New Chand and Bros., Roorkee.
3) NPTEL Course: Structural Dynamics.
4) NPTEL Course: Structural Dynamics: Theory and Computation.

9. Course Contents and Lecture Schedule

Module No	Topics	No of Periods	Course Outcomes
1	**Single degree of freedom systems - Free Vibration**		CO1
1.1	Introduction, Principles of structural Dynamics	1	
1.2	Formulation of equation of motion	2	
1.3	Dynamic vs static load, D'Alembert's principle	1	
1.4	Analysis of free vibration - Undamped	1	
1.5	Damped free vibration	1	
2	**Single degree of freedom systems - Forced Vibration**		CO2
2.1	SDOF system to harmonic	2	
2.2	SDOF system to periodic	2	
2.3	Dynamic amplification factor, Duhamel Integral	1	
2.4	Undamped and Damped system	1	
3	**Elastic Response Spectra**		CO3
3.1	Elastic Response Spectra	1	
3.2	Displacement Response Spectra	2	
3.3	Velocity Response Spectra		
3.4	Acceleration Response Spectra		
3.5	Tripartite Graph, Design Response spectrum IS 1893	2	
4	**Multiple degree of freedom systems**		CO4
4.1	Two-degree of freedom system - Undamped and damped - free and forced vibration	1	
4.2	Elastic Force (Spring Force), Damping Force, Inertia Force	1	
4.3	Eigenvalue Problem, Rayleigh's Quotient - Orthogonality Condition of Modes Normalization of Modes	2	
4.4	Response spectrum Analysis - Member Forces - Modal Mass	1	
4.5	Modal mass - Mode superposition	1	
4.6	Rayleigh Damping	1	
	Total Periods	**24**	

10. List of Experiments with CO Mapping

Sl. No.	Name of the Experiment	Level of Experiment	Objectives	COs Addressed
1	Simple pendulum behaviour and its dynamic parameters	1	1, 2, 3, 6, 7, 10, 12, 13	CO1

2	Determination of logarithmic decrement and damping ratio of MDOF system by conducting free vibration test	2	5, 9, 11, 13	CO4
3	Estimation of natural frequency of a MDOF system by conducting free vibration test	2	2, 4, 5, 9, 11, 13	CO4
4	Study the Dynamics of a three-storied building frame subjected to harmonic base motion.	2	1, 2, 3, 4, 6, 7, 9, 10, 11, 12, 13	CO2
5	Study the Dynamics of a three-storied building frame with bracing system subjected to harmonic base motion.	2	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13	CO2
6	Investigation of the dynamics of a three-storied building frame without an open ground floor	2	2, 4, 5, 9, 11, 13	CO4
7	Investigation of the dynamics of a three-storied building frame with an open ground floor	2	2, 4, 5, 8, 9, 11, 13	CO4
8	MATLAB onramp	2	1, 2, 3, 4, 6, 7, 10, 12, 13	CO1
9	Solving ordinary differential equations using MATLAB	3	1, 2, 3, 4, 6, 7, 10, 12, 13	CO1
10	MATLAB application to solve undamped free vibration of a SDOF system and illustrate the plots of displacement, velocity and acceleration	3	1, 2, 3, 4, 6, 7, 10, 11, 12, 13	CO1
11	MATLAB application to solve damped free vibration of SDOF system and illustrate the plots of displacement, velocity and acceleration	3	1, 2, 3, 4, 6, 7, 9, 10, 11, 12, 13	CO1
12	Study of vibration using FFT analyser (Demo)	1	1, 2, 4, 7, 10, 11, 13	CO3

11. Course Designers:

1. Dr.S.Arul Mary, samciv@tce.edu
   Professor & Head,
   Department of Civil Engineering
2. Dr.K.Malavan, kmnciv@tce.edu
   Assistant Professor,
   Department of Civil Engineering

26PACD0	STRUCTURAL ENGINEERING LABORATORY	Category	L	T	P	Credits
		PCC	0	0	4	2

1. Preamble

The course imparts knowledge on various construction material selection through testing based on specifications. It develops practical skills for inspection and evaluation of various structural components using both Destructive and Non-Destructive Testing (NDT) methods in accordance with IS codal provisions.

2. Prerequisite

NIL

3. Course Outcomes

On the successful completion of the course, students will

No.	Course Outcome	TPS Level	SDG addressed	SDG Level
CO1	Examine the material properties for mix design	TPS 4	9,11	1
CO2	Design the concrete mix design with and without mineral admixtures	TPS 4	9,11	1
CO3	Examine the fresh and hardened properties of self-compacting concrete	TPS 3	9,11	1
CO4	Perform corrosion test and permeability test on concrete and RCC members.	TPS 3	9,11	1
CO5	Conduct the static load test on RCC beam.	TPS 3	9,11	1
CO6	Conduct the load test on RCC column under concentric loading conditions.	TPS3	9,11	1

4. Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2
CO1	S	S	M	L	M	-	-	M	M	L	L	M	L
CO2	S	S	M	L	M	-	-	M	M	L	L	M	L
CO3	S	M	L	-	L	-	-	L	M	L	L	L	L
CO4	S	M	L	-	L	-	-	L	M	L	L	L	L
CO5	S	S	S	M	M	-	-	M	M	L	L	S	L
CO6	S	S	M	L	M	-	-	M	M	L	L	S	L

5. Assessment Pattern: Cognitive Domain

Type of Assessment	Component	Marks	Remarks
Continuous Assessment	Pre-lab, In-lab, Post-lab	75	Conducted throughout the semester

Model Test	CO-wise (Cognitive, Psychomotor, Affective)	25	Mid/End semester internal test
Total Internal Marks		**100**	
End Semester Examination	CO-wise (Cognitive, Psychomotor, Affective)	100	As directed by COE or as per curriculum

6.List of Experiments with CO Mapping

Sl. No.	**Name of the Experiment**	**Level of Experiment**	**COs Addressed**
1.	Determination of properties of construction materials for mix design.	03	CO1, CO2
2.	Perform Mix design of concrete as per IS method and study of effect of minerals and chemical admixtures on workability, strength and durability.	01	CO1, CO2
3.	Perform Mix design for high performance concrete	03	CO2, CO3
4.	Determination of flow characteristics / workability of self-compacting concrete.	03	CO2, CO3
5.	Non-destructive evaluation of concrete – Ultrasonic Pulse Velocity and Rebound Hammer test.	03	CO2, CO3
6.	Identification of placement of reinforcement in reinforced concrete structures.	01	CO3
7.	Evaluating the internal flaws and properties of concrete in existing structural members using NDT methods.	01	CO3
8.	Permeability test on hardened concrete using Rapid Chloride Penetration Test (RCPT).	03	CO3
9.	Carbonation test on concrete cubes and cylinders.	03	CO4
10.	Evaluating the corrosion of reinforcement in structural members using corrosion meter.	03	CO5
11.	Fabrication, casting and testing of reinforced concrete beam subjected to static load.	01	CO6
12.	Fabrication, casting and testing of reinforced concrete column subjected to concentric loading.	01	CO6

7. Course Designer(s):

1.Dr. D. Rajkumar, Assistant Professor, Department of Civil Engineering rajkumarcivil@tce.edu
2.Dr.V.Ganga, Assistant Professor, Department of Civil Engineering vgaciv@tce.edu
3.Dr.Angelin Lincy, Assistant Professor, Department of Civil Engineering galciv@tce.edu

26PAPA0	COMPUTATIONAL METHODS IN STRUCTURAL ANALYSIS	Category	L	T	P	Credit
		PEC	2	1	0	3

Preamble

This course covers flexibility, stiffness, and direct stiffness matrix methods for analysing trusses and beams, with special techniques like static condensation, sub-structuring, symmetry and reanalysis for efficient computer-based structural analysis.

Prerequisite

Fundamentals of Mathematics, Basic knowledge of the mechanics of structures and structural analysis.

Course Outcomes

After the successful completion of the course, students will be able to:

No.	Course Outcome	TPS Level	CO Weightage	SDG Addressed	SDG Level
CO1	Explain the fundamental concepts of structural analysis and derive the stiffness and flexibility matrices using force-displacement transformation.	TPS2	15	SDG 9	1
CO2	Solve statically indeterminate trusses, beams and frames using the flexibility method.	TPS3	20	SDG 9	1
CO3	Solve displacement problems of trusses, beams and frames using the stiffness method.	TPS3	20	SDG 9	1
CO4	Apply special matrix method techniques to analyse complex structural systems.	TPS3	20	SDG 11	1
CO5	Demonstrate the direct stiffness method to solve 2D and 3D trusses, beams and frames.	TPS3	15	SDG 9	1
CO6	Compare the flexibility and stiffness methods for different structural types.	TPS4	10	SDG 11	1

Mapping with Program Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	M	M	L	L	-	-	-	L	-	M	S	L
CO2	S	S	M	M	L	-	-	L	L	-	M	S	M
CO3	S	S	S	M	L	-	-	L	M	-	M	S	M
CO4	S	S	S	M	M	-	-	L	M	L	M	S	M
CO5	S	S	S	M	S	L	-	M	M	L	S	S	S
CO6	S	S	S	M	S	L	-	M	M	L	S	S	S

S-Strong, M-Medium, L-Low

Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	30	30			15
CO2	30	30			20
CO3	40	40			20
CO4			40	40	20
CO5			30	30	15
CO6			30	30	10
Total	**100**	**100**	**100**	**100**	**100**

Syllabus

Module 1: Review of Fundamental Concepts: Introduction - Forces and Displacement Measurements - Principle of superposition - Methods of Structural Analysis - Betti's Law - Stiffness and Flexibility matrices of the Elements - a review. Transformation of Information: Indeterminate Structures - Transformation of system force to element forces.
Module 2: Flexibility Method: Choice of redundants - ill and well-conditioned equations - Automatic choice of redundants - Rank technique - Transformation of one set of redundants to another set - Thermal expansion - Lack of fit - Application to pin-jointed plane truss - Continuous beams - Simple frames - Problem solving
Module 3: Stiffness Method: Development of stiffness method - Analogy between flexibility and stiffness - Analysis due to thermal expansion - Lack of fit - Application to pin-jointed plane trusses - Continuous beams – Simple frames - Problem solving.
Module 4: Matrix Displacement Methods - Special Topics: Static condensation Technique - Substructure Technique - Transfer Matrix method - Symmetry & Anti symmetry of structures - Reanalysis Technique.
Module 5: Direct Stiffness Method: Discrete system - Direct stiffness approach - Application to two and three dimensional pin-jointed trusses - Continuous beams– Simple frames - Problem solving.
Module 6: Comparative Analysis and Method Selection: Computational efficiency comparison of flexibility, stiffness and direct stiffness methods - Suitability of methods for trusses and beams - Selection of appropriate method for given structural problems - Interpretation and critical evaluation of results - Comparative numerical problems.

Learning Resources

Text Book

1. Damodar Maity, "Computer Analysis of Framed Structures", I K International, 2007
2. Meek J.L., "Matrix Structural Analysis", McGraw Hill, 1971.
3. Moshe F Rubinstein- "Matrix Computer Analysis of Structures"- Prentice Hall, 1969.
4. Mukhopadhyay M., "Matrix Finite Element Computer and Structural Analysis", Oxford & IBH, 1984.
5. Pezemieniecki, J.S, "Theory of Matrix Structural Analysis", McGraw Hill Co., 1984.
6. Rajesekharan & Sankarasubramanian G., "Computational Structural Mechanics", Prentice Hall of India, 2001.
7. Seeli F.B. & Smith J.P., "Advanced Mechanics of Materials", John Wiley &Sons, 1993.
8. Smith J.C. "Structural Analysis", Macmillian Pub. Co. 1985.
9. Weaver & Gere, "Matrix Analysis of Structures", 3ª edition, East West Press, 1988.

Reference Books & Web resources

1. Wang C.K & Solomon C.G.," Introductory Structural Analysis", McGraw Hill, 1968.
2. Reddy C.S., "Basic Structural Analysis", Tata McGraw Hill Publishing Co. 1996.
3. NPTEL Course: Matrix methods of Structural Analysis.

Course Contents and Lecture Schedule

Module No	Topics	No of Periods	Course Outcomes
1	**Fundamentals and Transformation**		CO1
1.1	Introduction to Computational Methods & Forces and Displacement Measurements	1	
1.2	Principle of Superposition & Methods of Structural Analysis — Overview, Betti's law		
1.3	Stiffness and Flexibility Matrices of Elements - A Review	1	
1.4	Indeterminate Structures - Introduction to Transformation		
1.5	Transformation of System to Element - Forces & Displacement - Orthogonal Transformation	2	
1.6	Tutorial	2	
2	**Flexibility Method**		CO2
2.1	Choice of Redundants - Rank Technique	1	
2.2	Thermal Expansion & Lack of Fit - Effect and Analysis		
2.3	Application to Pin Jointed Plane Truss and continuous beams	2	
2.4	Simple frames	1	
2.5	Tutorial	2	
3	**Stiffness Method**		
3.1	Development of Stiffness Method, Analogy between Flexibility and Stiffness	1	
3.2	Pin-Jointed Plane Trusses.	2	
3.3	Continuous beams		
3.4	Simple frames	1	
3.5	Tutorial	2	
4	**Matrix Displacement Methods: Special Topics**		CO4
4.1	Static Condensation Technique, Substructure Technique	1	
4.2	Transfer Matrix Method, Symmetry & Anti-Symmetry of Structures, Reanalysis Technique	2	
4.3	Tutorial	2	
5	**Direct Stiffness Method**		CO5
5.1	Discrete System - Application to Two and Three Dimensional Pin-Jointed Trusses	2	
5.2	Continuous beams	1	

5.3	Simple frames	1	
5.4	Tutorial	2	
6	**Comparative Analysis and Method Selection**		CO6
6.1	Computational efficiency comparison of flexibility, stiffness and direct stiffness methods	2	
6.2	Suitability of methods for trusses and beams - Selection of appropriate method for given structural problems	2	
6.3	Interpretation and critical evaluation of results	1	
6.4	Tutorial	2	
	Total Periods (24+12)	**36**	

Course Designer(s):

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   Department of Civil Engineering
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   Assistant Professor,
   Department of Civil Engineering

26PAPB0	CREEP AND FATIGUE BEHAVIOUR OF MATERIALS	Category	L	T	P	Credit
		PEC	3	0	0	3

Preamble

This course offers to the students having studied the basics of properties and strength of materials, shall be introduced to dislocation theories of plasticity behaviour, initiation and fatigue crack propagation. It will expose students to failure mechanisms due to fatigue and creep as well as in their testing methods.

Prerequisite

Strength of Materials, Physics

Course Outcomes

After the successful completion of the course, students will be able to:

No.	Course Outcome	TPS Level	CO Weightage	SDG Addressed	SDG Level
CO1	Explain the elastic and plastic behaviour of materials and examine dislocation theory and its role in material deformation.	TPS3	15	SDG 4, SDG 9	1
CO2	Compare the fatigue behaviour of materials using S-N curves and analyse the effect of mean stress and cumulative damage.	TPS4	20	SDG 4, SDG 9	1
CO3	Examine the creep behaviour of materials and apply parametric methods for high temperature applications.	TPS3	20	SDG 4, SDG 9, SDG 13	1
CO4	Demonstrate Non-Destructive Evaluation methods to detect and evaluate material defects.	TPS3	20	SDG 9, SDG 11	1
CO5	Evaluate the residual strength of cracked structural members using fracture mechanics principles.	TPS5	15	SDG 9, SDG 11	1
CO6	Determine fracture toughness of different materials and interpret strain energy release rate in structural applications.	TPS4	10	SDG 4, SDG 9	1

Mapping with Program Outcomes

Cos	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO11	PSO1	PSO2
CO1	S	M	M	L	-	-	-	-	L	-	M	S	L
CO2	S	S	S	M	M	-	-	M	M	L	M	S	M
CO3	S	S	S	M	M	-	-	M	M	L	M	S	M
CO4	S	S	M	S	S	L	-	M	M	L	S	S	S
CO5	S	S	S	M	M	-	-	M	M	L	S	S	M
CO6	S	S	S	M	M	L	-	M	M	M	S	S	S

S - Strong, M - Medium, L - Low

Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	30	30			15
CO2	35	35			20
CO3	35	35			20
CO4			40	40	20
CO5			30	30	15
CO6			30	30	10
Total	**100**	**100**	**100**	**100**	**100**

Syllabus

Module 1: Elastic and Plastic behaviour: Elastic behaviour of materials - plastic behaviour: dislocation theory - Burger's vectors and dislocation loops, dislocations in the FCC, HCP and BCC lattice - stress fields and energies of dislocations, forces on and between dislocations-dislocation climb, intersections of dislocations, Jogs, dislocation sources, multiplication of dislocations, dislocation pile-ups, Slip and twinning.

Module 2: Fatigue behaviour and testing-Fatigue: Stress cycles, S-N curves, Effect of mean stress, Factors affecting Fatigue, Structural changes accompanying fatigue, Cumulative damage, HCF / LCF, thermo-mechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines- Paris Equation, Residual life prediction under Fatigue. Fatigue based design.

Module 3: Creep behaviour and testing: Creep curve, Stages in creep curve and explanation, Structural changes during creep, Creep mechanisms, Metallurgical factors affecting creep, High temperature alloys, Stress rupture testing, Creep testing machines, Parametric methods of extrapolation. Deformation Mechanism Maps according to Frost.

Module 4: NDE methods: Liquid Penetrant Testing - Principles, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, Interpretation and evaluation of test Eddy indications, demagnetization Eddy Current Testing-Generation of eddy currents Interpretation/Evaluation- UT and AE - Transmission and pulse-echo method, straight beam and angle beam- data representation, A-Scan, B-Scan, C-Scan. Phased Array Ultrasound, Acoustic Emission Technique -Principle, AE parameters, Applications

Module 5: Evaluation of residual strength: Elastic fields - Analytical solutions yielding near a crack front- Irwin's approximation - plastic zone size - Dugdale model - J integral and its relation to crack opening displacement. Strain energy release and stress intensity factor.

Module 6: Fracture Toughness Evaluation: Evaluation of Fracture Toughness — Introduction & Size Effect - Fracture Toughness of Metallic Materials - Fracture Toughness of Concrete & Composite Materials - Size Effect Control & Fracture Control in Structural Applications

Learning Resources

Text Book

1. Dieter, G. E., "Mechanical Metallurgy", McGraw-Hill Co., SI Edition, 1995.
2. Richard. W. Hertzberg," Deformation and Fracture Mechanism of Engineering Materials". John Willey and Sons, 4th edition, 1996.
3. Ravi Prakash, "Non-Destructive Testing Techniques", New Age International Publishers, 1st revised edition, 2010
4. Honeycombe R. W. K., "Plastic Deformation of Materials" 1984, Edward Arnold Publishers,
5. Anderson, T. L.," Fracture Mechanics: Fundamentals and Applications", CRC Press, 2nd edition, 1995.

6. ASM Metals Handbook,"Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17

Reference Books & Web resources

1. NPTEL Course: Creep deformation of materials. https://nptel.ac.in/courses/113106088
2. NPTEL Course: Fracture, Fatigue and Failure Of Materials. https://nptel.ac.in/courses/113105106

Course Contents and Lecture Schedule

Module No	Topics	No of Periods	Course Outcomes
1	**Elastic & Plastic Behaviour — Dislocation Theory**		CO1
1.1	Elastic Behaviour Plastic Behaviour — Introduction to Dislocation Theory	1	
1.2	Burger's Vectors and Dislocation Loops	1	
1.3	Dislocations in FCC, HCP and BCC Lattice - Stress Fields and Energies of Dislocations	1	
1.4	Forces on and Between Dislocations & Dislocation Climb	1	
1.5	Intersections of Dislocations, Jogs & Dislocation Sources	1	
1.6	Multiplication of Dislocations & Dislocation Pile-ups	1	
1.7	Slip and Twinning	1	
2	**Fatigue Behaviour & Testing**		CO2
2.1	Fatigue — Stress Cycles & S-N Curves	1	
2.2	Effect of Mean Stress & Factors Affecting Fatigue	1	
2.3	Structural Changes Accompanying Fatigue & Cumulative Damage	1	
2.4	HCF, LCF & Thermo-mechanical Fatigue	1	
2.5	Application of Fracture Mechanics to Fatigue Crack Propagation — Paris Equation	1	
2.6	Fatigue Testing Machines & Residual Life Prediction	1	
2.7	Fatigue Based Design	1	
3	**Creep Behaviour & Testing**		CO3
3.1	Creep Curve, Structural Changes During Creep & Creep Mechanisms	1	
3.2	Metallurgical Factors Affecting Creep & High Temperature Alloys	1	
3.3	Stress Rupture Testing & Creep Testing Machines	1	
3.4	Parametric Methods of Extrapolation & Deformation Mechanism Maps according to Frost	1	
4	**NDE Methods**		CO4
4.1	Liquid Penetrant Testing — Principles & Testing Procedure & Interpretation of Results	1	
4.2	Magnetic Particle Testing — Theory of Magnetism & Interpretation of Indications & Demagnetization	1	
4.3	Eddy Current Testing — Generation of Eddy Currents & Interpretation & Evaluation	1	
4.4	Ultrasonic Testing — Transmission and Pulse-Echo Method & Straight Beam and Angle Beam	1	
4.5	UT Data Representation — A-Scan, B-Scan & C-Scan	1	
4.6	Phased Array Ultrasound Testing — Principles & Applications	1	

4.7	Acoustic Emission Technique — Principle, AE Parameters & Applications	1	
5	**Evaluation of Residual Strength**		CO5
5.1	Elastic Fields — Analytical Solutions & Yielding Near a Crack Front	1	
5.2	Irwin's Approximation & Plastic Zone Size	1	
5.3	Dugdale Model	1	
5.4	J-Integral & its Relation to Crack Opening Displacement	1	
5.5	Strain Energy Release Rate & Stress Intensity Factor	1	
6	**Fracture Toughness Evaluation**		CO6
6.1	Evaluation of Fracture Toughness — Introduction & Size Effect	1	
6.2	Fracture Toughness of Metallic Materials	1	
6.3	Fracture Toughness of Concrete & Composite Materials	2	
6.4	Size Effect Control & Fracture Control in Structural Applications	1	
6.5	Integrated Fracture Mechanics Examples	1	
	Total Periods	36	

Course Designer(s):

1. Dr.V.Ganga, vgaciv@tce.edu
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   Assistant Professor,
   Department of Civil Engineering

26PAPC0	THEORY OF PLATES	Category	L	T	P	Credit
		PEC	3	0	0	3

Preamble

This course covers the bending behaviour of thin plates — rectangular, circular and anisotropic — under various loading and boundary conditions using classical approaches including differential equations, Navier's and Levy's methods, finite difference approach and energy methods.

Prerequisite

Fundamentals of Mathematics, Structural Mechanics

Course Outcomes

After the successful completion of the course, students will be able to:

No.	Course Outcome	TPS Level	CO Weightage	SDG Addressed	SDG Level
CO1	Explain the assumptions of thin plate theory and analyse the bending behaviour of long rectangular plates and circular plates under various loading and boundary conditions	TPS3	20	NC	-
CO2	Apply Navier's solution to solve simply supported rectangular plates under various loads	TPS3	20	NC	-
CO3	Apply Levy's method to solve simply supported rectangular plates under various loads	TPS5	15	NC	-
CO4	Analyse simply supported and fixed square and rectangular plates under various loads using the finite difference approach	TPS4	15	NC	-
CO5	Apply energy methods to solve laterally loaded thin plate problems	TPS3	15	NC	-
CO6	Formulate and solve the differential equation of anisotropic plates and analyse the bending behaviour of anisotropic plates	TPS4	15	NC	-

Mapping with Program Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	M	M	L	-	-	-	-	L	-	M	S	L
CO2	S	S	M	M	L	-	-	L	M	-	M	S	M
CO3	S	S	S	M	L	-	-	L	M	-	M	S	M
CO4	S	S	S	M	M	-	-	M	M	L	S	S	M
CO5	S	S	S	M	M	-	-	M	M	L	S	S	S
CO6	S	S	S	M	M	L	-	M	M	L	S	S	M

S - Strong, M - Medium, L - Low

Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	40	40			20
CO2	30	30			20
CO3	30	30			15
CO4			30	30	15
CO5			30	30	15
CO6			40	40	15
Total	**100**	**100**	**100**	**100**	**100**

Syllabus

Module 1: Thin plate theory: Assumptions, Bending of long rectangular plates to a cylindrical surface - Differential equation; Plates with simply supported edges; Plates with built-in edges; Pure bending of plates; Slope and curvature of slightly bent plates; Relation between bending moment and curvature; Circular plates - Symmetrical bending of laterally loaded circular plates - Differential equation;

Module 2: Small deflections & Navier's solution: Classical approach and Methods - Small deflections of laterally loaded plates - Differential equation of the deflection surface; Simply supported rectangular plates under sinusoidal loading; Navier's solution for simply supported rectangular plates under uniform loading, under hydrostatic pressure, under concentrated load and under a load uniformly distributed over the area of a rectangle;

Module 3: Levy's method: Advantages over Navier's solution; Simply supported rectangular plates under uniform loading and under hydrostatic pressure.

Module 4: Finite difference approach: Bending of laterally loaded thin plates - Differential equation; Simply supported and fixed square and rectangular plates under uniform loading, partial loading, triangular loading and trapezoidal loading;

Module 5: Energy methods: Principle of Virtual Work - Theory and Application to Plates
Principle of Minimum Potential Energy - Theory and Application; Application of Energy Methods to Simply Supported Plates; Application of Energy Methods to Fixed Plates; Problem Solving - Energy Method Applications;

Module 6: Anisotropic plates: Bending of Anisotropic plates - Differential equation of the bent plate; Bending of rectangular plates; Bending of circular and elliptic plates.

Learning Resources

Text Book

Timoshenko S. and Kruger S.W. "Theory of plates and Shells," McGraw Hill Education, New York, 2017.

Ansel. C. Ugural, "Stresses in Plates and Shells," McGraw Hill Book Company, New York, 1999.

Bairagi N. K., "A text book of Plate Analysis," Khanna Publishers, New Delhi, 1996

Chandrashekahara K., "Theory of Plates," University Press (India) Ltd., Hyderabad, 2001.

Reddy J.N., "Theory and Analysis of Elastic Plates and Shells", CRC Press, 2006.

Szilard R., "Theory and Analysis of Plates, Classical and Numerical methods" Prentice Hall, USA, 2009.

Szilard R., "Theories and Application of Plate Analysis: Classical, Numerical and Engineering methods" Wiley, USA, 2004

Ventsel E. and T. Krauthammer, "Thin Plates and Shells: Theory, Analysis and applications," CRC Press, 2001.

Reference Books & Web resources

1. Ansel. C. Ugural, "Stresses in Beams, Plates and Shells," Taylor and Francis, 2009.
2. NPTEL Course: Plates and Shells. https://nptel.ac.in/courses/105103209

Course Contents and Lecture Schedule

Module No	Topics	No of Periods	Course Outcomes
1	**Thin Plate Theory, Cylindrical Bending, Pure Bending & Circular Plates**		CO1
1.1	Thin Plate Theory — Assumptions	1	
1.2	Bending of Long Rectangular Plates to a Cylindrical Surface — Differential Equation	1	
1.3	Plates with Simply Supported Edges and Built-in-edges	2	
1.4	Pure Bending of Plates — Relation between Bending Moment and Curvature	1	
1.5	Uniformly and Laterally Loaded Circular Plates — Differential Equation	2	
2	**Small Deflections & Navier's Solution**		CO2
2.1	Small Deflections of Laterally Loaded Plates — Differential Equation of Deflection Surface	1	
2.2	Simply Supported Rectangular Plates under Sinusoidal Loading	1	
2.3	Navier's Solution — Simply Supported Rectangular Plates under Uniform Loading	1	
2.4	Navier's Solution — Simply Supported Rectangular Plates under Hydrostatic Pressure	1	
2.5	Navier's Solution — Simply Supported Rectangular Plates under Concentrated Load	1	
2.6	Navier's Solution — Simply Supported Rectangular Plates under Load Uniformly Distributed over Rectangle	1	
3	**Levy's Method**		CO3
3.1	Levy's Method — Introduction & Advantages over Navier's Solution	1	
3.2	Simply Supported Rectangular Plates under Uniform Loading — Levy's Method	1	
3.3	Simply Supported Rectangular Plates under Hydrostatic Pressure — Levy's Method	1	
3.4	Problem Solving — Comparative Examples using Navier's & Levy's Methods	1	
3.5	Problem Solving — Practice Session	1	
4	**Finite Difference Approach**		CO4
4.1	Finite Difference Approach — Differential Equation of Laterally Loaded Thin Plates	1	
4.2	Simply Supported Square Plates under Uniform Loading	1	
4.3	Fixed Square Plates under Uniform Loading	1	
4.4	Simply Supported Rectangular Plates under Uniform Loading	1	
4.5	Fixed Rectangular Plates under Uniform Loading	1	
4.6	Plates under Partial Loading	1	
4.7	Plates under Triangular Loading	1	
4.8	Plates under Trapezoidal Loading	1	

5	**Energy Methods**		CO5
5.1	Principle of Virtual Work — Theory and Application to Plates	1	
5.2	Principle of Minimum Potential Energy — Theory and Application	1	
5.3	Application of Energy Methods to Simply Supported Plates	1	
5.4	Application of Energy Methods to Fixed Plates	1	
5.5	Problem Solving — Energy Method Applications	1	
6	**Anisotropic Plates**		CO6
6.1	Bending of Anisotropic Plates — Differential Equation of the Bent Plate	1	
6.2	Bending of Rectangular Anisotropic Plates	1	
6.3	Bending of Circular Anisotropic Plates	1	
6.4	Bending of Elliptic Anisotropic Plates	1	
6.5	Problem Solving — Anisotropic Plate Examples	1	
	Total Periods	36	

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