DETAIL

COURSE CURRICULUM

FOR

POSTGRADUATE PROGRAMME

M.TECH

IN

CIVIL ENGINEERING

Specialization in

STRUCTURAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY AGARTALA

TRIPURA (WEST), INDIA

PIN: 799046

Preface

Civil Engineering Department of NIT Agartala, awards the degree of Master of Technology (M. Tech) in seven different specializations viz, Environmental Engineering, Geotechnical Engineering, Hydro-Informatics Engineering, Structural Engineering, Seismic Science and Engineering, Transportation Engineering and Water Resources Engineering.

The course structures of all post graduate degree programmes are carrying a total of 80 credits and 2000 marks. Semester wise distribution of course and credits are as follows: First semester: 25 credits and 800 marks for five theory subjects (comprises core, basic core and elective subjects), two laboratory subjects and seminar; Second semester: 25 credits and 800 marks for four theory subject (comprises core, basic core and elective subjects), two laboratory subjects, comprehensive viva-voce and project preliminaries; Third semester: 10 credits and 100 marks; and Fourth semester: 20 credits and 300 marks. Third and fourth semester of PG courses will be fully devoted for project works. Minimum number of class hours for each theory course should be 40 hours.

There will be continuous assessment of the performance of students throughout the semester. Each theory subject in a semester is evaluated for 100 marks, with the following weightages. Sub-component weightage: Continuous evaluation: 30 Marks (Attendance: 5 Marks, Quiz: 5 Marks, Class test: 10 Marks, Assignment: 10 Marks); Mid-semester Examination: 20 Marks; and End-semester Examination: 50 Marks

The course curriculum of all Post- graduate programmes are designed considering the following six Programme outcomes (Pos) as formulated by National Board of Accreditation (NBA) and two Programme specific outcomes (PSOs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: Ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: An ability to identify, formulate and solve Structural system related problems using advanced level computing techniques.

PO5: An ability to understand the impact of Structural Engineering solutions in a global, economic, environmental and societal context.

PO6: Able to demonstrate knowledge understanding of the engineering and management principles and apply these to multidisciplinary environments.

PSO1: An ability to get exposed to advanced courses in Analysis, and Design of RC, PSC, Steel and composite structures as per the latest design codes and considering current national and international scenario on Structural Engineering.

PSO2: Students should be industry ready / ready to pursue advanced research by getting hands on training on latest equipment / software.

Expert opinions are being taken in regular basis in order to improve the quality of teaching learning process and to attain the programme outcomes efficiently.

In the Final year of M. Tech. programmes (Third and Fourth Semesters) students may also opt for industrial research. If any student desire to pursue his/her research in reputed industries, he/she may be allowed to do so, provided:

a. The selected industry is a permanent member of NASSCOM, FICCI and other such industry bodies.

a. The selected industry is approved by the DPPC of the concerned Department.

b. The student selects one supervisor from industry and another supervisor from the Institute.

If any student opts for such industrial research he/she will not receive any scholarship from the institute in this tenure, even if he/she wants to return back. In such cases the student will be allowed to complete his/her project in the institute but without any scholarship.

CONTENT

Professor
Department of Civil Engineering
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Guwahati-781039

	SECOND SEMESTER	
1	**Basic Core** **PCE12B01**: Theory of Elastic Stability	SE58-SE60
2	**Core Subject-I** **PCE12C01**: Theory of Plates and Shells	SE61-SE63
3	**Elective Paper-III (Any One)**	
	PCE12E01: Seismic Analysis and Design of Structures	SE64-SE66
	PCE12E02: Random Vibration	SE66-SE69
	PCE12E03: Wind Engineering	SE70-SE72
	PCE12E04: Advanced Design of Metal Structures	SE72-SE75
	PCE12E05: Experimental Methods of Structural Analysis	SE75-SE77
	PCE12E06: Bridge Engineering	SE78-SE80
	PCE12E07: Behaviour of Concrete Structures	SE80-SE83
	PCE12E08: Repair and Rehabilitation of Structures	SE83-SE85
4	**Elective Paper-IV (Open Elective) (Any One)**	
	PCE12E09: Finite Element Method	SE86-SE89
	PCE12E10: Structural Health Monitoring	SE89-SE92
	PCE12E11: Nonlinear Analysis	SE92-SE94
	PCE12E12: Advanced Solid Mechanics (**Students** can also opt for one open elective subject offered by any other department)	SE95-SE98
	Project Preliminary, Laboratory & Comprehensive Viva-voce	
5	**PCE12P01**: Project Preliminaries	SE98-SE100
6	**PCE12P02**: Structural Engineering Laboratory	SE100-SE102
7	**PCE12P03**: Computer Aided Design Laboratory	SE102-SE104
8	**PCE12P04**: Comprehensive Viva-voce	SE104-SE105
	THIRD SEMESTER	
1	**PCE13P01**: Project &Thesis– I	SE-106
	FOURTH SEMESTER	
1	**PCE14P01:** Project & Thesis– II	SE-106

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Syllabus: M. Tech. (Structural Engineering)

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	First Semester			
1	**Basic Core** **PCE11B01:** Theory of Elasticity and Plasticity	4	4	100
2	**Core Subject-I** **PCE11C01**: Structural Dynamics	4	4	100
3	**Core Subject-II** **PCE11C02**: Advanced Structural Analysis	4	4	100
4	**Elective Paper-I (Any One)** **PCE11E01**: Advanced Design of R. C. Structures **PCE11E02**: Advanced Design of Pre-stressed Concrete **PCE11E03**: Tall Structures **PCE11E04**: Structural Reliability **PCE11E05**: Soil Structure Interaction **PCE11E06:** Rock Mechanics	4	4	100
5	**Elective Paper-II (Any One)** **PCE11E07:** Advanced Mathematics **PCE11E08:** Numerical Method in Structural Analysis **PCE11E09:** Construction Management and Quality Control **PCE11E10:** Structural Masonry **PCE11E11:** Advanced Concrete Technology **PCE11E12:** Optimization in Engineering (Open Elective) **PCE11E13:** Mechanics of Composite Structures (Open Elective)	4	4	100
6	**PCE11P01**: Cement and Concrete Laboratory	2	3	100
7	**PCE11P02**: Stress Analysis Laboratory	2	3	100
8	**PCE11P03**: Seminar	1	2	100
	Total	**25**	**28**	**800**

	Second Semester			
1	**Basic Core** **PCE12B01**: Theory of Elastic Stability	4	4	100
2	**Core Subject-I** **PCE12C01**: Theory of Plates and Shells	4	4	100
3	**Elective Paper-III (Any One)** **PCE12E01**: Seismic Analysis and Design of Structures **PCE12E02**: Random Vibration **PCE12E03**: Wind Engineering **PCE12E04:** Advanced Design of Metal Structures **PCE12E05:** Experimental Methods of Structural Analysis **PCE12E06:** Bridge Engineering **PCE12E10:** Behaviour of Concrete Structures **PCE12E12:** Repair and Rehabilitation of Structures	4	4	100
4	**Elective Paper-IV (Open Elective) (Any One)** **PCE12E07:** Finite Element Method **PCE12E08:** Structural Health Monitoring **PCE12E11:** Nonlinear Analysis **PCE12E12:** Advanced Solid Mechanics **(** Students can also opt for one open elective subject offered by any other department or one course under MOOCs**)**	4	4	100
5	**PCE12P01**: Project Preliminaries	3	6	100
6	**PCE12P02**: Structural Engineering Laboratory	2	3	100
7	**PCE12P03**: Computer Aided Design Laboratory	2	3	100
8	**PCE12P04**: Comprehensive Viva-voce	2	0	100
	Total	**25**	**28**	**800**
	Third Semester			
1	**PCE13P01**: Project & Thesis – I	**10**	**-**	**100**
	Fourth Semester			
1	**PCE14P01**: Project & Thesis – II	**20**	**-**	**300**
		80	**Total Marks**	**2000**

THEORY OF ELASTICITY AND PLASTICITY

(PCE11B01)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:

By the end of the course the student is expected:

1. To have a complete knowledge of mechanics of deformable bodies.
2. To establish basic equations to solve any isotropic and anisotropic indeterminate problem.
3. To have a full understanding of mechanical properties and behaviour of materials and system.
4. To have an understanding of material and geometric non-linearity of a problem
5. To have a full understanding of the uncertainties involved in system and the resulting risk.
6. To utilize different analytical, numerical and statistical methods for the mathematical modelling and analysis of any system under different type of loads and underlying assumption.
7. To be able to evaluate unknown parameters of mathematical model of any deformable system and the safety in terms of the reliability of its components considering different failure modes.

Course Content:

Elasticity:

Unit 1

Base vectors and metric tensors- Analysis of Strain and equations of compatibility- Stresses and equations of equilibrium- Constitutive relations- Semi-inverse method- boundary conditions. Airy's stress function in Cartesian coordinates and problems in polar coordinates, application to engineering problems.

Unit 2

Torsion of solid sections – Laplace- and Poisson's equations – solution in complex variables. Solutions of bi-harmonic equations using complex-variables.

Unit 3

Three-dimension potential problems. Variational methods- Theorem of minimum potential energy- Theorem of minimum complementary energy. Approximate solutions- Error orthogonalization and Galerkin's method- Ritz method.

Plasticity:

Unit 4

Definitions and physical properties – Yield criteria of Von-Mises and Tresca – Drucker's strain hardening and associative and non-associative flow rules.

Unit 5

Elasto-plastic deformation of beams. Elasto-plastic torsion. Non-uniqueness of load paths. Solution of rigid-perfectly plastic problems.

Reference:

Sl.No	Name of Book	Author	Publisher
1	Theory of Elasticity	Timoshenko, S.P. and Goodier	Chennai McGraw-Hill Education (India) Private Limited, 3rd Edition, 2010
2	Foundation of Solid Mechanics	Y.C.Fung	Prentice-Hall, 1965
3	Mathematical Theory of Elasticity	I.S. Sokolnikoff	Mcgraw-Hill, 1956
4	Theory of Elasticity and Plasticity	H.M. WesterGard	Harvard University Press, 2017
5	Fundamentals of the Theory of Plasticity	L.M. Kachanov	Dover Publications Inc., 2004
6	Theory of perfectly plastic Solids	Prager and Hodge	Dover Publication, Inc., Newyork,1968
7	Theory of Elasticity	H. Leipholz	Noordhoff International Publishing, Layden, 1974
8	Applied Elasticity	Z. Xu	New Age International Private Limited, 1997
9	Advanced Mechanics of Solids	L.S. Srinath	Tata McGraw Hill, India, 3rd Edition, 2017
10	Computational Elasticity—Theory of Elasticity, Finite and Boundary Element Methods	M. Ameen	Alpha Science International Ltd, Revised Edition, 2014
11	Plasticity: Fundamentals and General Results	Martin, J.B.,	MIT Press, London, 1975
12	Theory of Plasticity	J. Chakrabarty	Butterworth-Heinemann, 2006
13	Mathematical Theory of Plasticity	R. Hill	Oxford University Press, 1998

14	Plasticity for Structural Engineers	W.F. Chen and D.J. Han	J Ross Publishing, 2007

Course Outcomes:

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

1. To formulate/establish the basic equations of elasticity and plasticity in Cartesian and polar coordinate system.
2. To differentiate plain stress and plain strain problems of elasticity and plasticity in Cartesian and Polar coordinate system.
3. To validate the elasticity and plasticity concepts for formulating real problems.
4. Solve torsion problems in circular and non-circular cross-sections
5. To comprehend failure mechanisms in materials.
6. Solve analytically the simple boundary value problems with elasto-plastic and strain hardening properties.

To establish the Correlation between COs and POs

Table 1

No of Course Outcome (CO)	Course Outcome
PCE11B01.1	To formulate/establish the basic equations of elasticity and plasticity in Cartesian and polar coordinate system.
PCE11B01.2	To differentiate plain stress and plain strain problems of elasticity and plasticity in Cartesian and Polar coordinate system.
PCE11B01.3	To validate the elasticity and plasticity concepts for formulating real problems.
PCE11B01.4	Solve torsion problems in circular and non-circular cross-sections
PCE11B01.5	To comprehend failure mechanisms in materials.
PCE11B01.6	Solve analytically the simple boundary value problems with elasto-plastic and strain hardening properties.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11B01.1	**3**	**2**	**3**	**1**	**1**	**1**
PCE11B01.2	**3**	**2**	**3**	**1**	**1**	**1**
PCE11B01.3	**3**	**1**	**2**	**1**	**1**	**1**
PCE11B01.4	**3**	**1**	**2**	**1**	**1**	**1**
PCE11B01.5	**3**	**2**	**3**	**1**	**1**	**1**
PCE11B01.6	**3**	**2**	**3**	**1**	**1**	**1**
Total	**18**	**10**	**16**	**6**	**6**	**6**
Average	**3**	**1.66**	**2.66**	**1**	**1**	**1**
Equivalent Avg. Attainment	**3**	**2**	**3**	**1**	**1**	**1**

Table-3

To establish the correlation between COs & PSOs

CO	**PSO1**	**PSO2**
PCE11B01.1	2	2
PCE11B01.2	1	1
PCE11B01.3	1	2
PCE11B01.4	2	3
PCE11B01.5	2	2
PCE11B01.6	2	3
Total	10	13
Average	1.67	2.16
Equivalent Avg. Attainment	2	2

STRUCTURAL DYNAMICS

(PCE11C01)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course Objectives: By the end of the course the student is expected

1. To have a fundamental understanding of dynamics of different oscillating systems and to establish mathematical model of any system under different type of loads and underlying assumption.
2. To solve mathematical models by different analytical, numerical methods.
3. To have the understanding of the structural dynamics and the problem-solving ability for dynamic response of structural system.
4. To prepare the ground for research students to undertake research in this field.

Course Content:

Unit 1:

Types of vibration- spring action- and damping- degrees of freedom-Application of Newton's Law- Free body diagram-D'Alembert's principle, single degree of freedom system- mathematical model of physical systems- Free vibrations of undamped and viscously damped system. Critically damped, overdamped and underdamped system, Logarithmic decrement.

Unit 2:

Response of viscously damped SDOF systems to harmonic excitations; vibration isolation- Force Transmissibility and base motion – principle of vibration measuring instruments.

Unit 3:

Response to general dynamic excitation; Response of an undamped SDOF system to short duration impulse; unit impulse response. Response of undamped system of constant force, rectangular, and triangular loading; Numerical evaluation of Duhamel's integral – undamped and damped system.

Frequency domain analysis; Fourier analysis; Response to a loading represented by Fourier series.

Unit 4

Multi Degree of Freedom Systems: Selection of the degrees of freedom-Evaluation of inertia and stiffness matrices, proportional damping. Formulation of the MDOF equations of motion- undamped free vibrations- Solutions of Eigen value problem for natural frequencies and mode shapes, forced vibration response – Normal coordinates-uncoupled equations of motion-Orthogonal properties of normal modes- Modal superposition method, response of a shear building to base motion.

Unit 5

Vibration of Continuous Systems: Free vibrations of Continuous Systems- axial and transverse vibration of bars / beams. Response of continuous systems to dynamic loads. Energy Principle, Rayleigh-Ritz method.

References:

Sl.No	Name of Book	Author	Publisher
1	Dynamics of Structures	Chopra, A.K.	Pearson Education, 5th Edition, India, 2020
2	Dynamics of Structures	Clough, R.W. & Penzin, J.	McGraw Hill, 2nd Edition, 1993
3	Dynamics of Structures	Humar, J.L.	CRC Press, 3rd Edition, 2012

4	Structural Dynamics	Mario, Paz	Springer (sie), 5th Edition, 2007
5	Advanced Dynamics	Timoshenko, S.	Literary Licensing, LLC, 2012
6	Elements of Vibration Analysis	Meirovitch, L.	McGraw Hill Education, 2nd Edition, 2014.
7	Introduction of Structural Dynamics	Biggs, J.M.	McGraw Hill, NY, 1964
8	Engineering Vibration	Daniel Inman	Pearson Prentice Hall, 2013

Course Outcomes:

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

1. Convert structure into SDOF system.
2. Find response of free and force vibration (harmonic, periodic and transient) of SDOF system.
3. Find natural frequency and mode shapes of MDOF system.
4. Carry out modal analysis of MDOF system.
5. Perform experiments and computer simulation of vibrating system.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	**Course Outcome**
PCE11C01.1	Convert structure into SDOF system.
PCE11C01.2	Find response of free and force vibration (harmonic, periodic and transient) of SDOF system.
PCE11C01.3	Find natural frequency and mode shapes of MDOF system.
PCE11C01.4	Carry out modal analysis of MDOF system.
PCE11C01.5	Perform experiments and computer simulation of vibrating system.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11C01.1	3	2	3	1	1	1
PCE11C01.2	3	2	3	1	1	1
PCE11C01.3	3	2	3	2	1	1

PCE11C01.4	1	1	1	1	1	2
Total	**10**	**7**	**10**	**5**	**4**	**5**
Average	**2.5**	**1.75**	**2.5**	**1.25**	**1**	**1.25**
Equivalent Avg. Attainment	**3**	**2**	**3**	**1**	**1**	**1**

To establish the correlation between COs & PSOs

Table 3

CO	PSO1	PSO2
PCE11C01.1	2	2
PCE11C01.2	3	3
PCE11C01.3	2	2
PCE11C01.4	2	2
PCE11C01.5	2	3
Total	**11**	**12**
Average	**2.2**	**2.4**
Equivalent Avg. Attainment	**2**	**2**

ADVANCED STRUCTURAL ANALYSIS

(PCE11C02)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course Objectives:

1. To understand basic concepts of Matrix Methods of Structural Analysis.
2. To learn fundamentals of Flexibility and Stiffness Methods of Structural Analysis.
3. To analyse the behaviour of plane trusses, continuous beams, and portal frames using Stiffness Matrix Method.
4. To analyse the behaviour of plane trusses, continuous beams, and portal frames using Flexibility Matrix Method.
5. To analyse the behaviour of beams on elastic foundation.

Course Content:

Unit- 1

Basic concepts of structural analysis and methods of solving simultaneous equations: Introduction, Types of framed structures, Static and Kinematic Indeterminacy, Equilibrium equations, Compatibility conditions, Principle of superposition, Energy principles, Equivalent joint loads, Methods of solving linear simultaneous equations- Gauss elimination method, Cholesky method and Gauss-Siedal method.

Unit- 2

Fundamentals of Flexibility and Stiffness Methods: Concepts of stiffness and flexibility, Local and Global coordinates, Development of element flexibility and element stiffness matrices for truss, beam and grid elements, Force-transformation matrix, Development of global flexibility matrix for continuous beams, plane trusses and rigid plane frames, Displacement-transformation matrix, Development of global stiffness matrix for continuous beams, plane trusses and rigid plane frames.

Unit- 3

Analysis using Stiffness Method (including secondary effects): Continuous beams, plane trusses and rigid plane frames.

Unit- 4

Analysis using Flexibility Method (including secondary effects): Continuous beams, plane trusses and rigid plane frames.

Unit- 5

Analysis of beams on elastic foundation: Introduction to infinite, semi-infinite and finite beams, analysis of infinite and semi-infinite beams resting on elastic foundation for different support conditions.

References:

Sl. No.	Name of Book	Author	Publisher
1.	Structural Analysis – A matrix approach	Pandit, G. S. & Gupta, S. P.	McGraw Hill Education, 2nd Edition, 2008
2.	Matrix Analysis of Framed Structures	Weaver, W. & Gere, James M.	CBS Publishers & Distributors, 2nd Edition, 2004
3.	Computational Structural Mechanics	S. Rajasekaran, S. &Sankarasubramanian, G.	Prentice Hall India Learning Private Limited, 2001
4.	Introduction to Matrix Methods of Structural Analysis	Martin, Harold C.	McGraw-Hill Inc.,US, 1966
5.	Matrix Computer Analysis of Structures	Rubinstein, Moshe F.	Prentice-Hall, 1967
6.	Computer Methods of Structural Analysis	Beaufait, F. W., Rowan, W. H., Jr., Hoadely, P. G., and Hackett, R. M.	Prentice-Hall, 1971
7.	Elementary Matrix Analysis of Structures	Kardestuncer, H.	McGraw-Hill Inc.,US, 1974
8	Beams on elastic foundation: Theory with applications in the Fields of Civil and Mechanical Engineering	Miklos Hetenyi	The University of Michigan Press, 1946

Course Outcomes:

Upon completing this course, the students will be able to:

1. Formulate force displacement relation by flexibility and stiffness method.
2. Analyse the plane trusses, continuous beams and portal frames by transformation approach.
3. Analyse the structures by direct stiffness method.
4. Analyse beams on elastic foundation.

To establish the correlation between COs & POs

Table - 1

No. of Course Outcome (CO)	Course Outcome
PCE11C02.1	Students will able to formulate force displacement relation by flexibility and stiffness method.
PCE11C02.2	Students will able to analyse the plane trusses, continuous beams and portal frames by transformation approach.
PCE11C02.3	Students will able to analyse the structures by direct stiffness method.
PCE11C02.4	Students will able to analyse beams on elastic foundation.

Table- 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11C02.1	3	3	3	1	1	1
PCE11C02.2	3	3	3	1	1	1
PCE11C02.3	3	3	3	1	1	1
PCE11C02.4	3	3	3	1	1	1
PCE11C02.5	3	3	3	1	1	1
Total	**15**	**15**	**15**	**5**	**5**	**5**
Average	**3**	**3**	**3**	**1**	**1**	**1**
Equivalent Avg. Attainment	**3**	**3**	**3**	**1**	**1**	**1**

Table - 3

To establish the correlation between COs & PSOs

CO	**PSO1**	**PSO2**
PCE11C02.1	3	2

PCE11C02.2	3	2
PCE11C02.3	3	2
PCE11C02.4	3	2
Total	**12**	**8**
Average	**3**	**2**
Equivalent Avg. Attainment	**2**	**2**

Elective Paper-I

ADVANCED DESIGN OF R. C. STRUCTURES

(PCE11E01)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course Objectives:

To be familiar with professional and existing issues in the design and construction of different structural members by using the appropriate relevant design parameter.

Course Content:

Unit- 1:

Introduction: Design Philosophy, modelling of loads, material characteristics. Reinforced Concrete: M-φ relationship: IS code, ACI code, Behaviour of RC element under flexure, shear, torsion and combined axial load-bending moment, Provision of IS ACI code.

Unit- 2:

Design of Special RCC structures: Design of RC member in tension, Design of Chimney, Grid slab, Dome, Water tank, folded plate.

Unit- 3:

Pre-stressed concrete: Introduction, pre-stressed systems, Pre-tensioned and post tensioned members, Analysis, Losses in pre-stressed concrete, Pressure line, Load balancing concept, Factors influencing deflection, Analysis and design of statically determinate pre-stressed concrete structure for flexure and shear, statically indeterminate beams. Provision of IS codes.

Unit- 4:

Design of pre-stressed Concrete Structures: Design of flexural members, Design for Shear, bond and torsion. Design of end blocks and their importance.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Reliability analysis	R. Ranganathan	Jaico Publishing House, 2006
2	Reinforced concrete design	S.U. Pillai and Devdas Menon	McGraw Hill Education, 3rd Edition, 2017
3	Pre-stressed concrete	N. Krishna Raju	McGraw Hill Education, 6th Edition, 2018
4	Structural Modelling and Experimental Techniques	H.G. Harris and G.M. Sabnis	CRC Press, 2nd Edition, 1999
5	Non destructive Evaluation	E. Bray and R.K. Stanley	CRC Press, Revised Edition, 1996
6	Design of Pre-stressed concrete	T.Y. Lin	Wiley India Private Limited, 3rd Edition, 2010

Course Outcomes:

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

1. Understand the different design philosophy and methods of structural design using IS and ACI codes.
2. Analyze different parameter required to design of various structural elements.
3. Compute the design parameters for different structural elements under different parameter.
4. Implement the structural design parameters in structural drawing for site execution.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE11E01.1	Student will be able to understand the different design philosophy and methods of structural design using IS and ACI codes.
PCE11E01.2	Student will be able to Analyze different parameter required to design of various structural elements.
PCE11E01.3	Student will be able to Compute the design parameters for different structural elements under different parameter.
PCE11E01.4	Student will be able to implement the structural design parameters in structural drawing for site execution.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E01.1	2	-	2	1	1	1
PCE11E01.2	2	1	2	1	1	1
PCE11E01.3	2	1	2	1	1	1
PCE11E01.4	2	2	-	-	1	1
Total	**8**	**4**	**6**	**3**	**4**	**4**
Average	**2**	**1**	**1.5**	**0.75**	**1**	**1**
Equivalent Avg. Attainment	**2**	**2**	**2**	**1**	**1**	**1**

To establish the correlation between COs & PSOs

Table 3

CO	**PO1**	**PO2**
PCE11E01.1	2	1
PCE11E01.2	2	1
PCE11E01.3	2	1
PCE11E01.4	2	1
Total	**2**	**1**
Average	**2**	**1**
Equivalent Avg. Attainment	**2**	**1**

ADVANCED DESIGN OF PRE-STRESSED CONCRETE

(PCE11E02)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course Objectives:

1. To understand basic concepts of pre-stressed concrete structures.
2. To understand the behaviour of pre-stressed concrete elements and sections.
3. To learn design of pre-stressed concrete section for flexure and shear.
4. To understand the transfer of pre-stress in pre-tensioned members.
5. To understand the behaviour of statically indeterminate pre-stressed concrete structure.

Course Content:

Unit – 1

Introduction to the Pre-stressed concrete: Pre-tensioned and post tensioned members, Analysis of section for flexure, Pressure line, Load balancing concept, Loss of prestress in pre-tensioned and post-tensioned members due to various causes like elastic shortening of concrete, shrinkage of concrete, creep of concrete, relaxation of steel, slip in anchorage, bending of member and frictional loss. Provision of IS codes.

Unit – 2

Design of Section for Flexure: Allowable stresses, Elastic design of simple beams having rectangular and I-section for flexure, kern lines, cable profile and cable layout.

Design of Sections for Shear: Shear and Principal stresses, Improving shear resistance by different prestressing techniques- horizontal, sloping and vertical prestressing, Analysis of rectangular and I–beam, Design of shear reinforcement, Indian code provisions.

Unit – 3

Deflections of Prestressed Concrete Beams: Short term deflections of uncracked members, Prediction of long-term deflections, load–deflection curve for a PSC beam, IS code requirements for maximum deflections.

Unit – 4

Transfer of Prestress in Pretensioned Members: Transmission of prestressing force by bond, Transmission length, Flexural bond stresses, IS code provisions, Anchorage zone stresses in post tensioned members, stress distribution in End block, Anchorage zone reinforcements.

Unit – 5

Statically Indeterminate Structures: Advantages and disadvantages of continuous PSC beams, Primary and secondary moments, P and C lines, Linear transformation, concordant and non-concordant cable profiles, Analysis of continuous beams.

References:

Sl. No.	Name of Book	Author	Publisher
1.	Advanced Mechanics of Solids	Srinath L.S.	Tata McGraw Hill Education Private Limited, 3rd Edition, 2010
2.	Pre-stressed concrete	N. Krishna Raju	McGraw Hill Education, 6th Edition, 2018
3.	Design of Prestress Concrete Structures	Lin T.Y. and Burns N.H.	Wiley India Private Limited, 3rd Edition, 2010

4.	Prestressed Concrete	Ramamrutham S.	Dhanpat Rai Publishing Company, 2013
5.	Design of Pre-stressed concrete	T.Y. Lin	Wiley India Private Limited, 3rd Edition, 2010

Course Outcomes:

Upon completing this course, the students will be able to:

1. Analyse pre-stressed concrete elements.
2. Design pre-stressed concrete section for flexure and shear.
3. Analyse transfer of pre-stress in pre-tensioned members.
4. Analyse behaviour of statically indeterminate pre-stressed concrete structure.

Table 1

To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE11E02.1	Students will able to analyse pre-stressed concrete elements.
PCE11E02.2	Students will able to design pre-stressed concrete section for flexure and shear.
PCE11E02.3	Students will able to analyse transfer of pre-stress in pre-tensioned members.
PCE11E02.4	Students will able to analyse behaviour of statically indeterminate pre-stressed concrete structure.

Table – 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E02.1	3	2	3	1	1	1
PCE11E02.2	3	2	3	1	1	1
PCE11E02.3	3	2	1	1	1	1
PCE11E02.4	3	2	3	1	1	1
Total	**12**	**8**	**10**	**4**	**4**	**4**
Average	**3**	**2**	**2.5**	**1**	**1**	**1**
Equivalent Avg. Attainment	**3**	**2**	**3**	**1**	**1**	**1**

Table – 3

To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE11E02.1	3	3
PCE11E02.2	3	3
PCE11E02.3	3	3
PCE11E02.4	3	3
PCE11E02.5	3	3
Total	**15**	**15**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

TALL STRUCTURES

(PCE11E03)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Courses Objectives:

1. To understand the different types of loads may act on tall structures as well the methodology to be chosen to analyze these.
2. To understand about the behavior of various types of structural system.
3. To carry out analysis and design of different tall structures.
4. To check the stability of tall buildings.

Course Content:

Unit-1

Design philosophy- materials- loading- Gravity loading- Wind loading- Earthquake loading-blast loading.

Unit -2

Behavior of various structural systems- factors affecting growth, height and structural form- High rise behavior, rigid frames, braced frames, infilled frames, shear walls, coupled shear walls, wall frames, tubular, cores, outrigger-braced and hybrid mega system.

Unit -3

Analysis and design: -modelling for approximate analysis, accurate analysis and reduction techniques. Analysis of building as total structural systems considering overall integrity and major subsystem interaction, Analysis for member forces, drift and twist, computerised general three-dimensional analysis- Shear wall frame interaction. Structural elements: - Sectional shapes, properties and resisting capacity, deflection, cracking. Prestressing, design for differential movement, creep, and shrinkage effects, temperature effects and fire resistance.

Unit -4

Stability of tall building. Overall buckling analysis of frames- P- Delta analysis- Translational, torsional instability, out of plumb effects, effect of foundation rotation.

References:

Sl No.	Name Of Book	Author	Publisher
1.	Structural Analysis and design of Tall Building	Taranath , B.S.	CRC Press, 2011
2.	High Rise Building Structures	Wolf gang Schuller	John Wiley and Sons, 1977
3.	Advances in Tall Buildings	Lynn S. Beedle	Van Nostrand Reinhold, 1986
4.	Tall Building Structures: Analysis and Design	Brayan Stafford Smith	Wiley India Pvt Ltd, 2011
5.	Wind effects on structures	Emil Simiu & Robert H. Scanlan	John Wiley & Sons, 2nd Edition, 1986
6.	Earthquake resistant design	Pankaj Agarwal and Manish Shrikhande	PHI, 2011

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

1. Apply the knowledge of engineering fundamentals to understand the design criteria and structural forms of tall buildings.
2. Identify the effects of loading in high rise structures.
3. Analysis and design the tall structures.
4. Stability check of tall structures.
5. Select the modern sophisticated software to analyze and design the tall structures.

To establish the correlation between COs & Pos

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE11E03.1	Students will be able to apply the knowledge of engineering

	fundamentals to understand the design criteria and structural forms of tall buildings
PCE11E03.2	Students will be able to identify the effects of loading in high rise structures.
PCE11E03.3	Students will be able to analyze and design the tall structures.
PCE11E03.4	Students will be able to do stability check of tall structures.
PCE11E03.5	Student will be able to select the modern sophisticated software to analyze and design the tall structures.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E03.1	2	2	1	-	2	2
PCE11E03.2	2	2	1	-	2	2
PCE11E03.3	2	1	2	1	1	2
PCE11E03.4	2	2	2	1	1	2
PCE11E03.5	2	2	2	1	1	2
Total	**10**	**9**	**8**	**3**	**7**	**10**
Average	**2**	**1.8**	**1.6**	**0.6**	**1.4**	**2**
Equivalent Avg. Attainment	**2**	**2**	**2**	**1**	**1**	**2**

Table-3

To establish the correlation between COs & PSOs

CO	**PSO1**	**PSO2**
PCE11E03.1	3	2
PCE11E03.2	3	3
PCE11E03.3	3	3
PCE11E03.4	3	3
PCE11E03.5	3	3
Total	**15**	**14**
Average	**3**	**2.8**
Equivalent Avg. Attainment	**3**	**3**

Structural Reliability
(PCE11E04**)**

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course Objectives:

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

1. To understand different mathematical tools for quantifying uncertainties using theories of probability, random variables and random processes.
2. To carry out statistical analysis of materials and loads.
3. To develop the theory of methods of structural reliability based on concept of reliability indices. This includes discussions on FORM and SORM.
4. To introduce methods of reliability analysis using Monte Carlo simulations that includes discussion of variance reduction techniques and RSM.
5. To provide the necessary background to carry out reliability-based design. Code provisions for reliability-based design.
6. To correlate fundamentals of probability theory to structural reliability.
7. To prepare the ground for research students to undertake research in this field.

Course Content:
Unit 1:
Basic Statistics: - Introduction, data reduction
Probability theory: Introduction, random events, random variables, functions of random variables, moments and expectation, common probability distributions.

Unit 2:
Resistance distributions and parameters: - Introduction, Statistics of properties of concrete, steel and other building materials, statistics of dimensional variations, characterization of variables, allowable stresses based on specified reliability.
Probabilistic analysis of loads: gravity loads, wind loads.
Unit 3:
Basic structural reliability: - Introduction, computation of structural reliability.
Level 2 Reliability methods: Introduction, basic variables and failure surface, first order second moment methods (FOSM)
Unit 4:
Reliability based design: Introduction, determination of partial safety factors, development of reliability-based design criteria, optimal safety factors**.**
Unit 5:
Monte Carlo study of structural safety: - General, Monte Carlo method, applications
Unit 6:
Reliability of Structural system: Introduction, system reliability, modelling of structural systems, bounds of system reliability, reliability analysis of frames.

Reference:

Sl. No	Name of Book	Author	Publisher
1	Reliability Analysis and Design of Structures	R. Ranganathan	Jaico Publishing House, 2006
2	Probability Concepts in Engineering Planning and Design, Vol. I Basic Principles	A. H. S Ang and W. H. Tang	John Wiley & Sons, 1975
3	Probability Concepts in Engineering Planning and Design, Vol. II Decision, Risks and Reliability	A. H. S Ang and W. H. Tang	John Wiley & Sons, 1984
4	Probability, Statistics and Decision for Engineers	Jack R. Benjamin & C. Allin Cornell	Dover Publications Inc., 2014

Course Outcomes:

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

1. To have a full understanding of the uncertainties involved in structural problems and the resulting risks.
2. To utilize different statistical and probabilistic methods for the modelling and analysis of component capacities and different types of materials and loads.
3. To be able to evaluate the safety of a structural system in terms of the reliability of its components considering different failure modes.
4. To be able to understand the philosophy and underlying assumptions in the probabilistically based code specifications.
5. To correlate fundamentals of probability theory to structural reliability.

To establish the Correlation between COs and POs

Table 1

No of Course Outcome (CO)	Course Outcome
PCE11E04.1	To have a full understanding of the uncertainties involved in structural problems and the resulting risks.
PCE11E04.2	To utilize different statistical and probabilistic methods for the modelling and analysis of component capacities and different types of materials and loads.
PCE11E04.3	To be able to evaluate the safety of a structural system in terms of the reliability of its components considering different failure modes.
PCE11E04.4	To be able to understand the philosophy and underlying assumptions in the probabilistically based code specifications
PCE11E04.5	To correlate fundamentals of probability theory to structural reliability.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E04.1	3	2	3	1	1	1
PCE11E04.2	3	2	3	1	1	1
PCE11E04.3	3	2	3	1	2	2
PCE11E04.4	3	2	3	1	1	1
PCE11E04.5	3	2	2	1	1	1
Total	**15**	**10**	**14**	**5**	**6**	**6**
Average	**3**	**2**	**2.8**	**1**	**1.2**	**1.2**
Equivalent Avg. Attainment	**3**	**2**	**3**	**1**	**1**	**1**

Table-3

To establish the correlation between COs & PSOs

CO	**PSO1**	**PSO2**
PCE11E04.1	2	2
PCE11E04.2	3	3
PCE11E04.3	3	3
PCE11E04.4	3	3
Total	**11**	**11**
Average	**2.75**	**2.75**
Equivalent Avg. Attainment	**3**	**3**

SOIL STRUCTURE INTERACTION

(PCE11E05)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course objectives:

1. To understand about the importance of interaction mechanics.
2. To understand the effect of soil-structure interaction on response of structural system.
3. To know the SSI modeling techniques and analysis.
4. To understand the design implications.

Course Content:

Unit-1

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

Unit-2

Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behaviour, Time dependent behaviour. Isotropic elastic half space

Unit-3

Beam on Elastic Foundation-Soil Models: Infinite beam, Two parameters, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness. 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. Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. Uplift capacity of piles and anchors.

Unit-4

Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.

Unit- 5

Dynamic Soil Structure interaction, Inertial and Kinematic Interaction, Direct and substructure approach of model analysis, Dynamic stiffness, Dynamic equilibrium equation.

References:

Sl No.	Name Of Book	Author	Publisher
1.	Advanced Geotechnical Engineering Soil–Structure Interaction Using Computer and Material Models	Chandrakant S. Desai Musharraf Zaman	CRC Press Taylor and Francis Group 2014
2.	Elastic Analysis of Soil-Foundation Interaction	SelvaDurai, A. P. S	Elsevier, 1979.
3.	Pile Foundation Analysis and Design	Poulos, H. G., and Davis, E. H.	Prentice Hall, 1981
4.	Structure Soil Interaction		State of Art Report, Institution of Structural Engineers, 1978
5	Suggested Analysis and Design Procedures for combined	ACI 336. (1988)	American Concrete Institute,1988.

	footings and Mats		
6	Foundation Analysis	Scott, R. F.	Prentice-Hall
7	Dynamic Soil Structure Interaction	John P Wolf	Prentice Hall, 1985

Course Outcomes:

1. Students will be able to learn the behavior of whole system.
2. Students will be able to learn linear and nonlinear behavior of soil-structure system.
3. Students will be able to develop in depth idea about design of foundation.
4. Students will be able to learn both static and dynamic SSI based design.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE11E05.1	Students will be able to learn the behavior of whole system.
PCE11E05.2	Students will be able to learn linear and nonlinear behavior of soil-structure system.
PCE11E05.3	Students will be able to develop in depth idea about design of foundation.
PCE11E05.4	Students will be able to learn both static and dynamic SSI based design.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E05.1	2	2	2	1	2	1
PCE11E05.2	1	1	1	1	1	1
PCE11E05.3	2	1	1	1	2	2
PCE11E05.4	2	1	1	1	1	1
Total	**7**	**5**	**5**	**4**	**6**	**5**
Average	**1.75**	**1.25**	**1.25**	**1**	**1.5**	**1.25**
Equivalent Avg. Attainment	**2**	**1**	**1**	**1**	**2**	**1**

Table-3

To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE11E05.1	2	2
PCE11E05.2	3	3

PCE11E05.3	3	3
PCE11E05.4	3	3
Total	**11**	**11**
Average	**2.75**	**2.75**
Equivalent Avg. Attainment	**3**	**3**

ROCK MECHANICS
(PCE11E06)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course Objectives:

1. The course objective is to understand physical and mechanical properties as well as mechanical behaviours of fractured rock mass.
2. To study the static and dynamic stability of blocky rock mass
3. To understand the applications in the majority of infrastructure projects including dams, roads, tunnels, bridges, buildings on fractured rock mass and protection of unstable rock slopes.

Course Content:

Unit-1

Classification and Index Properties of Rocks.

Unit-2

Rock Strength and Failure Criteria.

Unit-3

Initial Stresses in Rocks and Their Measurement, Planes of Weaknesses in Rocks.

Unit-4

Dynamic properties of Rocks: Types of waves, waves propagation, Factors influencing wave velocity, Static and dynamic moduli of elasticity.

Unit-5

Applications of rock mechanics in engineering for underground openings, Applications of rock mechanics to rock slope engineering, Applications of rock mechanics to foundation engineering.

References:

Sl No.	**Name Of Book**	**Author**	**Publisher**
1.	Introduction to Rock Mechanics Rock Mechanics and Engineering	Richard E. Goodman	Wiley, 2nd Edition,

			1989
2.	Engineering Rock Mass Classification	Bieniawski, Z. T	John Wiley and Sons, 1989
3.	Analytical and computational methods in engineering rock mechanics.	E.T. Brown	Allen and Unwin Australia, 1987
4.	Rock Engineering Course note by Evert Hoek	Evert Hoek	A.A. Balkema Publishers

Course Outcomes:

1. Students will be able to understand the principles of rock mechanics for effective strata stability.
2. Students will be able to evaluate strength and failure of fractured rock mass.
3. Students will be able to understand the concepts of lined and unlined tunnels.
4. Students will be able to understand the control of rock deformation and fracture processes provides topic such as rock yielding criteria, numerical analysis procedures and behaviour of rock joints.
5. Students will be able to evaluate the in situ and induced stresses using different numerical methods such as DDA and DEM.
6. Students will able to learn how these govern rock slope stability and underground rock excavation methods in a given stress environment.

To establish the correlation between COs & Pos

Table-1

No. of Course Outcome (CO)	**Course Outcome**
PCE11E06.1	Students will be able to understand the principles of rock mechanics for effective strata stability.
PCE11E06.2	Students will be able to understand the analysis of stresses in case of rocks
PCE11E06.3	Students will be able to understand the concepts of lined and unlined tunnels.
PCE11E06.4	Students will be able to understand the control of rock deformation and fracture processes provides topic such as rock yielding criteria, numerical analysis procedures and behaviour of rock joints.
PCE11E06.5	Students will be able to evaluate the in situ and induced stresses using different numerical methods such as DDA and DEM.
PCE11E06.6	Students will able to learn how these govern rock slope stability and underground rock excavation methods in a given stress environment

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E06.1	2	2	2	1	2	2
PCE11E06.2	2	2	2	1	2	2
PCE11E06.3	3	2	2	1	1	1
PCE11E06.4	3	3	2	2	2	2
PCE11E06.5	2	2	2	1	1	1
PCE11E06.6	2	2	2	1	2	2
Total	**14**	**13**	**12**	**7**	**10**	**10**
Average	**2.33**	**2.16**	**2**	**1.16**	**1.66**	**1.66**
Equivalent Avg. Attainment	**2**	**2**	**2**	**1**	**2**	**2**

Table-3

To establish the correlation between COs & PSOs

CO	**PSO1**	**PSO2**
PCE11E06.1	3	3
PCE11E06.2	3	3
PCE11E06.3	3	3
PCE11E06.4	3	3
PCE11E06.5	3	3
PCE11E06.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

ELECTIVE II

ADVANCED MATHEMATICS

(PCE11E07)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course Objectives:

1. Introduce students to ordinary differential equations and the methods for solving these equations Use differential equations as models for real world phenomena.

2. Integrate the knowledge accumulated in the calculus sequence to solve applied problems.
3. Introduce the fundamentals of Linear Algebra and Complex Analysis.
4. Provide a rigorous introduction to upper-level mathematics which is necessary for students of engineering, physical sciences and mathematics.

Course Content:

Unit-1

Calculus of Variations – Variation and its properties – Euler's equation – Conditional extreme – Isoperimetric problems – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables – some applications – Direct methods – Ritz and Kantorovich methods, Euler's finite difference method.

Unit-2

Laplace Transforms and Fourier Transforms. Application of Fourier Transform in solving initial and boundary value problems. Laplace Equation, Heat equation and wave equation.

Unit-3

Hankel's Transform, elementing properties of Hankel transforms, Hankel inversion and transform theorems. Hankel transforms of derivatives of functions. Parsevel's theorem. Hankel transforms of $\frac{d^2 f}{dx^2} + \frac{1}{x}\frac{df}{dx} = \frac{n^2}{x^2} f$.

Unit-4

Simulation – Types, case studies in various fields using simulation techniques, simulation softwares used, use of mathematical models based on probabilistic and statistical methods.

Partial Differential Equations – Formation of PDE, Solutions of PDE, Equations solvable by direct integration, Linear equations of the first order, Non-linear equations of the first order, Charpit's Method, Homogeneous Linear equations with constant coefficient, Non-Homo geneous Linear equations, Non-Linear equations of the second order.

Unit-5

Solution of Parabolic and Hyperbolic equations – Implicit and Explicit Schemes, ADI methods, Non-Linear parabolic equations – Iteration method, Solution of elliplic equation – Jacobi method, Gauss - Seidel & SOR method. Richardson method, RKF4.

Unit-6

Introduction to finite element method and its scope.

References:

Sl. No.	Name Of Book	Author	Publisher
1.	Advanced Engineering Mathematics	Kreyszig Erwin	John Wiley & Sons (Asia) Pvt. Ltd., 10th Edition, 2015
2.	Numerical Algorithms	Krishnamurthy & Sen	Afiliated East-west press private Limited, New Delhi, 2008
3.	Higher Engineering Mathematics	Ramana, B. V.	McGraw-Hill Companies, New-Delhi, 2017

Course Outcomes:

1. To utilize various methods for solving ODEs and solve initial value problems, understand the existence and uniqueness of such solutions and to Recognize ODEs of varying order and use these to solve problems involving population dynamics, oscillation of a spring and resistance in a circuit.

2. Ability to Work with and solve homogeneous and non-homogeneous ODEs and systems of ODEs. Moreover, to learn additional methods for solving ODEs including Euler's method, the power series method and Laplace transforms.

3. Perform basic operations with matrices, find the inverse of a matrix, determinant of a square matrix, as well as eigen values and eigen vectors and investigate associated applications, and to use matrices to solve systems of equations.

4. Express complex numbers in trigonometric and polar form, and to perform operations with complex numbers, including finding the roots of unity.

5. Explore functions of a single complex variable and calculate derivatives of analytic functions.

6. Calculate line integrals in the complex plane, and Study Cauchy-Riemann equations, Cauchy's integral theorem and Cauchy's integral formula.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE11E07.1	To utilize various methods for solving ODEs and solve initial value problems, understand the existence and uniqueness of such solutions and to

	Recognize ODEs of varying order and use these to solve problems involving population dynamics, oscillation of a spring and resistance in a circuit.
PCE11E07.2	Ability to Work with and solve homogeneous and non-homogeneous ODEs and systems of ODEs. Moreover, to learn additional methods for solving ODEs including Euler's method, the power series method and Laplace transforms.
PCE11E07.3	Perform basic operations with matrices, find the inverse of a matrix, determinant of a square matrix, as well as eigen values and eigen vectors and investigate associated applications, and to use matrices to solve systems of equations.
PCE11E07.4	Express complex numbers in trigonometric and polar form, and to perform operations with complex numbers, including finding the roots of unity.
PCE11E07.5	Explore functions of a single complex variable and calculate derivatives of analytic functions.
PCE11E07.6	Calculate line integrals in the complex plane, and Study Cauchy-Riemann equations, Cauchy's integral theorem and Cauchy's integral formula.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E07.1	2	1	2	2	2	1
PCE11E07.2	2	2	2	2	1	1
PCE11E07.3	2	2	2	2	1	1
PCE11E07.4	2	2	2	2	1	1
PCE11E07.5	2	2	2	2	1	1
PCE11E07.6	2	2	2	2	1	1
Total	**12**	**11**	**12**	**12**	**7**	**6**
Average	**2**	**1.83**	**2**	**2**	**1.16**	**1**
Equivalent Avg. Attainment	**2**	**2**	**2**	**2**	**1**	**1**

To establish the correlation between COs & PSOs

Table-3

CO	**PSO1**	**PSO2**
PCE11E07.1	3	1
PCE11E07.2	3	1
PCE11E07.3	3	1
PCE11E07.4	3	1
PCE11E07.5	3	1

PCE11E07.6	3	1
Total	**18**	**6**
Average	**3**	**1**
Equivalent Avg. Attainment	**3**	**1**

NUMERICAL METHOD OF STRUCTURAL ANALYSIS

(PCE11E08)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Courses Objectives:

1. Develop knowledge to formulate the mathematical model of the civil engineering problems to solve.
2. Analyze and asses the accuracy of common numerical methods.
3. Apply numerical methods to obtain approximate solutions to mathematical problems related to structures.
4. To imbibe the applications of mathematical tools and statistical methods for the solution of the problems related to structures.

Course Content:

Unit-1

Fundamentals of numerical methods: error analysis, differentiation, integration, interpolation and extrapolation. Empirical laws, Curve fitting

Unit -2

Solution of non-linear algebraic and transcendental equations.

Unit -3

Solutions of systems of linear and non-linear algebraic equations.

Unit -4

Eigen value problems initial and boundary value problems, use of finite difference, finite element and other numerical technique for solving problems of equilibrium, stability and vibration of structure.

Unit -5

Correlation and regression, Principles of least squares. Introduction to application of MATLAB in numerical methods.

References:

Sl No.	Name Of Book	Author	Publisher
1.	Numerical Mathematical Analysis	J.B. Scarborough	Oxford & IBH Publishing Co Pvt., 2000
2.	Numerical methods in Engineering	Salvadori and Baron	Prentice Hall; 2nd edition (1 December 1961)
3.	Numerical Methods-problems and Solutions	K.K. Jain, S.R.K. Iyengar and R.K. Jain	Wiley Eastern Limited, 2001
4.	Numerical Methods for Scientists and Engineers	R.W. Hamming	Mcgraw Hill, 1998
5.	Numerical Methods using MATLAB	J.H. Mathews and K.D. Fink	Pearson Education, 2004
6.	Probability and Statistics	A.J. Hayter	Duxbury, 2002.

Web Resources:

1. www.scilab.org/
2. http://nptel.ac.in/
3. http://ocw.mit.edu

Course Outcomes:

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

1. Solve algebraic equations.
2. Obtain numerical solution of ordinary and partial differential equations.
3. Apply integration method/s for structural analysis.
4. Carry out interpolations and curve fitting.
5. Obtain solution of Eigen value problems and Fourier series for structural analysis.
6. Apply iterative and transformation methods in structural engineering.

To establish the correlation between COs & Pos

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE11E08.1	Students will be able to solve algebraic equations.
PCE11E08.2	Students will be able to obtain numerical solution of ordinary and partial differential equations..
PCE11E08.3	Students will be able to apply integration method/s for

	structural analysis.
PCE11E08.4	Students will be able to carry out interpolations and curve fitting.
PCE11E08.5	Students will be able to obtain solution of Eigen value problems and Fourier series for structural analysis.
PCE11E08.6	Students will be able to apply iterative and transformation methods in structural engineering.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E08.1	3	2	3	1	1	1
PCE11E08.2	3	2	3	1	1	1
PCE11E08.3	3	2	3	1	1	1
PCE11E08.4	3	2	3	1	1	1
PCE11E08.5	3	2	3	1	1	1
PCE11E08.6	3	2	3	1	1	1
Total	**15**	**10**	**15**	**6**	**6**	**6**
Average	**2.5**	**1.66**	**2.5**	**1**	**1**	**1**
Equivalent Avg. Attainment	**3**	**2**	**3**	**1**	**1**	**1**

To establish the correlation between COs & PSOs

Table 3

CO	**PO1**	**PO2**
PCE11E08.1	2	1
PCE11E08.2	2	1
PCE11E08.3	2	1
PCE11E08.4	2	1
PCE11E08.5	2	1
PCE11E08.6	2	1
Total	**2**	**1**
Average	**2**	**1**
Equivalent Avg. Attainment	**2**	**1**

CONSTRUCTION MANAGEMENT AND QUALITY CONTROL

(PCE11E09)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course objectives:

1. To acquire knowledge in modern trends in management.
2. To understand Network techniques like bar charts, CPM and PERT and the use of Management software.
3. To apply optimization techniques to materials management and work assignment problems.
4. To perform budget estimation and the use of cost control techniques. Use computer aided cost estimation.
5. To learn the technique of quality control and safety in construction project.

Course Content:

Unit-1

Project Management - Trends in Modern Management - Strategic Planning and Project Programming - Effects of Project Risks on Organization - Organization of Project Participants - Traditional Designer Constructor Sequence - Professional Construction Management - Owner-Builder Operation - Turnkey Operation - Leadership and Motivation for the Project Team - Interpersonal Behavior in Project Organizations - Perceptions of Owners and Contractors.

Unit-2

Network techniques: – bar charts – Critical path method – Programme evaluation and review technique – Time estimates- uncertainties of time - time computations – monitoring of projects – updating - Crashing and time-cost trade off PERT and CPM- Software Development - Use of Management Software.

Unit-3

Optimization techniques: - Resource allocation – Heuristic approach - Linear programming – Graphical and Simplex methods – Optimality Analysis - Material transportation and Work assignment problems

Materials management: - planning and budgeting – inventory control – management of surplus materials - equipment control Process control: - work study- crew size – job layout- process operation.

Unit-4

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. Costs Associated with Constructed Facilities - Approaches to Cost Estimation - Type of Construction Cost Estimates - Effects of Scale on Construction Cost - Unit Cost Method of Estimation - Methods for Allocation of Joint Costs - Historical Cost Data - Cost Indices - Applications of Cost Indices to Estimating - Estimate Based on Engineer's List of Quantities - Allocation of Construction Costs Over Time - Computer Aided Cost Estimation - Estimation of Operating Costs.

Unit-5

Quality and Safety Concerns in Construction - Organizing for Quality and Safety - Work and Material Specifications - Total Quality Control - Quality Control by Statistical Methods - Statistical Quality Control with Sampling by Attributes - Statistical Quality Control with Sampling by Variables – Safety.

References:

Sl No.	Name Of Book	Author	Publisher
1.	Construction Project Management: Planning, Scheduling and Control	Chitkara, K.K.	Tata McGraw-Hill Publishing Company, New Delhi, 1998.
2.	Construction Scheduling with Primavera Project Planner	Feigenbaum., L.	Prentice Hall Inc., 1999.
3.	Financial and Cost Concepts for Construction Management	Halpin, D.	John Wiley & Sons, New York, 1985.
4.	Project Management	Choudhury, S.	Tata McGraw-Hill Publishing Company, New Delhi, 1988.
5.	Materials Management	A.K Datta	Prentice Hall, India, 1984.
6.	Introduction to Materials	Arnold, J.R Tony	Prentice Hall, India, 2007

Course Outcomes:

1. To be familiar with the modern trends in construction management.
2. To understand the networking technique and application of relevant software.
3. To be conversant with the optimization techniques for materials management and work assignment problems.
4. To become well acquainted to perform budget estimation and the use of cost control techniques.
5. To be familiar with safety measures and quality control in construction project.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome

PCE11E09.1	Students will be able to learn the modern trends in construction management.
PCE11E09.2	Students will be able to understand the networking technique and application of relevant software.
PCE11E09.3	Students will be familiar with the optimization techniques for materials management and work assignment problems.
PCE11E09.4	Students will be well acquainted to perform budget estimation and the use of cost control techniques.
PCE11E09.5	Students will be familiar with safety measures and quality control in construction project.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E09.1	2	3	2	1	1	1
PCE11E09.2	2	3	2	1	1	1
PCE11E09.3	2	3	2	1	1	1
PCE11E09.4	2	3	2	1	1	1
PCE11E09.5	2	3	2	1	1	1
Total	**10**	**15**	**10**	**5**	**5**	**5**
Average	**2**	**3**	**2**	**1**	**1**	**1**
Equivalent Avg. Attainment	**2**	**3**	**2**	**1**	**1**	**1**

Table-3

To establish the correlation between COs & PSOs

CO	**PSO1**	**PSO2**
PCE11E01.1	3	3
PCE11E09.2	3	3
PCE11E09.3	3	3
PCE11E09.4	3	3
PCE11E09.5	3	3
Total	**15**	**15**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

STRUCTURAL MASONRY
(PCE11E10)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:

To be familiar with different behaviour of masonry structures as per different parameter and will able to design the masonry structure in various condition.

Course Content:

Unit 1:

Introduction: Masonry construction - National and International perspective - Historical development, Modern masonry, Principles of masonry design, Masonry standards: IS 1905 and others.

Unit 2:

Material Properties: Masonry units: clay and concrete blocks, Mortar, grout and reinforcement, Bonding patterns, Shrinkage and differential movements.

Unit 3:

Masonry under Compression and lateral loads: Prism strength, Eccentric loading, Kern distance. In-plane and out-of-plane loads, Analysis of perforated shear walls, Lateral force distribution -flexible and rigid diaphragms.

Unit 4:

Behavior of Masonry: Shear and flexure - Combined bending and axial loads - Reinforced and unreinforced masonry - Cyclic loading and ductility of shear walls for seismic design – Infill masonry.

Unit 5:

Structural design of Masonry: Working and Ultimate strength design - In-plane and out-of-plane design criteria for load-bearing and infill's, connecting elements and ties - Consideration of seismic loads - Code provisions.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Brick and Reinforced Brick Structures	Dayaratnam, P	Oxford & IBH Publishing Co, 1987.
2	Masonry Structures: Behaviour & Design	Drysdale, R. G. Hamid, A. H. and Baker, L. R	Masonry Structures: Behaviour & Design", Prentice Hall Hendry,1994.
3	Design of Masonry Structures	A.W. Hendry, B.P. Sinha and Davis, S.	E & FN Spon, UK, 1997

		R	
4	Structural Masonry	Sahlin, S	Prentice Hall, Englewood Cliffs, NJ, 1971.
5	Reinforced Masonry Design	R.S. Schneider and W.L. Dickey	Prentice Hall, 3rd edition, 1994.
6	Seismic Design of Reinforced Concrete and Masonry Buildings	Paulay, T. and Priestley, M. J. N.	John Wiley, 1992.
7	Structural Masonry	A.W. Hendry	2nd Edition, Palgrave McMillan Press, 1998.

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

1. Analyze the behaviour of masonry structures under gravity and lateral loads.
2. Design masonry structures for gravity, wind and seismic loads.
3. Design masonry infill as shear walls for lateral action.
4. Apply strengthening techniques for repair and rehabilitation of masonry structures.

To establish the correlation between COs & POs

Table 1

No. of course Outcome (CO)	Course Outcome
PCE11E10.1	Student will be able to analyze the behaviour of masonry structures under gravity and lateral loads.
PCE11E10.2	Student will be able to design masonry structures for gravity, wind and seismic loads
PCE11E10.3	Student will be able to design masonry infill as shear walls for lateral action
PCE11E10.4	Student will be able to apply strengthening techniques for repair and rehabilitation of masonry structures.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E10.1	2	1	2	1	2	2
PCE11E10.2	2	1	2	1	2	2
PCE11E10.3	2	1	2	1	2	2
PCE11E10.4	2	1	2	1	2	2
Total	**8**	**4**	**8**	**4**	**8**	**8**
Average	**2**	**1**	**2**	**1**	**2**	**2**

Equivalent Avg. Attainment	**2**	**1**	**2**	**1**	**2**	**1**

Table-3

To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE11E10.1	3	3
PCE11E10.2	3	3
PCE11E10.3	3	3
PCE11E10.4	3	3
Total	12	12
Average	3	3
Equivalent Avg. Attainment	3	3

ADVANCED CONCRETE TECHNOLOGY (PCE11E11)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Courses objectives:

1. To learn the cement chemistry and its microstructure.
2. To learn about various types of admixtures and their effect on strength, durability and rheology of concrete.
3. To learn about various phenomenon responsible for volume instability and deterioration process of concrete.
4. To get exposure to sustainable concrete, special concrete, characterization technique and modeling of concrete properties.

Course Content:

Unit-1
Hydration of cements and microstructural development.

Unit-2
Mineral additives, Supplementary cementitious materials, Chemical admixtures,

Rheology of concrete.

Unit-3
Creep and relaxation, Shrinkage, cracking and volume stability, deterioration processes.

Unit-4

Special concretes, advanced characterization techniques, Sustainability issues in concreting, modelling properties of concrete.

Unit-5

Special concrete-Light weight concrete-fibre reinforced concrete-foamed concrete-Geopolymer concrete- Polymer impregnated concrete.

References

Sl No.	Name Of Book	Author	Publisher
1.	Concrete Technology	M.S.Shetty	S.Chand & Comp.Ltd, 2006
2.	Properties of concrete	A.M.Neville	Pearson Education India, 5th Edition, 2012
3.	Concrete Structure, properties and materials	P.K.Mehta	Prentice Hall.Inc.USA, 1986
4.	Concrete technology	M.L.Gambhir	Tata McGraw Hill, New Delhi, 2017
5	Polymers in Civil Engg.	J.H.Bungey	Surrey University Press, New York, 2012

Course Outcomes:

1. Students will be able to learn the cement chemistry, its hydration mechanism and microstructure.
2. Students will be able to learn about various additive materials and supplementary cementitious materials for modifying various properties of concrete.
3. Students will be able to learn about various factors which are responsible for deterioration of concrete.
4. Students will be able to learn about special types of concrete, characterization technique and modelling of concrete properties.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE11E11.1	Students will be able to learn the cement chemistry, its hydration mechanism and microstructure.
PCE11E11.2	Students will be able to learn about various additive materials and supplementary cementitious materials for modifying various properties of concrete.
PCE11E11.3	Students will be able to learn about various factors which are responsible for deterioration of concrete.
PCE11E11.4	Students will be able to learn about special types of concrete, characterization technique and modelling of concrete properties.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E11.1	2	1	2	2	2	2
PCE11E11.2	2	1	2	2	2	2
PCE11E11.3	2	1	2	2	2	2
PCE11E11.4	2	1	2	2	2	2
Total	**8**	**4**	**8**	**8**	**8**	**8**
Average	**2**	**1**	**2**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**1**	**2**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table 3

CO	**PO1**	**PO2**
PCE11P01.1	2	1
PCE11P01.2	2	1
PCE11P01.3	2	1
PCE11P01.4	2	1
Total	**2**	**1**
Average	**2**	**1**
Equivalent Avg. Attainment	**2**	**1**

OPTIMIZATION IN ENGINEERING

(PCE11E12)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course objectives:

1. This course will introduce the students to the basic fundamentals of optimization methods that can be used during a design process.
2. To understand unified and exact mathematical basis as well as the general principles of various soft computing techniques.
3. To understand and apply detailed theoretical and practical aspects of intelligent modeling, optimization and control of linear and non-linear systems.
4. To understand the concept of some advance topics of optimization and apply accordingly.

Course content:

Unit- 1

Introduction. Problem formulation with examples.
Single Variable Unconstrained Optimization Techniques Optimality Criteria. Bracketing methods: Unrestricted search, Exhaustive search.

Unit- 2

Region Elimination methods: Interval Halving methods, Dichotomous search, Fibonacci method, Golden section method.
Interpolation methods: Quadratic Interpolation method, Cubic Interpolation method. Gradient Based methods: Newton-Raphson method, Secant method, Bisection method.

Unit 3

Multi Variable Unconstrained Optimization Techniques. Optimality Criteria. Unidirectional Search.
Direct Search methods: Random search, Grid search, Univariate method, Hooke's and Jeeves' pattern search method, Powell's conjugate direction method, Simplex method. Gradient based methods: Cauchy's (Steepest descent) method, Conjugate gradient (Fletcher-Reeves) method, Newton's method, Variable metric (DFP)method, BFGS method.

Unit 4

Constrained Optimization Techniques.

Classical methods: Direct substitution method, Constrained variation method, method of Lagrange multipliers, Kuhn-Tucker conditions.

Unit 5

Linear programming problem: Standard form, Simplex method.
Indirect methods: Elimination of constraints, Transformation techniques, and Penalty function method.
Direct methods: Zoutendijk's method of feasible direction, Rosen's gradient Projection method.

Unit – 6

Specialized Optimization techniques, Dynamic programming, Geometric programming, Genetic Algorithms.

References:

Sl. No.	Name of Book	Author	Publisher

1	Engineering Optimization– Theory and Practice	Rao, S. S.	John Wiley & Sons, 4th Edition, 2009
2	Optimization for Engineering Design – Algorithms and examples	Deb, K.	Prentice Hall India Learning Private Limited, 2nd Edition, 2012
3	Optimum Structural Design	Kirsch U.	McGraw Hill, 1981
4	Introduction to Optimum Design	Arora, J. S.	Academic Press, 3rd Edition, 2011
5	Discrete Optimization of Structures using Genetic Algorithms	Rajeev, S. and Krishnamoorthy, C. S	Journal of Structural Engineering, Vol. 118, No. 5, 1992, 1223- 1250.

Course outcomes:

1. Students will be able to understand basic theoretical principles for formulation of optimization models and its solution.
2. Students will be able to learn the unified and exact mathematical basis as well as the general principles of various soft computing techniques.
3. Students should be able to apply detailed theoretical and practical aspects of intelligent modeling, optimization and control of linear and non-linear systems.
4. Students will be able to understand some advance topic of optimization and apply accordingly.

To establish the correlation between COs & POs

Table-1

No of course outcome	Course Outcome
PCE11E12.1	Students will be able to understand basic theoretical principles for formulation of optimization models and its solution.
PCE11E12.2	Students will be able to learn the unified and exact mathematical basis as well as the general principles of various soft computing
PCE11E12.3	Students should be able to apply detailed theoretical and practical aspects of intelligent modeling, optimization and control of linear and non-linear systems.
PCE11E12.4	Students will be able to understand some advance topic of optimization and apply accordingly.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E12.1	2	1	2	3	2	2
PCE11E12.2	2	1	2	3	2	2

PCE11E12.3	2	1	2	3	2	2
PCE11E12.4	2	1	2	3	2	2
Total	**8**	**4**	**8**	**12**	**8**	**8**
Average	**2**	**1**	**2**	**3**	**2**	**2**
Equivalent Avg. Attainment	**2**	**1**	**2**	**3**	**2**	**2**

To establish the correlation between COs & PSOs

Table 3

CO	PO1	PO2
PCE11E12.1	3	2
PCE11E12.2	3	2
PCE11E12.3	3	2
PCE11E12.4	3	2
Total	**12**	**8**
Average	**3**	**2**
Equivalent Avg. Attainment	**3**	**2**

MECHANICS OF COMPOSITE STRUCTURES

(PCE11E013)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:

1. To explain the behaviour of constituents in the composite materials.
2. To illuminate the knowledge and analysis skills in applying basic laws in mechanics to the composite materials.
3. To enlighten the students in different types of reinforcement.

Course Content:

Unit- 1

Introduction: Composite beams- Elastic behaviour of composite beams, No interaction case, Full interaction case, Shear connectors, Characteristics of shear connectors, Ultimate load behaviour, Serviceability limits, Basic design considerations-Design of composite beams.

Unit- 2

Composite floors: Structural Elements- Profiled sheet decking-Bending resistance, Serviceability criteria, Analysis for internal forces and moments.

Unit- 3

Composite columns: Materials, Structural steel, concrete-reinforced steel, composite column design, fire resistance, combined compression and uniaxial bending.

Unit- 4

Continuous beams and slab: Hogging moment regions of composite beams, Vertical shear and moment Shear Interaction-Global analysis of continuous beams-Design strategies, Beam-column connection.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Mechanics of Laminated Composite Plates and Shells: Theory and Analysis, Second Edition	Reddy, J.N.	CRC Press, 2003
2	Finite Element Analysis of Composite Laminates	Ochoa, O. O. and Reddy, J.N.	Springer,1992
3	Mechanics of Composite Materials and Structures	Mukhopadhyay, M.	Universities Press
4	Composite Structures of Steel Concrete, Vol. I, Beams, Slabs, Columns and Frames in Buildings	Johnson, R. P.	Wiley-Blackwell, 3rd Edition, 2004
5	Mechanics of Composite Structures	Vasiliev, V. V.	CRC Press, 1993
6	Engineering Mechanics of Composite Materials, (2nd edition)	Isaac and Daniel, M.	Oxford University Press, 2006
7	Analysis and performance of fibre Composites, (Second Edition)	Agarwal, B. D. and Broutman, L. J.	John Wiley & sons, New York , New York, 1990

Course Outcomes:

Upon completion of this course the student will be able to

1. Explain the mechanical behaviour of layered composites compared to isotropic materials.
2. Determine stresses and strains relation in composites materials.
3. Determine composite mechanical properties from constituent fiber and matrix material properties including longitudinal and lateral moduli, Poisson's ratio, and shear modulus.

4. Determine the generalized stiffness and compliance matrix relating in-plane stresses to strains for a composite layer assuming plane stiffness.
5. Apply classical laminated plate theory to determine extensional, coupling, and bending stiffness of a composite laminate.
6. Perform calculations using MATLAB for a composite laminate with many layers.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE11E13.1	Student will be able to explain the mechanical behaviour of layered composites compared to isotropic materials.
PCE11E13.2	Student will be able to determine stresses and strains relation in composites materials.
PCE11E13.3	Student will be able to determine composite mechanical properties from constituent fibre and matrix material properties including longitudinal
PCE11E13.4	Student will be able to determine the generalized stiffness and compliance matrix relating in-plane stresses to strains for a composite layer assuming plane stiffness.
PCE11E13.5	Student will be able to apply classical laminated plate theory to determine extensional, coupling, and bending stiffness of a composite laminate.
PCE11E13.6	Student will be able to perform calculations using MATLAB for a composite laminate with many layers.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E13.1	3	2	3	1	1	1
PCE11E13.2	3	2	3	1	1	1
PCE11E13.3	3	2	3	1	1	1
PCE11E13.4	3	2	3	1	1	1
PCE11E13.5	3	2	3	1	1	1
PCE11E13.6	3	2	3	1	1	1
Total	**18**	**12**	**18**	**6**	**6**	**6**
Average	**3**	**2**	**3**	**1**	**1**	**1**
Equivalent Avg. Attainment	**3**	**2**	**3**	**1**	**1**	**1**

To establish the correlation between COs & PSOs

Table 3

CO	PO1	PO2
PCE11E12.1	3	2
PCE11E12.2	3	2
PCE11E12.3	3	2
PCE11E12.4	3	2
PCE11E12.5	3	2
PCE11E12.6	3	2
Total	**18**	**12**
Average	**3**	**2**
Equivalent Avg. Attainment	**3**	**2**

CEMENT AND CONCRETE LABORATORY

(PCE11P01)

Total Credits	02	L – T – P	0 – 0 – 3 = 3

Course Objectives:

To understand the properties of concrete and cement ingredients and to study the compressive, flexural, split strengths etc. and other non-destructive tests.

Course Content:

Study of the effect of water/cement ratio on workability and strength of concrete - Effect of aggregate/cement ratio on strength of concrete - Effect of fine aggregate/coarse aggregate ratio on strength and permeability of concrete - Study of Mix design methods - study of stress-strain curve of concrete - correlation between cube strength, cylinder strength, split tensile strength and modulus of rupture - effect of cyclic loading on steel - Non-Destructive testing of concrete.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Properties of Concrete	A.M. Neville	5th Edition, Prentice Hall, 2012
2	Concrete Technology	M.S. Shetty	Eighth edition, S Chand Publishing; 2018
3	Concrete Technology	Santhakumar A.R.	2nd Edition, Oxford University Press, New Delhi, 2018.

Course Outcomes:

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

1. Determine the influence of constituents on the properties of concrete and cement.
2. Design the Concrete Mix based on IS and ACI methods for various grades.
3. Analyze the stress strain behaviour of concrete
4. Evaluate the properties of special concretes.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE11P01.1	Student will be able to determine the influence of constituents on the properties of concrete and cement.
PCE11P01.2	Student will be able to design the Concrete Mix based on IS and ACI methods for various grades.
PCE11P01.3	Student will be able to analyze the stress strain behaviour of concrete
PCE11P01.4	Student will be able to Evaluate the properties of special concretes.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11P01.1	3	3	3	2	2	2
PCE11P01.2	3	3	3	2	2	2
PCE11P01.3	3	3	3	2	2	2
PCE11P01.4	3	3	3	2	2	2
Total	**12**	**12**	**12**	**8**	**8**	**8**
Average	**3**	**3**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table 3

CO	**PO1**	**PO2**
PCE11P01.1	2	1
PCE11P01.2	2	1
PCE11P01.3	2	1
PCE11P01.4	2	1
Total	**2**	**1**
Average	**2**	**1**
Equivalent Avg. Attainment	**2**	**1**

STRESS ANALYSIS LABORATORY

(PCE11P02)

Total Credits	02	L – T – P	0 – 0 – 3 = 3

Course Objectives:

1. This course facilitates the student to implement the theoretical concepts of stress and strain in their measurement procedures.
2. To know the concepts and uses of strain gauges and mounting approaches.

Course Content:

Unit- 1

Measurement of Strain: Mechanical Strain Gauges, Electrical Strain Gauges, Extensometers and Compressometers.

Unit- 2

Measurement of Deflection: Dial gauges - Linear Variable Differential Transducers, Principles of operations of UTM, hydraulic loading systems and force measuring devices.

Unit- 3

Behaviour of structural materials and structural members: Casting and testing of simple compression, tension and flexural members. Introduction Non-Destructive Testing of RCC members.

Unit- 4

New Reinforced Cement Composites: Introduction to Steel fibre reinforced concrete, Ferrocement, Polymer concrete, Self Compacting Concrete, High Performance Concrete.

Course Requirement:

Number of suitable experiments will be designed involving the use of above instruments, so that a student on successful completion of the course shall be in a position to use any of these instruments for experiments and testing work. A student will be required to conduct specified number of experiments and submit a report/record of such work. The grades will be awarded based on the performance in the laboratory work, report/record of experiments and a viva-voce examination conducted at the end of the course.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Experimental Stress Analysis, 3rd	Shukla and Dally	Mcgraw Hill, 2010

	edition,		
2	Experimental Stress Analysis,	Singh, S.	Khanna Publishers, 1981

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

1. Demonstrate a basic understanding of experimental methods (e.g. strain gages, Extensometers, Compressometers etc.) commonly used in experimental solid mechanics.
2. Demonstrate the ability to complete a detailed laboratory report and present their findings in a structured, logical manner.
3. Demonstrate the ability to apply knowledge learned in the classes.
4. Demonstrate the ability to analyze experimental data and develop appropriate, logical conclusions based on comparisons to theoretical results and other experimental evidence.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE11P02.1	Student will be able to demonstrate a basic understanding of experimental methods (e.g. strain gages, Extensometers, Compressometers etc.) commonly used in experimental solid mechanics.
PCE11P02.2	Student will be able to demonstrate the ability to complete a detailed laboratory report and present their findings in a structured, logical manner.
PCE11P02.3	Student will be able to demonstrate the ability to apply knowledge learned in the classes.
PCE11P02.4	Student will be able to demonstrate the ability to analyze experimental data and develop appropriate, logical conclusions based on comparisons to theoretical results and other

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11P02.1	2	1	2	1	1	1
PCE11P02.2	2	1	2	1	1	1
PCE11P02.3	2	1	2	1	1	1
PCE11P02.4	2	1	2	1	1	1
Total	**8**	**4**	**8**	**4**	**4**	**4**
Average	**2**	**1**	**2**	**1**	**1**	**1**
Equivalent Avg.	**2**	**1**	**2**	**1**	**1**	**1**

Attainment						

To establish the correlation between COs & PSOs

Table 3

CO	PO1	PO2
PCE11P01.1	2	1
PCE11P01.2	2	1
PCE11P01.3	2	1
PCE11P01.4	2	1
Total	**2**	**1**
Average	**2**	**1**
Equivalent Avg. Attainment	**2**	**1**

SEMINAR

(PCE11P03)

Total Credits	**01**	**L – T – P**	**0 – 0 – 2 = 2**

Course objectives:

1. To understand the current research and field application in structural engineering.
2. To address the structural engineering problems and convey the ideas efficiently.
3. To acquire expertise in technical writing and report preparation.

Course Content:

Each Student shall prepare a Report and present a Seminar on any topic related to the branch of specialization under the guidance of a faculty member. The student shall submit typed copy of the report to the Department/Concerned faculty member. Grades will be awarded on the basis of contents of the report and its related presentation.

Course Outcome:

1. To be familiar with current research problems and application of modern structural engineering techniques.
2. To be conversant with the elaboration of any one of the research topic or field application technique.
3. To be well acquainted in literature review and report preparation on technical matter.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE11P03.1	Students will be able to identify the current research problems and application of modern structural engineering techniques.
PCE11P03.2	Students will be able to elaborate any one of the research topic or field application technique.
PCE11P03.3	Students will be able to conduct literature review and report preparation on technical matter.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11P03.1	2	2	2	1	1	1
PCE11P03.2	2	2	2	1	1	1
PCE11P03.3	2	2	2	1	1	1
Total	**6**	**6**	**6**	**3**	**3**	**3**
Average	**2**	**2**	**2**	**1**	**1**	**1**
Equivalent Avg. Attainment	**2**	**2**	**2**	**1**	**1**	**1**

Table-3

To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE11P03.1	3	3
PCE11P03.2	3	3
PCE11P03.3	3	3
Total	**9**	**9**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

	Second Semester			
1	**Basic Core** **PCE12B01**: Theory of Elastic Stability	4	4	100
2	**Core Subject-I** **PCE12C01**: Theory of Plates and Shells	4	4	100
3	**Elective Paper-III** **PCE12E01**: Seismic Analysis and Design of Structures **PCE12E02**: Random Vibration **PCE12E03**: Wind Engineering **PCE12E04:** Advanced Design of Metal Structures **PCE12E05:** Experimental Methods of Structural Analysis **PCE12E06:** Bridge Engineering **PCE12E07:** Behaviour of Concrete Structures **PCE12E08:** Repair and Rehabilitation of Structures	4	4	100
4	**Elective Paper-IV (Open Elective)** **PCE12E09:** Finite Element Method **PCE12E10:** Structural Health Monitoring **PCE12E11:** Nonlinear Analysis **(** Students can also opt for one open elective subject offered by any other department or one course under MOOCs**)**	4	4	100
5	**PCE12P01**: Project Preliminaries	3	6	100
6	**PCE12P02**: Structural Engineering Laboratory	2	3	100
7	**PCE12P03**: Computer Aided Design Laboratory	2	3	100
8	**PCE12P04**: Comprehensive Viva-voce	2	0	100
	Total	**25**	**28**	**800**

THEORY OF ELASTIC STABILITY

(PCE12B01)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:

By the end of the course the student is expected

1. To achieve fundamental understanding for mathematical aspects of stability;
2. To have a complete knowledge for analytical formulation of different problems due to static and dynamic secondary effects;
3. To evaluate stiffness and geometric stiffness of different problems through finite element approach;
4. To understand the warping phenomena and its consequence in mathematical formulation;
5. To have a knowledge for solving all analytical and numerical formulations.
6. To have a knowledge for analysing and evaluating the critical load and elasto-plastic deformation path.

Course Content:

Unit 1

Concepts and different models of stability – Mathematical aspects and Fredholm alternatives;

Unit 2

Deflection of beam-column—Derivation of stability matrix for matrix displacement method—Approximate stability matrix for determining critical load—Finite element approach for stability of trusses and frames -Effect of shear deformation, effect of imperfection in column.

Unit 3

Torsional buckling of thin-walled open sections – Lateral buckling of beams, Elasto-Plastic buckling of columns. Influence of locked stresses on buckling. Buckling of rings – asymmetric instability of arches

Unit 4

Buckling of rectangular plates – buckling of plates with holes – Post buckling deformation –

Local buckling of thin cylinders in axial compression – growth of imperfections and its influence on local stability – imperfection sensitivity.

Unit 5

Path tracking in displacement-load space for locating critical point and post buckling continuation. Introduction to dynamic stability.

Reference:

Sl. No	Name of Book	Author	Publisher

1	Theory of Elastic Stability	Timoshenko, S.P. and Gere	Mc Graw Hill, Singapore, 1 July 2017
2	Principles of Structural Stability Theory	A.Chajes	Prentice Hall Inc., Englewood Cliffs, New Jersey, 1 August 1974
3	The Dynamic Stability of Elastic Systems	V. V. Bolotin	Holden-Day, INC, San Francisco, London, Amsterdam, 25 December 2010
4	Principles of Structural stability	HansZiegler	Blaisdell Publishing Company, Toronto,1977
5	Buckling of Bars, Plates and Shells	D.O. Brushand B.O. Almorth	McGraw Hill,1978
6	Stability of Structures	A Kumar	Allied Publishers Limited,
7	Structural Stability of Columns and Plates	N.G.R. Iyengar	East West Press, 1 July 1988
8	Stress, Stability and Chaos in structural Engineering-An Energy Approach	Naschie	Mc Graw Hill Book Company, 1992

Course Outcomes:

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

1. To understand instability phenomenon of different problems due to secondary effects;
2. To formulate the mathematical models of different problems by different approaches under action static and dynamic secondary effects;
3. To find the critical loads for columns, beam-columns, plates, rings, thin cylinders, arches and their post buckling phenomenon;
4. To analyse the torsional instability open thin sections;
5. To formulate instability phenomenon through imperfection model;
6. To evaluate post-buckling path.

To establish the Correlation between COs and POs

Table 1

No of Course Outcome (CO)	Course Outcome
PCE12B01.1	To understand instability phenomenon of different problems due to secondary effects;
PCE12B01.2	To formulate the mathematical models of different problems by different approaches under action static and dynamic secondary effects;

PCE12B01.3	To find the critical loads for columns, beam-columns, plates, rings, thin cylinders, arches and their post buckling phenomenon;
PCE12B01.4	To analyse the torsional instability open thin sections;
PCE12B01.5	To formulate instability phenomenon through imperfection model;
PCE12B01.6	To evaluate post-buckling path.

Table 2

Slight (Low): 1	**Moderate: 2**	**Substantial (High): 3**			**No Correlation: - '-'**
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12B01.1	3	-	3	3	3	3
PCE12B01.2	3	-	3	3	3	3
PCE12B01.3	3	-	3	3	3	3
PCE12B01.4	3	-	3	3	3	3
PCE12B01.5	3	-	3	3	3	3
PCE12B01.6	3	-	3	3	3	3
Total	18	-	18	18	18	18
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

Table-3

To establish the correlation between COs & PSOs

CO	**PSO1**	**PSO2**
PCE12B01.1	2	1
PCE12B01.2	2	1
PCE12B01.3	1	2
PCE12B01.4	2	1
PCE12B01.5	1	2
PCE12B01.6	2	1
Total	**10**	**8**
Average	**1.66**	**1.33**
Equivalent Avg. Attainment	**2**	**1**

THEORY OF PLATES AND SHELLS

(PCE12C01)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:

1. Introduce different types of plate with deflection.
2. To develop the differential equation for cylindrical bending of rectangular plates.
3. To develop the differential equation for circular plates.
4. Introduce Strain energy method in pure bending of plates.
5. Introduce the Navier's method and Levy's method.
6. Introduce the basic concept of shell theory.

Course Content:

Unit- 1

Cylindrical Bending: Different kind of plates – Assumptions - Derivation of differential equation for cylindrical bending of long rectangular plates - Analysis of uniformly loaded rectangular plates with edges simply supported and fixed subjected to uniform load. Cylindrical bending of uniformly loaded rectangular plates with elastically built-in edges.

Unit- 2

Pure Bending of Plates: Slope and curvature of slightly bent plates – Relations between moments and curvature - Particular cases of pure bending - Strain energy in pure bending of plates. Navier's and Levy's solution for rectangular plate. Approximate methods of plate bending.

Unit- 3

Circular Plates: Symmetrical loading – Relations between slope, deflection, moments and curvature – Governing differential equation – Uniformly loaded plates with clamped and simply supported edges – Central hole – bending by moments and shearing forces uniformly distributed.

Unit-4

Small Deflection Equation of the deflection surface: Theory of Thin Rectangular Plates: Assumptions – Derivation of governing differential equation for thin plates –Boundary conditions –simply supported plate under sinusoidal load – Navier's solution – Application to different cases – Levy's solution for various boundary conditions subjected to different loadings like uniform and hydrostatic pressure.

Unit- 5

Geometry and classification of shells, membrane analysis of surface of revolution, membrane analysis of pressure vessel. Membrane theory of cylindrical shell roof, simplified bending analysis of cylindrical shell using beam and arch action.

Sl. No.	Name of the Book	Author	Publisher
1	Theory of Plates and Shells	Timoshenko, S.P. and Krieger, S.W.	McGraw Hill, 1 July 2017
2	Reinforced Concrete Shells and Folded Plates	Varghese, P. C.	Prentice Hall India Publications, January 2010
3	Analysis of Thin Concrete Shells	Chandrasekhara, K.	New Age International (P)
4	Theory and Analysis of Elastic Plates and Shells	Reddy, J. N.	CRS Press, 20 November 2006
5	A Text Book of Shell Analysis	Bairagi, K.	Khanna Publisher, New Delhi, 1986
6	Design and Construction of Concrete Shell Roofs	Ramaswamy, G.S.	Mc Graw Hill, New York, 2005
7	Theory of plates and shells	S. S. Bhavikatti	Newage International Publication, 3rd. edition, 2012

Course Outcomes:

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

1. Have knowledge about various plate theories due to bending.
2. Gain the knowledge of Navier's solution, Levy's solution and solve for the rectangular and square plates.
3. Analyze circular plates with various boundary conditions.
4. Analysis the cylindrical bending of rectangular plates on elastic foundation.
5. Ability to realize the potential energy principle and find the solution of rectangular plates for various loadings.
6. Understand the behaviour of shells.

Table-1

To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE12C01.1	Have knowledge about various plate theories due to bending.
PCE12C01.2	Gain the knowledge of Navier's solution, Levy's solution and solve for the rectangular and square plates.
PCE12C01.3	Analyze circular plates with various boundary conditions.
PCE12C01.4	Analysis the cylindrical bending of rectangular plates on elastic foundation.
PCE12C01.5	Ability to realize the potential energy principle and find the solution of rectangular plates.
PCE12C01.6	Understand the behavior of shells.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12C01.1	3	-	3	3	3	3
PCE12C01.2	3	-	3	3	3	3
PCE12C01.3	3	-	3	3	3	3
PCE12C01.4	3	-	3	3	3	3
PCE12C01.5	3	-	3	3	3	3
PCE12C01.6	3	-	3	3	3	3
Total	18	-	18	18	18	18
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

Table 3

To establish the correlation between COs & PSOs

CO	**PSO1**	**PSO2**
PCE12C01.1	2	2
PCE12C01.2	2	2
PCE12C01.3	2	2
PCE12C01.4	3	3
PCE12C01.5	3	3
PCE12C01.6	2	2
Total	**14**	**14**
Average	**2.33**	**2.33**
Equivalent Avg. Attainment	**2**	**2**

Elective III

SEISMIC ANALYSIS AND DESIGN OF STRUCTURES

(PCE12E01)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:

1. To understand seismic parameter, movements of the plates, earthquakes.
2. To Predict the Dynamic Behaviour of simple structural systems and soil structure interaction.
3. To understand the structural design of simple systems subject to harmonic, impulse and/or arbitrary loading.

Course Content:

Unit- 1:

Introduction to Earthquake: Interior of earth; Causes, strength and effects of earthquakes; seismic waves; Measurements of earthquakes.

Unit- 2:

Seismic response of soils and structures: Dynamic properties of soils, site response to earthquake, Seismic response of soil-structure system; seismic consideration for foundation; Elastic seismic response of structures; Non-linear seismic response of structures; level of damping in different structures; Interaction of frames and infill panels; Method of seismic analysis of structures.

Unit- 3:

Earthquake resistant Design Philosophy: Criteria for earthquake resistant design; Principles of reliable seismic behaviour- form, materials and failure modes; specific structural forms for earthquake resistance-moment-resisting frames, shear wall, concentrically braced frames, hybrid structural system. Energy isolating and dissipating devices.

Unit- 4:

Earthquake resistant design of structures: Seismic response of masonry, Design and construction details for reinforced masonry. Seismic response of reinforced concrete, Design and Detailing of Reinforced concrete Structures. Restoration and strengthening.

References:

Sl. No.	Name of the Book	Author	Publisher

1	Seismic design of RC and masonry buildings	Paulay, T & Priestley	John Wiley & Sons, 1996
2	Design of multi-storey RC buildings for earthquake motions Newmark and Corning	Blume, J.A.	Portland Cement Association, 1992
3	Earthquake resistant design.	Dowrick, D.J.	John Wiley & Sons, November 1988
4	Earthquake Resistant Design of Structures	Agarwal & Shrikande	PHI, July 2011
5	Criteria for Earthquake Resistance design of Structures	I.S. 1893 - 2016	Bureau of Indian Standards, New Delhi,
6	Ductile detailing of Reinforced concrete structures subjected to seismic forces	IS.13920 - 2003	Bureau of Indian Standards, New Delhi.

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

1. Understand the concept and terminology related to earthquake.
2. Analyze the different parameters as per zonal classification prescribe by code.
3. Apply the concept of design for earthquake resisting structure.
4. Implement the design parameters for ductile detailing as per codal provision.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	**Course Outcome**
PCE12E01.1	Student will be able to understand the concept and terminology related to earthquake.
PCE12E01.2	Student will be able to analyze the different parameters as per zonal classification prescribe by code.
PCE12E01.3	Student will be able to apply the concept of design for earthquake resisting structure.
PCE12E01.4	Student will be able to implement the design parameters for ductile detailing as per codal provision.

Table 2

Slight (Low): 1 **Moderate: 2** **Substantial (High): 3** **No Correlation: - '-'**						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12E01.1	3	-	3	3	3	3
PCE12E01.2	3	-	3	3	3	3
PCE12E01.3	3	-	3	3	3	3
PCE12E01.4	3	-	3	3	3	3
Total	12	-	12	12	12	12
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

To establish the correlation between COs & PSOs

Table 3

CO	**PSO1**	**PSO2**
PCE12E01.1	2	1
PCE12E01.2	2	1
PCE12E01.3	2	1
PCE12E01.4	2	1
Total	**2**	**1**
Average	**2**	**1**
Equivalent Avg. Attainment	**2**	**1**

RANDOM VIBRATION
PCE12E02

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course objectives:

1. The primary objective in studying the random vibration is to analyse and understand the uncertainty of stationary and nonstationary dynamic loads and their effects on the safety of the system.
2. Implement fundamental concepts to characterize the random excitations in the most realistic manner by a statistical approach and determination of excitation responses for the system.

Course Content:

Unit-1

Basic Theory of Stochastic Processes: Introduction, statistics of stochasticprocesses, ergodic processes, some properties of the correlation functions, spectralanalysis, Wiener-Khintchine equation.

Unit-2

Stochastic Response of Linear SDOF Systems: Deterministic dynamics, evaluation ofimpulse response function and frequency response function, impulse response functionand frequency response function as Fourier Transform pairs, stochastic dynamics,response to stationary excitation, time domain analysis, frequency domain analysis, levelcrossing, peak, first passage time and other characteristics of the response of SDOFSystems

Unit-3

Linear systems with multiple inputs and outputs: Linear MDOF Systems, uncoupledmodes of MDOF systems, stochastic response of linear MDOF Systems – time domainand frequency analysis.

Unit-4

Stochastic response of linear continuous system.Response of non-linear systems to random excitation: Approach to problems, Fokker-Plank equation, statistical linearization, perturbation and Markov Vector Methods.Fatigue damage of structure due to random loads.

Reference:

Sl.No	Name of Book	Author	Publisher
1	An Introduction to Random Vibrations, Spectral and Wavelet Analysis	Newland, D. E.	Longman Scientific & Technical, July 2005
2	Introduction to Random Vibrations	Nigam N. C	Cambridge, USA,1983
3	Vibration of solids and structures under moving loads	Ladislav Fryba	Noordhoff Int. Pub, 3rd edition, 1999
4	Stochastic Analysis of Structural and Mechanical Vibrations	Loren D Lutes &ShahramSarkani.,	Prentice Hall, NJ, December 1996
5	Stochastic Processes & Random Vibration, Theory and Practice	J Solnes	John Wiley,July 1997
6	Probabilistic Theory in Structural Dynamics	Lin, Y. K.	McGraw Hill, 1967
7	Random Data Analysis and Measurement Procedure	Bendat&Piesol	John Wiley, January 2010
8	Elements of Vibration Analysis	Meirovitch, L.	McGraw Hill, March 1986

9	Probability, Random Variables and Stochastic Processes	Papoulis, A.	McGraw Hill, July 2017
10	Dynamics of Structures	Ray W Clough & Joseph Penzien	McGraw Hill, 1993
11	Random Vibration of Structures	C. Y. Yang	John Wiley &Sons,1986

Course Outcomes:

1. Students will able to understand on how to make an assessment of the risk associated with structures which are excited by random loads.
2. Students will able to characterize the different random excitations by a statistical approach.
3. Students will able to modelling and evaluating the corresponding structural response by stochastic process and random vibration for earthquake, wind and ocean wave loads.
4. Students will able to understand the concepts of random processes for modelling dynamic structural behaviour under time-dependent excitations and finally a safety assessment based on various failure criteria.
5. Students will able to presents excitation response solutions for single degree of freedom systems, multi-degree of freedom systems, continuous systems and problem of nonlinear random vibrations.

Table-1

To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE12E02.1	Students will able to understand on how to make an assessment of the risk associated with structures which are excited by random loads.
PCE12E02.2	Students will able to characterize the different random excitations by a statistical approach.
PCE12E02.3	Students will able to modelling and evaluating the corresponding structural response by stochastic process and random vibration for earthquake, wind and ocean wave loads.
PCE12E02.4	Students will able to understand the concepts of random processes for modelling dynamic structural behaviour under time-dependent excitations and finally a safety assessment based on various failure criteria.
PCE12E02.5	Students will able to presents excitation response solutions for single degree of freedom systems, multi-degree of freedom systems, continuous systems and problem of nonlinear random vibrations.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12E02.1	3	-	3	3	3	3
PCE12E02.2	3	-	3	3	3	3
PCE12E02.3	3	-	3	3	3	3
PCE12E02.4	3	-	3	3	3	3
PCE12E02.5	3	3	3	3	3	3
Total	15	3	15	15	15	15
Average	3	3	3	3	3	3
Eq. Av Attainment	3	3	3	3	3	3

To establish the correlation between COs & PSOs

Table 3

CO	**PSO1**	**PSO2**
PCE12E02.1	2	1
PCE12E02.2	2	1
PCE12E02.3	2	2
PCE12E02.4	2	2
PCE12E02.5	2	2
Total	**10**	**8**
Average	**2**	**1.6**
Equivalent Avg. Attainment	**2**	**2**

WIND ENGINEERING

(PCE12E03)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Courses Objectives:

1. To understand Earth's boundary layer and wind characteristics.
2. To understand the bluff-body aerodynamics, wind and structure interaction.
3. To understand effect of wind load on structures and to consider it in analysis and design.

Course Content:

Unit-1

Climatology and meteorology of the Earth's boundary layer. Wind characteristics.

Unit -2

Extreme wind analysis, bluff-body aerodynamics, wind flow around buildings and structures.

Unit -3

Wind loading codes.

Unit -4

Basic aerodynamics. Structural dynamics, and principles of stochastic loadings applicable to the wind engineering of structures.

Unit -5

Wind tunnel modelling of buildings and bridges. Aero elastic and other special problems.

References:

Sl No.	Name of Book	Author	Publisher
1.	Wind Effects on Structures: Fundamentals and Application to Design	E Simiu, R H. Scanlan	John Wiley & Sons, 1996
2.	IS: 875(Part3) :2015 Design Loads (Other than Earthquake) for Buildings and Structures- Code of Practice, Part 3 Wind Loads, BIS, New Delhi		

Course Outcomes:

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

1. Understand the concept and terminology related to the wind engineering.
2. Evaluate the intensity of wind on different structures using different methods.
3. Analyze and design of different structures subjected to wind load using IS 875 (part 3):2015.
4. Design of structures for cyclone.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE12E03.1	Students will be able to understand the concept and terminology related to the wind engineering.
PCE12E03.2	Students will be able to evaluate the intensity of wind on different structures using different methods.
PCE12E03.3	Students will be able to analyze and design of different structures subjected to wind load using IS 875 (part 3):2015.
PCE12E03.4	Students will be able to design of structures for cyclone.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12E03.1	3	-	3	3	3	3
PCE12E03.2	3	-	3	3	3	3
PCE12E03.3	3	-	3	3	3	3
PCE12E03.4	3	-	3	3	3	3
Total	12	-	12	12	12	12
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

Table-3

To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE12E03.1	3	2
PCE12E03.2	3	3
PCE12E03.3	3	3
PCE12E03.4	3	3
Total	**12**	**11**
Average	**3**	**2.75**
Equivalent Avg. Attainment	**3**	**3**

ADVANCED DESIGN OF METAL STRUCTURES

(PCE11E04)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:

1. To learn the behaviour and design of laterally unrestrained beams.
2. To understand the behaviour of beam and column in frames.
3. To learn the behaviour and design of steel beams with web openings.
4. To learn different elements of cold formed steel sections.
5. To learn the design of structural sections for adequate fire resistance.
6. To learn the use of metal as engineering material which have relatively high values of elastic constants and can be made strong by alloying and proper heat treatment.

Course Content:

Unit- 1

Laterally Unrestrained Beams: Lateral Buckling of Beams, Factors affecting lateral stability, IS 800 code provisions, Design Approach. Lateral buckling strength of Cantilever beams, continuous beams, beams with continuous and discrete lateral restraints, Mono-symmetric and non-uniform beams – Design Examples. Concepts of Shear Center, Warping, Uniform and Non-Uniform torsion.

Unit- 2

Beam- Columns in Frames: Behaviour of Short and Long Beam - Columns, Effects of Slenderness Ratio and Axial Force on Modes of Failure, Biaxial bending, Strength of

Beam Columns, Sway and Non-Sway Frames, Strength and Stability of rigid jointed frames, Effective Length of Columns, Methods in IS 800 – Examples.

Unit- 3

Steel Beams with Web Openings: Shape of the web openings, practical guide lines, and Force distribution and failure patterns, Analysis of beams with perforated thin and thick webs, Design of laterally restrained castellated beams for given sectional properties, Vierendeel girders (design for given analysis results).

Unit- 4

Cold formed steel sections: Techniques and properties, Advantages, Typical profiles, Stiffened and unstiffened elements, Local buckling effects, effective section properties, IS 801& 811 code provisions- numerical examples, beam design, column design.

Unit- 5

Fire resistance: Fire resistance level, Period of Structural Adequacy, Properties of steel with temperature, Limiting Steel temperature, Protected and unprotected members, Methods of fire protection, Fire resistance ratings- Numerical Examples.

Unit- 6

Properties of metal: elastic constants, macro and microstructural features of metals, such as point defects, dislocations, grain boundaries, and second phase particles, control their yield, flow, and fracture stress.

References:

Sl. No.	Name of Book	Author	Publisher
1.	Steel Structures: Design and Practice	Subramanian N.	Oxford University Press, August 2010
2.	Design of Steel Structures	Duggal S.K.	Tata McGraw-Hill, July 2017
3.	IS 1641:2013	-	Bureau of Indian Standards
4.	IS 1642:2013	-	Bureau of Indian Standards
5.	IS 1643:2013	-	Bureau of Indian Standards
6.	IS 800:2007, general construction in steel	-	Bureau of Indian Standards

Course Outcomes:

Upon completing this course, the students will be able to:

1. Design laterally unrestrained beams.
2. Analyse the behaviour and design of beam and column in frames.
3. Analyse and design steel beams with web openings.
4. Design elements of cold formed steel sections.

5. Design structural sections for adequate fire resistance.
6. Use of metal as construction material as resistant to corrosion, ductile, and lightweight.

Table- 1

To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE11E04.1	Students will able to Design laterally unrestrained beams.
PCE11E04.2	Students will able to analyse the behaviour and design of beam and column in frames.
PCE11E04.3	Students will able to analyse and design steel beams with web openings.
PCE11E04.4	Students will able to design elements of cold formed steel sections.
PCE11E04.5	Students will able to design structural sections for adequate fire resistance.
PCE11E04.6	Students will able to use of metal as construction material as resistant to corrosion, ductile, and lightweight.

Table – 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE11E04.1	3	-	3	3	3	3
PCE11E04.2	3	-	3	3	3	3
PCE11E04.3	3	-	3	3	3	3
PCE11E04.4	3	-	3	3	3	3
PCE11E04.5	3	-	3	12	12	3
PCE11E04.6	3	-	3	3	3	3
Total	18	-	18	3	3	18
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

Table – 3

To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE11E04.1	3	3
PCE11E04.2	3	3
PCE11E04.3	3	3
PCE11E04.4	3	3
PCE11E04.5	3	3
PCE11E04.6	2	2
Total	**17**	**17**
Average	**2.83**	**2.83**
Equivalent Avg. Attainment	**3**	**3**

EXPERIMENTAL METHODS OF STRUCTURAL ANALYSIS (PCE12E05)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course objectives:

1. To learn the applications of dimensional analysis to check the accuracy of formulas and computations.
2. Recognize the various techniques available to measure the stress and Strains using different sources.
3. Realize the working of recording instruments and data logging methods.
4. Distinguish the principles of photo elasticity in two dimensional stress analyses.

Course Content:

Unit-1
Theories of similarities, Dimensional analysis,
Unit-2
Classification and Equivaience, Distorted models. Ultimate strength models.

Unit-3
Mechanical, Electrical, Optical and acoustic methods of measurement of static and dynamic quantities.
Unit-4

Transducers, Photoelasticity and photoelastic coating techniques. Brittle quoting and moiré method.

Unit 5

Nondestructive testing. In-situ tests. Short term and long term methods.

References:

Sl. No.	Name of Book	Author	Publisher
1.	Experimental stress Analysis	James W. Dally and William F Riley	McGraw-Hill Education, March 1991
2.	Experimental stress Analysis and motion measurement: theory, instruments and circuits , techniques	R. Dove & P. Adams	C. E. Merrill Books, 1964
3.	Experimental Method in structural Mechanics	C. B. Kukreja	Standard Publishers Distributors, January 2014
4.	Experimental Stress Analysis for Materials and Structures	Luca Cristofolini	Springer International Publishing, 2015
5.	Concrete, Microstructure, Properties and Materials	Mehta, P. K. and Monteiro, P. J. M.	McGraw-Hill Education, 2014

Course Outcomes:

1. Students will able to use dimension analysis as a tool to find or check relations among physical quantities by using their dimensions.
2. Students will able to use NDT and analysis technique used by industry to evaluate the properties of a material, component, structure or system for characteristic differences or welding defects and discontinuities without causing damage to the original part.
3. Students will able to understand the overall concepts of stress/strain analysis by experimental means.
4. Students will able to familiar with the theory and practice of common experimental stress analysis methods including moire methods, photo elasticity
5. Students will able to acquire the knowledge on Brittle coatings and working of strain gauges.

Table-1

To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome

PCE12E05.1	Students will able to use dimension analysis as a tool to find or check relations among physical quantities by using their dimensions.
PCE12E05.2	Students will able to use NDT and analysis technique used by industry to evaluate the properties of a material, component, structure or system for characteristic differences or welding defects and discontinuities without causing damage to the original part.
PCE12E05.3	Students will able to understand the overall concepts of stress/strain analysis by experimental means.
PCE12E05.4	Students will able to familiar with the theory and practice of common experimental stress analysis methods including moire methods, photo elasticity
PCE12E05.5	Students will able to acquire the knowledge on Brittle coatings and working of strain gauges.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12E05.1	3	-	3	3	3	3
PCE12E05.2	3	-	3	3	3	3
PCE12E05.3	3	-	3	3	3	3
PCE12E05.4	3	-	3	3	3	3
PCE12E05.5	3	-	3	3	3	3
Total	15	-	15	15	15	15
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

To establish the correlation between COs & PSOs

Table-3

CO	**PSO1**	**PSO2**
PCE12E05.1	3	3
PCE12E05.2	2	2
PCE12E05.3	2	2
PCE12E05.4	2	2
PCE12E05.5	3	3
Total	**12**	**12**
Average	**2.4**	**2.4**
Equivalent Avg. Attainment	**3**	**3**

BRIDGE ENGINEERING

(PCE12E06)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course objectives:

1. To learn the components of bridges, classification of bridges, importance of bridges and to understand the investigation for bridges, subsoil exploration, choice of bridge type.
2. To study the specification of road bridges, loads to be considered.
3. To familiarize students with various types of bridges and their design procedure.
4. To get exposure to evaluation of sub structures and foundations.
5. To understand the importance of bearings, expansion joints and lessons from bridge failures.

Course Content:

Unit-1

Introduction-Historical development of Bridge – Components of Bridges – Classification – Importance of Bridges – Investigation for Bridges – Selection of Bridge site – Economical span – Location of piers and abutments – Subsoil exploration – Scour depth – Traffic projection – Choice of bridge type.

Unit-2

Specification of road bridges – width of carriageway – loads to be considered - dead load – IRC standard live load – Impact effect.

Unit-3

General design considerations – Slab Bridge – Design of T-beam bridge – Box culvert- Overview on continuous bridge – balanced cantilever bridge- Arch Bridge – Box girder bridge decks.

Unit-4

Evaluation of sub structures – Pier and abutments caps – Design of pier – Abutments – Type of foundations.

Unit-5

Importance of Bearings – Bearings for slab bridges – Bearings for girder bridges – Elastomeric bearing – Joints – Expansion joints. Construction and Maintenance of bridges – Lessons from bridge failures.

References:

Sl No.	Name Of Book	Author	Publisher
1.	Bridge Engineering	Ponnuswamy, S.	Tata McGraw – Hill, New Delhi, 1997
2.	Essentials of Bridge Engineering	Victor, D. J.	Oxford and IBH Publishers Co., New Delhi, 1980.
3.	Bridge Superstructure	N. Rajagopalan	Narosa Publishing House, New Delhi, 2006
4.	Design of Bridge Structures	Jagadeesh. T. R. and Jayaram. M. A.	Prentice Hall of India Pvt. Ltd., 2004.
5	Concrete Bridge Practice	Raina. V. K.	Tata McGraw Hill Publishing Company, New Delhi, 1991.

Course Outcomes:

1. To be familiar with the components of bridges, classification of bridges, importance of bridges and to understand the methods of investigation for bridges, subsoil exploration, choice of bridge type.
2. To understand the specification of road bridges, loads to be considered.
3. To be familiar with various types of bridges such as slab-bridge, T-beam bridge, continuous bridge, balanced cantilever bridge, arch bridge, box girder bridge.
4. To get exposed to evaluation of sub structures and foundations.
5. To be familiar with importance of bearings, expansion joints and lessons from bridge failures.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE12E06.1	Students will be able to learn components of bridges, classification of bridges, importance of bridges and understand the methods of investigation for bridges, subsoil exploration, choice of bridge type.
PCE12E06.2	Students will be able to understand the specification of road bridges, loads to be considered.
PCE12E06.3	Students will be familiar with various types of bridges such as slab-bridge, T-beam bridge, continuous bridge, balanced cantilever bridge, arch bridge-box girder bridge.
PCE12E06.4	Students will be exposed to evaluation of sub structures and foundations
PCE12E06.5	Students will be familiar with importance of bearings, expansion joints and lessons from bridge failures.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12E06.1	3	-	3	3	3	3
PCE12E06.2	3	-	3	3	3	3
PCE12E06.3	3	-	3	3	3	3
PCE12E06.4	3	-	3	3	3	3
PCE12E06.5	3	-	3	3	3	3
Total	15	-	15	15	15	15
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

To establish the correlation between COs & PSOs

Table-3

CO	**PSO1**	**PSO2**
PCE12E06.1	3	3
PCE12E06.2	3	3
PCE12E06.3	3	3
PCE12E06.4	3	3
PCE12E06.5	3	3
Total	**15**	**15**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

BEHAVIOUR OF CONCRETE STRUCTURE

(PCE12E07)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course objectives:

1. To learn the materials property and historical developments of RC design philosophy.

2. To study the behavior of beam under different types of stress combination and collapse mechanism.
3. To learn the behavior of column under biaxial bending and yield line theory of slab, elastic and plastic analysis.
4. To learn ductile detailing, advantage of confinement and other durability detailing methods.
5. To understand the factors effecting serviceability of RC structure.

Course Content:

Unit-1

Introduction – Historical developments – Material properties – Limit State Design Philosophy.

Unit-2

Cracked concrete members under flexural moment and axial force – Deformations and collapse – – Moment curvature diagrams – M-P interaction – Beams without stirrups under flexural and torsional shear – Beams with stirrups under flexural and torsional shear.

Plane and space truss analogies – Modified compression field theory – Unified theory –P-M-V-T interaction – Strut and tie model.

Unit-3

Behavior of Columns – Biaxial bending – Interaction surfaces –Yield line theory of slabs, Elastic analysis– Redistribution of moments, Plastic analysis– Inelastic and hysteretic behaviour.

Unit-4

Ductility of R.C. members – Confined concrete – Durability detailing–Cracking – Bond slip– Development length – Tension stiffening.

Unit-5

Serviceability –Elastic, creep and shrinkage deformations.

References:

Sl No.	Name Of Book	Author	Publisher
1.	Reinforced Concrete Structures	Park, R. and Paulay, T.	John Wiley & Sons, New York, 1975
2.	Design of Concrete Structures	Arthur. H. Nilson, David Darwin and Charles W Dolan	Tata McGraw Hill, 2004.
3.	Reinforced Concrete-Mechanics and Design	James G MacGregor, James K Wight	Prentice Hall, Pearson Education South Asia Pte Ltd, 2006.

4.	Theory of Reinforced Concrete	Thomas T. C. Hsu	CRC Press, London, 1993.

Course Outcomes:

1. To be familiar with the materials property and historical developments of RC design philosophy.
2. To understand the behavior of beam under different types of stress combination and collapse mechanism.
3. To understand the behavior of column under biaxial bending and yield line theory of slab, elastic and plastic analysis.
4. To get exposed to ductile detailing, advantage of confinement and other durability detailing methods.
5. To understand the factors effecting serviceability of RC structure.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE12E07.1	Students will be able to learn the materials property and historical developments of RC design philosophy.
PCE12E07.2	Students will be able to understand the behavior of beam under different types of stress combination and collapse mechanism.
PCE12E07.3	Students will be able to understand the behavior of column under biaxial bending and yield line theory of slab, elastic and plastic analysis.
PCE12E07.4	Students will be able to know the ductile detailing, advantage of confinement and other durability detailing methods.
PCE12E07.5	Students will able to learn the factors effecting serviceability of RC structure.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE12E07.1	3	-	3	3	3	3
PCE12E07.2	3	-	3	3	3	3
PCE12E07.3	3	-	3	3	3	3
PCE12E07.4	3	-	3	3	3	3
PCE12E07.5	3	-	3	3	3	3
Total	15	-	15	15	15	15
Average	3	-	3	3	3	3

Eq. Av Attainment	3	-	3	3	3	3

Table-3

To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE12E07.1	3	3
PCE12E07.2	3	3
PCE12E07.3	3	3
PCE12E07.4	3	3
PCE12E07.5	3	3
Total	**15**	**15**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

REPAIR AND REHABILITATION OF STRUCTURES

(PCE12E08)

Total Credits	**04**	**L – T – P**	**3 – 1 – 0 = 4**

Course Objectives:

1. To investigate the cause of deterioration of concrete structures.
2. To strategize different repair and rehabilitation of structures.
3. To evaluate the performance of the materials for repair.
4. To learn the different techniques of repair of structures.

Course Content:

Unit – 1

General: Introduction, Cause of deterioration of concrete structures, Diagnostic methods & analysis, preliminary investigations, experimental investigations using NDT, load testing, corrosion mapping, core drilling and other instrumental methods, Quality assurance for concrete construction, as built concrete properties strength, permeability, thermal properties and cracking.

Unit – 2

Influence on Serviceability and Durability: Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism,

Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, and cathodic protection.

Unit – 3

Maintenance and Repair Strategies: Definitions, Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance, Preventive measures on various aspects. Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration, testing techniques

Unit – 4

Materials for Repair: Special concretes and mortars, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, Ferro cement, Fiber reinforced concrete.

Techniques for Repair: Rust eliminators and polymers coating for rebar during repair foamed concrete, mortar and dry pack, vacuum concrete, Gunite and Shot Crete Epoxy injection, Mortar repair for cracks, shoring and underpinning.

Unit – 5

Examples of Repair to Structures: Repairs to overcome low member strength, Deflection, Cracking, Chemical disruption, weathering wear, fire, leakage, marine exposure, engineered demolition techniques for dilapidated structures - case studies

Course Outcomes:

Upon completing this course, the students will be able to:

1. Understand the cause of deterioration of concrete structures.
2. Understand the concept of Serviceability and Durability.
3. Summarize the principles of repair and rehabilitation of structures.
4. Provide solution for different techniques of repair of structures.

References:

Sl. No.	Name of Book	Author	Publisher
1.	Deterioration, Maintenance and Repair of Structures	Johnson S.M.	McGraw-Hill,
2.	Concrete Structures: Materials, Maintenance, and Repair	Campbell-Allen D. & Roper H.	Longman Scientific & Technical, November1991
3.	Repair of Concrete Structures	Allen R.T.L., Edwards S.C. & Shaw J.D.N.	CRC Press, December 2019
4.	Learning from Failures: Deficiencies in Design, Construction and Service	Raikar R.N.	R&D Centre, Structwel Designers & Consultants Pvt. Ltd, 1987

Table- 1

To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE12E08.1	Students will able to understand the cause of deterioration of concrete structures.
PCE12E08.2	Students will able to understand the concept of Serviceability and Durability.
PCE12E08.3	Students will able to summarize the principles of repair and rehabilitation of structures.
PCE12E08.4	Students will able to provide solution for different techniques of repair of structures.

Table – 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12E08.1	3	-	3	3	3	3
PCE12E08.2	3	-	3	3	3	3
PCE12E08.3	3	-	3	3	3	3
PCE12E08.4	3	-	3	3	3	3
Total	12	-	12	12	12	12
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

Table – 3

To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE12E08.1	3	3
PCE12E08.2	3	3
PCE12E08.3	3	3
PCE12E08.4	3	3
Total	**12**	**12**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

ELECTIVE IV (OPEN ELECTIVE)

FINITE ELEMENT METHOD

(PCE12E09)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:

1. Understand the mathematical and physical principles underlying the Finite Element Method (FEM) focussed on stress analysis of common structural engineering problems.
2. Demonstrate the ability to formulate and implement to solve structural engineering problems using Finite Element Analysis.
3. Be able to evaluate accuracy of the Finite Element solutions using a range of techniques.
4. Be able to create his/her own FEM computer programs, for simple problems.
5. Understand the importance of analysis, using FEM, in the broader context of engineering practice.

Course Content:

Unit- 1

Introduction: Boundary Value Problem, Approximate Solution, Variational and Weighted Residual Methods, Ritz and Galerkin Formulations, Concepts of Piecewise Approximation and Finite Elements, Displacement and Shape Functions, Weak Formulation, Minimum Potential Energy, Generation of Stiffness Matrix and Load Vector.

Unit- 2

Stress Analysis: Two Dimensional problems, Plane Stress, Plain Strain and Axisymmetric Problems, Triangular and Quadrilateral Elements, Natural Coordinates, Isoparametric Formulation, Numerical Integration, Plate Bending and Shell Elements, Brick Elements, Elements for Fracture Analysis.

Unit- 3

Meshing and Solution Problems: Higher Order Elements, p and h Methods of refinement, IIL conditioned Elements, Discretization Errors -Auto and Adaptive Mesh Generation Techniques, Error Evaluation.

Unit- 4

Nonlinear and Vibration Problems: Material and Geometric Nonlinearity, Methods of Treatment, Consistent System Matrices, Dynamic Condensation, Eigen Value Extraction.

Unit- 5

Thermal Analysis: Thermal analysis problems.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Finite Element Method	Zeinkiewicz, O. C.	Tata Mcgraw Hill, 1988
2	The Finite Element Method- Vol. I	Zeinkiewicz & Taylor	Mcgraw-Hill International Editions
3	The Finite Element Method- Vol. II	Zeinkiewicz & Taylor	Mcgraw-Hill International Editions
4	The Finite Element Method- Vol. III	Zeinkiewicz & Taylor	Mcgraw-Hill International Editions
5	Vibrations, Dynamics and Structural System	Mukhopadhyay, M.	Oxford and IBH
6	An Introduction to the Finite Element Method	Reddy, J. N.	Mcgraw-Hill International Editions
7	The Finite Element Analysis	Seshu, P.	PHI
8	Finite Element Procedures	Bathe, K. J.	Prentice Hall, 1996
9	A First Course in Finite Elements	Fish, J. and Belytschko, T.	John Willey & Sons, 2007
10	Concepts and Applications of Finite Element Analysis	Cook, R. D.	John Willey & Sons
11	Finite Element Analysis- Theory and Programming	Krishnamurthy, C. S.	Tata Mcgraw Hill
12	Introduction to Finite Element Vibration Analysis	Petyt, M.	Cambridge University Press

Course Outcomes:

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

1. Analyze linear 1D problem such as bars, beams, 2D structural problems using CST element, 4 node quadrilateral element, axi-symmetric problems with triangular elements, 3 and 4 node plate elements.
2. Write shape functions for 8 node quadrilateral, 6 node triangular (LST) elements, 8 node brick element, shell element, and apply numerical integration to solve; 1D and 2D; stiffness integrations.
3. Understand p and h Methods of refinement, discretization Errors and auto and adaptive mesh generation techniques.
4. Apply suitable boundary conditions to a global equation for various structural engineering problems and solve them to determine displacements, stresses and strains.
5. Understand the finite element method to solve problems with material and geometric nonlinearity and vibration problems.
6. Critically assess a finite element analysis for correctness.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE12E09.1	Student will be able to analyze linear 1D problem such as bars, beams, 2D structural problems using CST element, 4 node quadrilateral element, axi-symmetric problems with triangular elements, 3 and 4 node plate elements.
PCE12E09.2	Student will be able to write shape functions for 8 node quadrilateral, 6 node triangular (LST) elements, 8 node brick element, shell element, and apply numerical integration to solve; 1D and 2D; stiffness integrations.
PCE12E09.3	Student will be able to understand p and h Methods of refinement, discretization Errors and auto and adaptive mesh generation techniques.
PCE12E09.4	Student will be able to apply suitable boundary conditions to a global equation for various structural engineering problems and solve them to determine displacements, stresses and strains.
PCE12E09.5	Student will be able to understand the finite element method to solve problems with material and geometric nonlinearity and vibration problems.
PCE12E09.6	Student will be able to critically assess a finite element analysis for correctness.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12E09.1	3	-	3	3	3	3
PCE12E09.2	3	-	3	3	3	3
PCE12E09.3	3	-	3	3	3	3
PCE12E09.4	3	-	3	3	3	3
PCE12E09.5	3	-	3	3	3	3
PCE12E09.6	3	-	3	3	3	3
Total	18	-	18	18	18	18
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

To establish the correlation between COs & PSOs

Table 3

CO	PSO1	PSO2
PCE12E09.1	2	1
PCE12E09.2	2	1
PCE12E09.3	2	1
PCE12E09.4	2	1
PCE12E09.5	2	1
PCE12E09.6	2	1
Total	**12**	**6**
Average	**2**	**1**
Equivalent Avg. Attainment	**2**	**1**

STRUCTURAL HEALTH MONITORING
(PCE12E10)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course objectives:

1. Implement fundamental concepts the fundamentals of structural health monitoring.
2. To study the various vibration-based techniques for structural health monitoring.
3. To learn the structural health monitoring using fiber-optic and Piezoelectric sensors.
4. To study the structural health monitoring using electrical resistance and electromagnetic techniques.

Course Content:

Unit-1

Review of Structural Modelling and Finite Element Models: Modelling for damage and collapse behaviour of structures, finite element modelling, theoretical prediction of structural failures.

Unit-2

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.

Unit-3

Sensors for Health Monitoring Systems: Acoustic emission sensors, ultrasonic sensors, piezoceramic sensors and actuators, fibre optic sensors and laser shearography techniques, imaging techniques.

Unit-4

Health Monitoring/Diagnostic Techniques: Vibration signature analysis, modal analysis, neural network-based classification techniques.

Unit 5

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.

Unit 6

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.

Unit 7

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.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Industrial sensors and applications for condition monitoring	Philip, W.	MEP, 1994
2	Monitoring and assessment of structures	Armer, G.S.T (Editor)	Spon, London, 2001
3	Structured health monitoring and intelligent infrastructure	Wu, Z.S. (Editor)	Volumes 1 and 2, Balkema, 2003.
4	Shock vibration handbook	Harris, C.M.	McGraw-Hill, 2000
5	Vibratory condition monitoring of machines	Rao, J.S.	Narosa Publishing House, India, 2000

Course Outcomes:

1. Students will able understand the fundamentals of maintenance and repair strategies.
2. Students will able diagnose for serviceability and durability aspects of concrete.
3. Students will able to acquire the knowledge of the materials and techniques used for repair of structures.
4. Decide the appropriate repair, strengthening, rehabilitation and retrofitting technique required for a case study building.
5. Students will able familiar to use an appropriate health monitoring technique and demolition technique.

6. Demonstrate understanding of working principles of sensors and actuators made from smart materials.

Table-1

To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE12E10.1	Students will able understand the fundamentals of maintenance and repair strategies.
PCE12E10.2	Students will able diagnose for serviceability and durability aspects of concrete.
PCE12E10.3	Students will able to acquire the knowledge of the materials and techniques used for repair of structures.
PCE12E10.4	Decide the appropriate repair, strengthening, rehabilitation and retrofitting technique required for a case study building.
PCE12E10.5	Students will able familiar to use an appropriate health monitoring technique and demolition technique.
PCE12E10.6	Demonstrate understanding of working principles of sensors and actuators made from smart materials.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12E10.1	3	-	3	3	3	3
PCE12E10.2	3	-	3	3	3	3
PCE12E10.3	3	-	3	3	3	3
PCE12E10.4	3	-	3	3	3	3
PCE12E10.5	3	-	3	3	3	3
PCE12E10.6	3	-	3	3	3	3
Total	18	-	18	18	18	18
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

To establish the correlation between COs & PSOs

Table 3

CO	PSO1	PSO2
PCE12E10.1	2	2
PCE12E10.2	2	2
PCE12E10.3	2	2
PCE12E10.4	2	1
PCE12E10.5	2	1
PCE12E10.6	2	1
Total	**12**	**9**
Average	**2**	**1.5**
Equivalent Avg. Attainment	**2**	**2**

NONLINEAR ANALYSIS
(PCE12E11)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:
In this course, student will learn how to formulate the system considering material and geometrical non-linearity. Students will then learn about solving of mathematical model using analytical and numerical tools to know the behaviour of system subjected static and dynamic loads.

Course Content:
Unit-1
Tensor analysis, deformation and velocity fields

Unit-2
Conservation laws, invariants, finite strain theories, nonlinear constitutive equations

Unit-3
Deformation and post buckling behaviour of elastic arches, beams, plates and columns.

Unit-4
Nonlinear oscillations and dynamic stability, critical points, elements of functional analysis

Unit-5
Linear spaces spectral theory, Eigen value problems bifurcation, applications.

REFERENCES:

Sl.No	Name of Book	Author	Publisher
1	Non-linear Mechanics	D.G. Fertis	CRC Press, December 1998
2	Non-linear Finite Element Analysis	J.N. Reddy	Oxford University Press, May 2008
3	Nonlinear Analysis of Structures	M. Sathyamoorthy	CRC Press, October 1997
4	Nonlinear Finite Element Analysis of Solids and Structures	M A Crisfield	John Wiley, October 1996
5	Variational Methods in Elasticity and Plasticity	K Washizu	Oxford-New York, Pergamon Press, May 1968
6	Problems in Perturbation	Ali Hasan Nayfeh	John Wiley & Sons, 1985
7.	Nonlinear Oscilations	Nayfey and Mook	Wiley, 1995

Course Outcomes:

On completion of the course, the student is expected to be able to

1. Understand and apply nonlinear analysis concepts and methods to non-linear model of physical system.
2. Select, understand and properly utilize appropriate nonlinear analysis and damping parameters.
3. Perform inelastic analysis flexural members.
4. Perform elastic and inelastic analysis of Plates.
5. Perform nonlinear and instability analysis of elastically supported beams.
6. Assess the behaviour of complex nonlinear structures subject to earthquake loadings using both pushover and time-history analysis methods.

To establish the Correlation between COs and POs

Table 1

No of Course Outcome (CO)	Course Outcome
PCE12E11.1	Understand and apply nonlinear analysis concepts and methods to non-linear model of physical system.
PCE12E11.2	Select, understand and properly utilize appropriate nonlinear analysis and damping parameters.
PCE12E11.3	Perform inelastic analysis flexural members.
PCE12E11.4	Perform elastic and inelastic analysis of Plates.
PCE12E11.5	Perform nonlinear and instability analysis of elastically supported beams.

PCE12E11.6	Assess the behaviour of complex nonlinear structures subject to earthquake loadings using both pushover and time-history analysis methods.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12E11.1	3	-	3	3	3	3
PCE12E11.2	3	-	3	3	3	3
PCE12E11.3	3	-	3	3	3	3
PCE12E11.4	3	-	3	3	3	3
PCE12E11.5	3	-	3	3	3	3
PCE12E11.6	3	-	3	3	3	3
Total	18	-	18	18	18	18
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

To establish the correlation between COs & PSOs

Table 3

CO	**PSO1**	**PSO2**
PCE12E11.1	2	2
PCE12E11.2	2	2
PCE12E11.3	3	3
PCE12E11.4	3	3
PCE12E11.5	2	2
PCE12E11.6	2	2
Total	**14**	**14**
Average	**2.33**	**2.33**
Equivalent Avg. Attainment	**2**	**2**

ADVANCED SOLID MECHANICS
(PCE12E12)

Total Credits	04	L – T – P	3 – 1 – 0 = 4

Course Objectives:

1. To provide the students with a foundation in nonlinear solid mechanics.
2. To learn the conservation principles and derive the equations governing the mechanics of solids within the continuum hypothesis.
3. To learn the constitutive equations for solids.
4. To develop practical skills in working with tensors.
5. To develop problem solving skills, applying the conservation principles and the constitutive equations.

Course Content:

Unit- 1

Introduction to Vectors and Tensors: Introduction to Vector space and Function Space, Algebra of Vectors and Tensors, Eigenvalues and Eigenvectors of Tensors, Transformation Laws for Basis Vectors and Components, Scalar, Vector and Tensor Functions, Gradients and Related operators, Integral Theorems.

Unit- 2

Kinematics: Configurations and Motions of Continuum Bodies, Displacement, Velocity and Acceleration Fields, Material and Spatial Derivatives, Deformation Gradient, Strain Tensor, Rotation and Stretch Tensors, Rates of Deformation Tensors.

Unit- 3

Concepts of Stress: Traction Vectors and Stress Tensors, Examples of States of Stress, Alternative Stress Tensors.

Unit- 4

Balance Principles: Conservation of Mass, Reynolds' Transport Theorem, Momentum Balance Principles, Balance of Mechanical Energy, Balance of Energy in Continuum Thermodynamics, Entropy Inequality Principle.

Unit- 5

Objectivity: Change of observer and Objective Tensor Fields, Superimposed Rigid-body Motions, Objective Rates, Invariance of Elastic Material Response.

Unit- 6

Constitutive Relations: Thermoelastic Materials, Linear Constitutive Relations for Finite Deformations of a Thermoelastic Body, Isotropic Thermoelastic Materials, Transversely Isotropic Thermoelastic Materials, Orthotropic Thermoelastic Materials, Incompressible Elastic Materials, Thermoviscoelastic Materials.

Unit- 7

Torsion of a Circular Cylinder: Torsion of a Linear Elastic Circular Cylinder, Torsion of a Second-order Elastic Circular Cylinder, Finite Torsion of a Circular Cylinder, Uniqueness Theorem.

Unit- 8

Bending of Beams: Bending of a Rectangular Beam, Bending of a Nonlinear Elastic Rectangular Beam, Airy Stress Function for Bending of a Beam.

References:

Sl. No.	Name of Book	Author	Publisher
1	Elements of Continuum Mechanics	Romesh C. Batra	AIAA Education Series, 2006
2	Nonlinear Solid Mechanics- A Continuum Approach for Engineering	Gerhard A. Holzapfel	John Wiley & Sons Ltd., 2000
3	The Non-Linear Field Theries of Mechanics	C. Truesdell and W. Noll	Springer- Verlag Berlin Heidelberg GmbH, 1992
4	The Classical Field Theories	C. Truesdell and R. Toupin	Springer- Verlag Berlin, 1960
5	Continuum Mechanics	D. S. Chandrasekharaiah and Lokenath Debnath	Academic Press, Inc., London, 1994
6	An Introduction to Continum Mechanics	Morton E. Gurtin	Academic Press, Inc., New York, 1981
7.	Continuum Mechanics	A. J. M. Spencer	Dover Publication, Inc, New York, 1980.
8	Mathematical Foundations of Elasticity	J. E. Marsden and T. J. R. Hughes	Dover Publication, Inc, New York, 1983.
9	Continuum Mechanics- Concise Theory and Problems	P. Chadwick	Dover Publication, Inc, New York, 1999.
10	Vector and Tensor Analysis with Applications	A. I. Borisenko and I. E. Tarapov	Dover Publication, Inc, New York,

11	Continuum Mechanics and Plasticity	Han-Chin Wu	Chapman & Hall/CRC, New York, 2005.
12	Classical and Computational Solid Mechanics	Y. C. Fung & Pin Tong	World Scientific Publishing Co. Pvt. Ltd., Singapore, 2001.
13	Nonlinear Elastic Deformation	R. W. Ogden	Dover Publication, Inc, New York, 1997.

Course Outcomes:

On completion of the course, the student is expected to be able to

1. work with tensors, both in indicial and in direct notation.
2. understand the concepts of various deformation and stress tensors.
3. derive the equations of conservation of mass, momenta, and energy.
4. understand and apply the concepts of material symmetry and frame indifference.
5. perform basic continuum modeling of solids.
6. understand scientific articles with continuum mechanical formulations.

To establish the Correlation between COs and POs

Table 1

No of Course Outcome (CO)	Course Outcome
PCE12E12.1	The student is expected to be able to work with tensors, both in indicial and in direct notation.
PCE12E12.2	The student is expected to be able to understand the concepts of various deformation and stress tensors.
PCE12E12.3	The student is expected to be able to derive the equations of con-
PCE12E12.4	The student is expected to be able to understand and apply the concepts of material symmetry and frame indifference.
PCE12E12.5	The student is expected to be able to perform basic continuum modeling of solids.
PCE12E12.6	The student is expected to be able to understand scientific articles with continuum mechanical formulations.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**

PCE12E12.1	2	-	3	3	3	3
PCE12E12.2	2	-	3	3	3	3
PCE12E12.3	2	-	3	3	3	3
PCE12E12.4	2	-	3	3	3	3
PCE12E12.5	2	-	3	3	3	3
PCE12E12.6	2	-	3	3	3	3
Total	12	-	18	18	18	18
Average	2	-	3	3	3	3
Eq. Av Attainment	2	-	3	3	3	3

To establish the correlation between COs & PSOs

Table 3

CO	PSO1	PSO2
PCE12E12.1	2	2
PCE12E12.2	2	2
PCE12E12.3	2	1
PCE12E12.4	2	1
PCE12E12.5	3	3
PCE12E12.6	2	2
Total	**13**	**11**
Average	**2.16**	**1.83**
Equivalent Avg. Attainment	**2**	**2**

PROJECT PRELIMINERIES

(PCE12P01)

Total Credits	**03**	**L – T – P**	**0 – 0 – 6 = 6**

Course objectives:

1. To understand the current research trend and field application in structural engineering field.

2. To understand the structural engineering problems and apply the knowledge in a specific area.
3. To acquire expertise in experimentation, modeling along with technical writing and report preparation**.**

Course Content:

Each student will be given a Thesis/Project problem at the beginning of Second Semester. He/ She will work on the literature survey, scope of work, equipment development etc. and submit a report/dissertation. The main Thesis/Project work will, however, is done in Third and Fourth Semester.

Course Outcomes:

1. To be familiar with current research trend and application of modern structural engineering techniques.
2. To be conversant with the elaboration of any specific area of the research topic or field application technique.
3. To be well acquainted in literature review, experimentation, modeling along with technical writing and report preparation.

To establish the Correlation between COs and POs

Table 1

No of Course Outcome (CO)	Course Outcome
PCE12P01.1	To be familiar with current research trend and application of modern structural engineering techniques.
PCE12 P01.2	To be conversant with the elaboration of any specific area of the research topic or field application technique.
PCE12 P01.3	To be well acquainted in literature review, experimentation, modeling along with technical writing and report preparation.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12P01.1	3	3	3	3	3	3
PCE12P01.2	3	3	3	3	3	3
PCE12P01.3	3	3	3	3	3	3
Total	9	9	9	9	9	9
Average	3	3	3	3	3	3

Eq. Av Attainment	3	3	3	3	3	3

To establish the correlation between COs & PSOs

Table 3

CO	PSO1	PSO2
PCE11P01.1	2	1
PCE11P01.2	2	1
PCE11P01.3	2	1
Total	**6**	**3**
Average	**2**	**1**
Equivalent Avg. Attainment	**2**	**1**

STRUCTURAL ENGINEERING LABORATORY

(PCE12P02)

Total Credits	**02**	**L – T – P**	**0 – 0 – 3 = 3**

Course Objectives:

To understand the different parameter of structural engineering and to study the different behaviour of beams.

Course Content:

Study of behaviour of Beams under flexure – Under Reinforced, Balanced and Over Reinforced Beams Study of Shear- Effect of Shear Span to Depth ratio- Torsion- Testing of Beams under Pure Torsion Testing of pre-stressed Concrete Beams.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Reinforced Cement Concrete Structures	R. Park and T. Paulay	MISL-WILEY Series, Wiley India Pvt. Ltd, 2009.
2	Concrete Technology	M.S. Shetty	Eighth edition, S Chand Publishing; 2018.

Course Outcomes:

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

1. Apply various testing techniques to structural members.
2. Analyze the behaviour of beams under flexure.
3. Perform the Non destructive testing of concrete structures.
4. Analyze the behaviour of beams under shear and torsion.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE12P02.1	Student will be able to apply various testing techniques to structural members.
PCE12P02.2	Student will be able to analyze the behavior of beams under flexure.
PCE12P02.3	Student will be able to perform the Non destructive testing of concrete structures.
PCE12P02.4	Student will be able to analyze the behaviour of beams under shear and torsion.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12P02.1	3	-	3	3	3	3
PCE12P02.2	3	-	3	3	3	3
PCE12P02.3	3	-	3	3	3	3
PCE12P02.4	3	-	3	3	3	3
Total	12	-	12	12	12	12
Average	3	-	3	3	3	3
Eq. Av Attainment	3	-	3	3	3	3

To establish the correlation between COs & PSOs

Table 3

CO	PSO1	PSO2
PCE11P02.1	2	1
PCE11P02.2	2	1
PCE11P02.3	2	1
PCE11P02.4	2	1

Total	**2**	**1**
Average	**2**	**1**
Equivalent Avg. Attainment	**2**	**1**

COMPUTER AIDED DESIGN LABORATORY

(PCE12P03)

Total Credits	**02**	**L – T – P**	**0 – 0 – 3 = 3**

Course Objectives:

1. To impart fundamental knowledge to students in the latest technological topics on Computer Aided Design and Computer Aided Engineering Analysis and to prepare them for taking up further research in the areas.
2. To provide guidance to students for their choices in research and professional career outlook and to encourage students to take up research.

Course Content:

Unit- 1

Developing computer codes in MATLAB, use of different in-built functions and toolboxes to solve different problems.

Unit- 2

Hands on experience on application softwares, STAAD, ANSYS, ABACUS, MIDAS - Development of software and application to Structural Engg Problems.

References:

Sl. No.	**Name of the Book**	**Author**	**Publisher**
1	Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers	Rudra Pratap	Oxford, 2010

Course Outcomes:

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

1. Apply/develop solutions or to do research in the areas of Design and simulation in Structural Engineering.
2. Have abilities and capabilities in developing and applying computer software and hardware to structural analysis.

3. Formulate relevant research problems; conduct experimental and/or analytical study and analyzing results with modern mathematical / scientific methods and use of software tools.
4. Design and validate technological solutions to defined problems and communicate clearly and effectively for the practical application of their work.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE12P03.1	Student will be able to apply/develop solutions or to do research in the areas of Design and simulation in Structural Engineering.
PCE12P03.2	Student will be able to have abilities and capabilities in developing and applying computer software and hardware to structural analysis.
PCE12P03.3	Student will be able to formulate relevant research problems; conduct experimental and/or analytical study and analyzing results with modern mathematical / scientific methods and use of software tools.
PCE12P03.4	Student will be able to design and validate technological solutions to defined problems and communicate clearly and effectively for the practical application of their work.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12P03.1	3	-	3	3	3	3
PCE12P03.2	3	-	3	3	3	3
PCE12P03.3	3	2	3	3	3	3
PCE12P03.4	3	2	3	3	3	3
Total	12	4	12	12	12	12
Average	3	2	3	3	3	3
Eq. Av Attainment	3	2	3	3	3	3

To establish the correlation between COs & PSOs

Table 3

CO	PSO1	PSO2
PCE12P03.1	3	2

PCE12P03.2	3	2
PCE12P03.3	3	2
PCE12P03.4	3	2
Total	**12**	**8**
Average	**3**	**2**
Equivalent Avg. Attainment	**3**	**2**

COMPREHENSIVE VIVA-VOCE

(PCE12P04)

Total Credits	**02**	**L – T – P**	**0 – 0 – 0**

Course objectives:

1. To assess the candidate's overall performances in subject matters related to Structural Engineering and their ability.
2. To understand the current research trend and field application in structural engineering field.
3. To assess the candidate's preparedness for facing any interview.

Course Content:

Viva-voce will be conducted for each of the post graduate students at the end of the Second Semester in the department by the board of examiners constituted by the Structural Engineering Section of Civil Engineering Department.

Course Outcomes:

1. It is for assessing the candidate's overall performances in subject matters related to Structural Engineering and their ability.
2. To be familiar with current research trend and application of modern structural engineering techniques.
3. To be able to prepare for facing any interview.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	**Course Outcome**
PCE12P04.1	It is for assessing the candidate's overall performances in subject matters related to Structural Engineering and their ability.

PCE12P04.2	To be familiar with current research trend and application of modern structural engineering techniques.
PCE12P04.3	To be able to prepare for facing any interview.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PCE12P04.1	1	-	2	2	2	3
PCE12P04.2	2	1	1	1	1	3
PCE12P04.3	1	-	1	1	1	3
Total	4	1	4	4	4	12
Average	1.33	1	1.33	1.33	1.33	3
Eq. Av Attainment	1	1	1	1	1	3

To establish the correlation between COs & PSOs

Table 3

CO	**PSO1**	**PSO2**
PCE12P04.1	3	2
PCE12P04.2	3	3
PCE12P04.3	3	2
Total	**9**	**7**
Average	**3**	**2.33**
Equivalent Avg. Attainment	**3**	**2**

Third & Fourth Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	Third Semester			
1	**PCE13P01**: Project & Thesis - I	**10**	**-----**	**100**
	Fourth Semester			
1	**PCE14P01**: Project & Thesis - II	**20**	**-----**	**300**

Third Semester

Project & Thesis- I
(PCE13P01)

Each student will devote full time in the Third Semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a Faculty Member. They will present a part of the Thesis/Project Report at the end of the Third Semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner. The evaluation of the above said Thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.

Fourth Semester

Project & Thesis- II
(PCE14P01)

Each student will devote full time in the Fourth Semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a Faculty Member. They will present a Final Thesis/Project Report at the end of the Fourth Semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner. The evaluation of the above said Thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.

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