

# Structure of Post Graduate (M.E. Structural Engineering)



THAPAR INSTITUTE  
OF ENGINEERING & TECHNOLOGY  
(Deemed to be University)



**THAPAR INSTITUTE OF ENGINEERING & TECHNOLOGY  
(DEEMED TO BE UNIVERSITY)  
PATIALA, PUNJAB, INDIA**



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# **CURRICULUM & SCHEME OF COURSES**

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*ME-Structural Engineering*

*Civil Engineering Department*

*2019*

## Curriculum Development – Guiding Principles

The statutory bodies of the institute, the Senate or the Planning and Monitoring Board oversee the design and development process so that the activity is carried out in a planned manner. The detailed planning for this activity is the responsibility of the Department Head. The systematic process of design and development includes the activities & sub activities including techniques & organizational interfaces and the time frame for completion of various activities. The plans are updated, as the instructional design evolves.

The design and development process generally begins with a need analysis report which comprises of (i) Stated needs (ii) Implied needs (iii) Overall goals of Instructions (iv) Relevant standards i.e. AICTE and UGC guidelines and Curricula of Entrance Tests like Indian Engineering Services (IES) and Graduate Aptitude Test for Engineers (GATE), etc. and (v) General characteristics of target population.

Organizational and Technical interfaces between different faculty and external expert groups providing input to the instructional design are defined, committees are constituted and their reports are documented. Faculty members from different disciplines connected with the design & development activity are associated with the process. The updation/restructuring is carried out as the design process progresses. Clear responsibilities are assigned and effective communication is ensured.

The requirements of instructional design are determined and recorded. For instructional design, the input is taken from various sources. Input requirements are clearly understood and reconciled. The design input may come from:

- Need analysis & Reviews.
- Recommendations from
  - Faculty & senior management
  - Employers and industry
  - Alumni
  - Regulatory Bodies
- Success/failure reports of similar courses & programs.
- Published literature relevant to programs.
- Boundary condition w.r.t GATE, IES, IAS curricula etc.

The general steps followed in curriculum development are as under:

- The need for starting a new programme or course(s) may arise from interaction with Industry, Faculty, Students, Alumni or PMB/Senate/BOG, UGC/AICTE etc.
- The idea of proposed programme is discussed in the HODs' meeting and if found appropriate, the Head of concerned department is asked to put up a proper proposal. A sub-committee of internal/external member(s) may sometimes be formed for making the feasibility and viability analysis.
- The DAAC (on the basis of recommendations of sub-committee, wherever required) does the need analysis and prepares the proposal for approval from Board of Studies (BOS).

- The BOS after deliberating on the proposal may make the desired modifications and then send the proposal to DOAA for consideration in SUGC/SPGC, along with the duly filled checklists.
- The proposal is put up for consideration to SUGC/SPGC and upon its approval the recommendations may be sent to the Senate and PMB.
- After the Senate approval, the proposal may be sent to concerned Department/School through academic section for allocation of appropriate course codes OR if required it is sent to AICTE/UGC for approval and the status is put up in the forthcoming meeting of BOG.
- Once approved, it is implemented by the concerned Department/School after allocation of proper course code by the academic section.

The employability, innovation and research in curriculum design and development is ensured by:

- Involvement of industry professionals in curriculum development
- Benchmarking exercises to extract customers (employer's) requirements
- Mandatory project semester in Industry for all UG and some PG students
- Synergizing curriculum with industry practices and needs

The curriculum design and development for all programs is done at least once every four years to ensure continuing suitability, adequacy and effectiveness in satisfying the requirements and the vision, mission and quality policy of the institute. The design process includes assessing opportunities for improvement and the need for ensuring suitable employability, innovation and research (more applicable to postgraduate programs). The process invites formal inputs from all stake holders and generally includes the following sources:

- Action taken report on the previous reviews and external accreditation reports (NAAC, NBA-AICTE)
- Results of student's performance in various examinations
- Result of Students Reaction Survey
- Feedback from
  - Industry,
  - Alumni,
  - Participating organizations in campus placement and other concerned sources
- Details of corrective/preventive actions
- Improvement programs suggested/recommended
- Training programs launched
- Review of mission and quality policy

The process of determining solutions to satisfy the identified needs is laid down and documented. Instructions are designed by incorporating these solutions. The analysis and mappings are recorded. The design output at this stage is taken as the initial design for subsequent reviews. The output of instructional design & development is documented in the form of a report named "Curriculum and Scheme of Courses". Through various reviews and verifications, it is ensured that the design output meets the design input requirements.

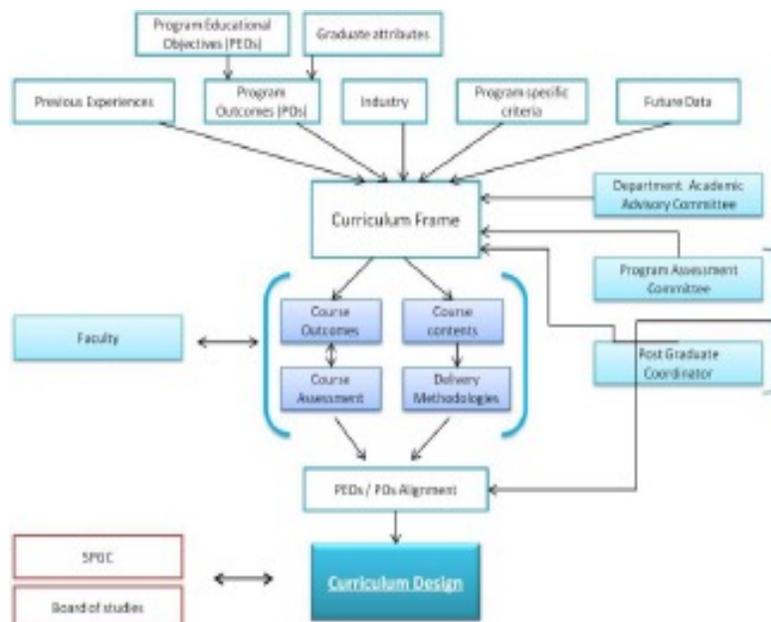
The design output report includes:

- The types and levels of skill and knowledge to be imparted
- Program Educational Objectives; Student Outcomes
- Course Outcomes
- Scheme of courses and the detailed syllabi
- Assessment and evaluation.

The output documents like curriculum and instructional strategies are reviewed and approved before release at various levels and stages.

Reviews are conducted at defined stages of the curriculum design, in which faculty members from the concerned area as well as experts from amongst the peer group from within and/or outside the institute are associated. Records of the reviews are maintained. Based on the reviews, the curriculum is updated.

New/revised curriculum and instructional design is made applicable to the prospective students. The curriculum is validated in the initial stages of its introduction by taking a feedback from students and faculty members regarding the effectiveness and applicability of the curriculum, with regard to the documented needs. Necessary changes, if required, are made to ensure that the design conforms to defined needs of the students. Wherever required, additional instructional sessions and allied inputs are arranged for students/participants.



## **Some Broad Guidelines**

### ***Undergraduate Programs***

Undergraduate engineering students are taught a series of courses in basic sciences to develop understanding of scientific principles and methods, analytical ability and rigor. These courses are followed by courses in engineering sciences to provide a smooth transition from basic sciences to professional engineering courses. A series of courses in technical arts are designed to develop engineering skills through training in engineering drawing, measurements, computing skills, manufacturing technology and effective communication. The professional courses in the chosen field of specialization are meant to develop creative abilities for the application of basic and engineering sciences to engineering problems involving planning, design, manufacturing, maintenance and research and development. In addition, courses in humanities and social sciences are incorporated to develop appreciation of the impact of science and technology on society. The undergraduate curriculum consists of two main components i.e. core courses and professional courses. The core courses lay emphasis on concepts and principles. It involves teaching of subjects in Basic Sciences, Humanities and Social Sciences and Engineering Science. Attention is also paid to develop communication skills in English language - the medium of instructions. The professional courses lay emphasis on system analysis, design, manufacturing and professional practice. There is an in-built flexibility to encourage students to specialize in streams of their choice through a system of professional and free electives. The institute strives to foster among its students a strong desire and capacity for continuous learning as well as self-appraisal to develop sterling human & professional qualities and a strong sense of service to society through designed, curricular, co-curricular activities and congenial campus environment.

### ***Post-graduate Programs***

#### **MASTER OF ENGINEERING/TECHNOLOGY (M.E./M.Tech.)**

The institute in offering various M.E./M.Tech. programs has uniformly maintained the basic structure and philosophy of the post-graduate education in engineering in the country. All these programs, regular or part-time, have their course work classified into two major categories: Core Courses and Elective Courses. The core courses are aimed at imparting knowledge of the relevant basics analytical-tools & techniques necessary to build-up on them elective (professional) courses. Core courses of a particular programme are compulsory for all the students registered in that programme. Elective courses are of professional nature. To be eligible for a degree, a student must complete requisite number of core and elective courses. However, to bring in flexibility a wide choice of electives is offered to the students in order to make their training broad based. Presentation of a seminar and a project in addition to the course work and further carrying out a thesis/dissertation are necessary components of post-graduate degree. The seminar and project should be on a topic relevant to the area of study, presenting the state-of-art work done on the subject. The literature survey conducted during the preparation of the seminar should highlight the areas for further research work on the subject. The problem taken up for the thesis/dissertation should be as far as possible on the work done for the seminar. Both the seminar and thesis/dissertation are submitted in bound form and are presented during their

respective evaluation. In case a student fails to undertake, complete & clear thesis work and completes seminar only he will be eligible for award of post-graduate diploma only.

#### **MASTER OF COMPUTER APPLICATIONS (M.C.A.)**

The MCA program aims to train and produce much needed human resource for software industry as increasing applications of computers in almost all areas of human endeavour has led to a vibrant software industry with concurrent rapid technological changes. The programme is spread over a period of three years consisting of six semesters. The students study courses for five semesters in the institute and carryout a Software Development Project (SDP) in the sixth semester in reputed national/multinational companies. The graduates of this programme are absorbed as software professionals, solution developers and system analysts in leading national/multinational companies and other industrial/service organizations working in the area of Information Technology (IT).

#### **MASTER OF SCIENCE (M.Sc.)**

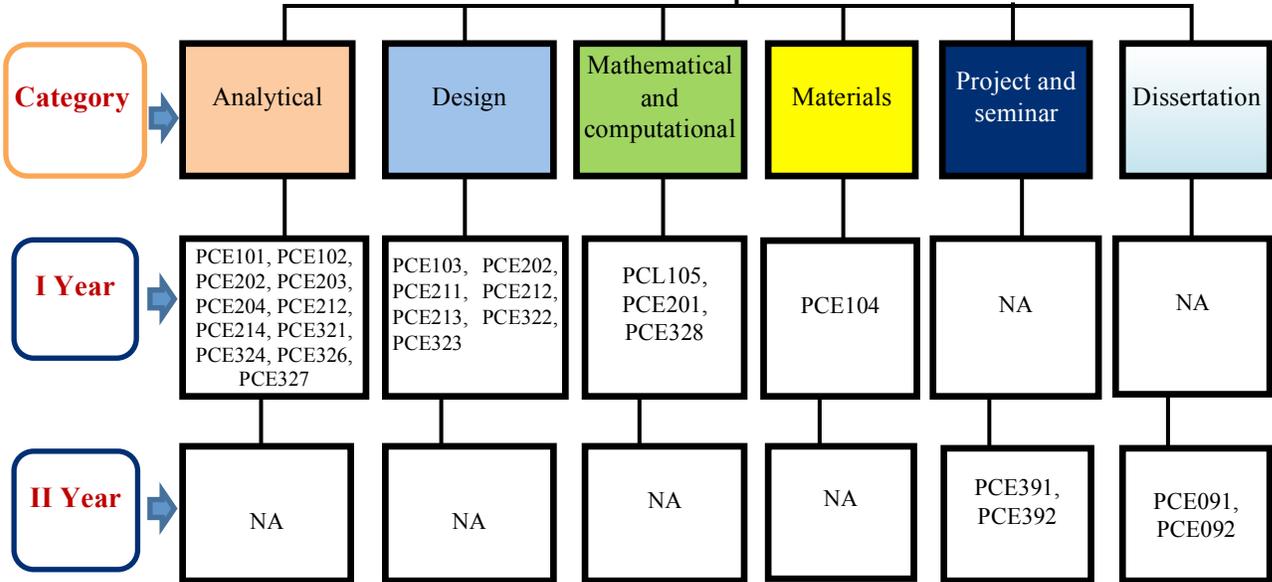
M.Sc. program aims to impart application-oriented education in the respective area with an integrated approach so as to turn out professionals who will have easy absorbability in industry as well as self-employment skills. The course curriculum has been structured to impart education in the areas desired by the industry as well as local needs. The programme is spread over four semesters, which include teaching of both core courses as well as elective courses for first two semesters, a project in the third semester and a dissertation in the final semester.

#### **DOCTORAL PROGRAM**

High caliber students with demonstrated capability can register themselves for Ph.D. degrees. There is a laid down course work requirement for the Doctoral Degree Program for candidates registering after obtaining M.E. degree. The provisions in the rules and regulations governing the programme, aim at ensuring high quality of research leading to Ph.D. degree. Ph.D. program are offered on both regular and part-time basis. Ph.D. thesis is evaluated by a panel of examiners drawn from the peer group on the topic, both from India and abroad.

The Program scheme and inter-relationships are shown below:

Post-graduate  
Program- M.E.  
(Structural Engg.)



1

PCE101

PCE102

PCE103

PCL105

PCE104

PCE204

2

PCE201

PCE202

PCE301

ELECTIVE  
-I

ELECTIVE  
-II

ELECTIVE -  
III

3

PCE391

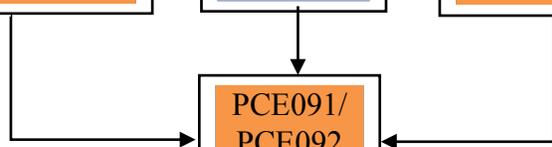
PCE392

PCE091/  
PCE092

4

PCE091/  
PCE092

Scheme consist of subjects of  
Structural Engineering



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# COURSES SCHEME & SYLLABUS

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## **M.E. STRUCTURAL ENGINEERING**

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## **Program Educational Objectives and Program Outcomes M.E. (Structural Engg.) Program**

The postgraduate degree program in Structural Engineering at Thapar Institute of Engineering and Technology is designed to prepare postgraduates for professional practice in industry and government and for further education to enter careers in research and academia.

To prepare our graduates to take their place in this environment, and consistent with this focus, the following **educational objectives** have been established for the students of Masters in Structural Engineering.

- To impart knowledge to students in the latest technological aspects of Structural Engineering and to provide them with opportunities in taking up advanced topics of the field of study.
- Moulding the graduate civil engineers to undertake safe, economical and sustainable design of civil and other structures.
- To broaden and deepen their capabilities in experimental research methods, analysis of data, and drawing relevant conclusions for scholarly writing and presentation.
- To create a congenial environment that promotes learning, growth and impart ability to work with inter-disciplinary groups in professional, industry and research organizations
- To inculcate human values and ethics in their personal and professional life.

Listed below are the **program outcomes** of the Masters in Structural Engineering program. After the completion of this program the student will be able to:

- Apply the knowledge of science, mathematics, and engineering principles for developing problem solving attitude.
- Independently carry out research /investigation and development work to solve practical problems.
- Conduct experimental and/or analytical work and analyse results using modern mathematical and scientific methods.
- Demonstrate mastery in advanced areas of structural engineering and critically assess the relevant technological issues.
- Write and present a substantial technical report/document.

**REVISED COURSE SCHEME & SYLLABUS FOR  
M.E. (STRUCTURAL ENGINEERING)**

**First Year: SEMESTER-I**

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PCE101	ADVANCED STRUCTURAL ANALYSIS	3	2	0	4.0
2	PCE102	ADVANCED SOLID MECHANICS	3	2	0	4.0
3	PCE103	ADVANCED STRUCTURAL DESIGN	3	2	0	4.0
4	PCL105	STATISTICAL METHODS AND ALGORITHM	3	0	2	4.0
5	PCE104	STRUCTURAL MATERIALS	3	0	2	4.0
6	PCE204	STRUCTURAL DYNAMICS	3	2	0	4.0
		<b>TOTAL</b>	<b>18</b>	<b>8</b>	<b>4</b>	<b>24.0</b>

**First Year: SEMESTER-II**

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PCE201	FINITE ELEMENT METHODS IN STRUCTURAL ANALYSIS	3	2	0	4.0
2	PCE202	PRE-STRESSED CONCRETE	3	2	0	4.0
3	PCE301	EARTHQUAKE RESISTANT DESIGN OF STRUCTURES	3	2	0	4.0
4		ELECTIVE – I	3	2	0	4.0
5		ELECTIVE – II	3	2	0	4.0
6		ELECTIVE – III	3	2	0	4.0
		<b>TOTAL</b>	<b>18</b>	<b>12</b>	<b>0</b>	<b>24.0</b>

**Second Year: SEMESTER-III**

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PCE391	SEMINAR	-	-	-	4.0
2	PCE392	MINOR DESIGN PROJECT	-	-	-	4.0
3	PCE091	DISSERTATION (STARTS)	-	-	-	0.0
		<b>TOTAL</b>	-	-	-	<b>8.0</b>

**OR** (For those who opted for one year industry internship)

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PCE391	SEMINAR	-	-	-	4.0
2	PCE392	MINOR DESIGN PROJECT*	-	-	-	4.0
3	PCE092	INDUSTRIAL PROJECT** (STARTS)	-	-	-	0.0
		<b>TOTAL</b>	-	-	-	<b>8.0</b>

\* Minor Design Project evaluation will be held in December at the end of odd semester.

\*\* Industrial Project offered to students going for one complete year in industry

**Second Year: SEMESTER-IV**

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PCE091	DISSERTATION(CONTD.)	-	-	-	16.0

**OR** (For those who opted for one year industry internship)

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PCE092	INDUSTRIAL PROJECT** (CONTD.)	-	-	-	16.0

\*\* Industrial Project offered to students going for one complete year in industry.

**TOTAL NUMBER OF CREDITS: 72**

**ELECTIVE – I**

<b>SR. NO.</b>	<b>COURSE NO.</b>	<b>TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>CR</b>
1	PCE211	ADVANCED BRIDGE DESIGN	3	2	0	4.0
2	PCE212	TALL STRUCTURES	3	2	0	4.0
3	PCE213	WIND EFFECT ON STRUCTURES	3	2	0	4.0
4	PCE214	SOIL STRUCTURE INTERACTION	3	2	0	4.0

**ELECTIVE – II**

<b>SR. NO.</b>	<b>COURSE NO.</b>	<b>TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>CR</b>
1	PCE321	ADVANCED DESIGN OF FOUNDATIONS	3	2	0	4.0
2	PCE322	RELIABILITY-BASED DESIGN	3	2	0	4.0
3	PCE323	INDUSTRIAL STRUCTURES	3	2	0	4.0
4	PCE324	STRUCTURAL HEALTH MONITORING AND RETROFITTING	3	2	0	4.0

**ELECTIVE – III**

<b>SR. NO.</b>	<b>COURSE NO.</b>	<b>TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>CR</b>
1	PCE203	PLATES AND SHELLS	3	2	0	4.0
2	PCE326	THEORY OF STRUCTURAL STABILITY	3	2	0	4.0
3	PCE327	ANALYSIS OF COMPOSITES PLATE	3	2	0	4.0
4	PCE328	STRUCTURAL OPTIMIZATION	3	2	0	4.0

## PCE101 ADVANCED STRUCTURAL ANALYSIS

L	T	P	Cr
3	2	0	4

**Course Objectives:** To analyse structural engineering systems by various approaches.

**Stiffness Method (Systems Approach):** Basis of stiffness method, Degrees of freedom, Force-displacement relationships, Nodal stiffness.

**Flexibility Method (Systems Approach):** Flexibility coefficients, Basis of the method, Application to various types of structures.

**Introduction to Element Approach:** Member stiffness matrix, Local or Member co-ordinate system, Global or Structural co-ordinate system, Rotation of axes etc, Structure stiffness matrix.

**Structural Stability Analysis:** Elastic Instability, Introduction to stability problem, Energy methods, buckling of axially loaded members for different end conditions, Concept of effective length, approximate techniques, Stability analysis of beam-column and frames.

**Plastic Analysis:** Concept of Limit load analysis, Upper and lower bounds, Plastic analysis of beams and multi-storey frames using mechanism method.

**Non-Linear Analysis:** Introduction to geometric and material non-linearity.

### Course Outcomes (CO):

The students will be able to:

- Develop stiffness matrix of structures and analyse them using displacement methods.
- Develop flexibility matrix of structures and analyse them using force methods.
- Perform plastic analysis of various structures.
- Carry out stability analysis of columns and beam-columns for various end conditions.

### Text Books:

1. Gere, G. M. and Weaver, Jr. W., *Matrix Analysis of Framed Structures*, CBS Publishers (1987).
2. McCormac, J. C. & Nelson, J. K., *Structural Analysis: A Classical and Matrix Approach*, John Wiley and Sons (1997).

### Reference Books:

1. Pandit & Gupta, *Matrix Analysis of Structures*, Tata McGraw Hill Publications (2003).
2. Iyengar, N.G.R., *Elastic Stability of Structural Elements*, Macmillan India Ltd (1980).

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE 102 ADVANCED SOLID MECHANICS

<b>L</b>	<b>T</b>	<b>P</b>	<b>Cr</b>
<b>3</b>	<b>2</b>	<b>0</b>	<b>4</b>

**Course Objectives:** To analyse the behaviour of a material in elastic and plastic stage.

**Basic Theory:** Concept of continuum, Vector and Tensor analysis.

**Elasticity:** Stress tensor and transformation, Equilibrium conditions, Simple state of stress, Strain displacement relations, strain tensors and its transformation, Compatibility conditions, Constitutive relations, Energy principles, Problems of linear elasticity- basic equation, Boundary value problems, Solution of basic equation and Equation of plane problems.

**Plasticity:** Plastic solid, Loading and unloading conditions, Isotropic stress deformation theory, Yield functions, Work hardening and Flow rules.

**Visco-elasticity:** Visco-elastic material, Stress strain relation, Various models, Creep and Relaxation, Compliance and Modulus of mechanical models, Navier's equation.

**Course Outcomes (CO):** The students will be able to:

- Develop stress and strain tensors and perform transformations.
- Analyse stress-strain relationships for materials in elastic state.
- Solve problems of linear elasticity using boundary value concept.
- Analyse problems of plasticity and behaviour of visco-elastic materials using various models.

### **Text Books:**

1. *Fung, Y.C., Fundamentals of Continuum Mechanics, Prentice Hall, Englewood Cliffs (1969).*
2. *Karasudhi, P., Fundamentals of Solid Mechanics, Kluwer Academy Boston (2007).*
3. *Khan, A.S and Huang, S., Continuum Theory of Plasticity, John Wiley (1995).*

### **Reference Books:**

1. *Shames, I.H and Cozzarelli, Elastic and Inelastic Stress Analysis, Taylor and Francis (1997).*
2. *Spencer, A.J.M., Continuum Mechanics, Longman Group. (1980).*
3. *Truessdell, C., The Elements of Continuum Mechanics, Springer-Verlag (1966).*

### **Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE103 ADVANCED STRUCTURAL DESIGN

L T P Cr  
3 2 0 4

**Course Objectives:** To design the specialized reinforced concrete structures.

**Building Frames:** Introduction, Loads, Analysis for vertical loads, Analysis for lateral loads, Concept of redistribution of moments, Reinforcement detailing in various components.

**Retaining Walls:** Review of design of cantilever type retaining walls, Design of counterfort retaining walls.

**Special Structural Elements:** Domes, Deep Beams, Brackets or Corbels, Grid floor systems.

**Flats Slabs:** Advantages and disadvantages of flat Slabs, Action of Flat Slab, Preliminary design of flat slabs, Basic action of two-way slab, Determination of minimum thickness of slab, Direct Design Method, Equivalent frame analysis of flat slabs.

**Yield Line Theory:** Introduction, Assumptions, Location of yield lines, Methods of Analysis, Analysis of one-way and two-way slabs.

**Course Outcomes (CO):** The students will be able to:

- Design and carry out the reinforcement detailing for different components of building frames.
- Design and detail reinforced concrete retaining walls.
- Design special reinforced concrete elements such as domes, deep beams, corbels and grid floors.
- Design of flat slab and analyse the slab using yield line theory.

**Text Books:**

1. Jain, A.K., *Reinforced Concrete-Limit State Design*, Nem Chand & Bros (1999).

**Reference Books:**

1. Varghese, P. C., *Limit State Design of Reinforced Concrete*, PHI Publishers (2002).

**Evaluation Scheme:**

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCL105: STATISTICAL METHODS AND ALGORITHMS

L	T	P	Cr
3	2	0	4

**Course Objective:** The course aims to introduce to the students, fundamental principles as well as advanced topics in statistics and sampling techniques. This course underscores the importance of statistical methods to perform scientific and engineering research.

**Review of basic probability and statistical principles:** Axioms of probability, conditional probability, Bayes' rule, Conditional probability distributions, conditional expectations, law of total probability and law of total expectation, introduction to Bernoulli, binomial, Poisson, geometric, Normal, exponential, distributions, joint and marginal distributions, central limit theorem, probability distribution of functions of random variables.

**Hypothesis tests:** Introduction to sampling distributions (standard Normal, chi-square, F and t distributions) and their properties, introduction to hypothesis tests (difference between one tailed and two tailed tests), level of significance of test and power of test, two sample test for means using t-distribution.

**Analysis of variance:** One Way ANOVA, two-way ANOVA with examples.

**Time Series Analysis:** Autoregressive models: AR(1), AR(p), moving average models: MA(1), MA(q), autoregressive moving average models: ARMA(p,q).

**Multivariate Data Analysis and regression:** Introduction to linear regression with trends and least squares estimate, definition of Covariance matrix and its application in engineering problems using Principal Component Analysis.

**Markov Chains:** Introduction to discrete Markov chains in finite state space, multi-step state transition probabilities, stationary (limiting distributions), Chapman-Kolmogorov equations, hitting probabilities, return and exit time distributions for discrete Markov chains, classification of states, detailed balance.

**Laboratory Work:** Each laboratory experiment will consist of numerical exercises on one of the above topics. Laboratory experiments will be performed using Matlab/SPSS.

**Course Outcomes (CO):** Upon the completion of this course, the students will able to:

- Compute probabilities of composite events along with an understanding of random variables and distributions.
- Obtain foundational understanding of discrete Markov processes.
- Make statistical inferences using principles of hypothesis tests and ANOVA.
- Perform analysis of time series data with different time series models.
- Perform multivariate data analysis using Principal Component Analysis and linear regression.

***Recommended Books***

1. *Medhi, J., Stochastic Processes, New Age International*
2. *Montgomery, Introduction to Statistical Quality Control, John Wiley and Sons*
3. *Populis, A., Random Variables and Stochastic Processes, Tata McGraw Hill (2002).*
4. *Bhuyan K.C., Multivariate Analysis and Its Applications, New Central Book Agency (2002).*

**Evaluation Scheme:**

S No.	Evaluation Elements	Weightage (%)
1.	MST	20
2.	EST	40
3.	Sessionals (May include Assignments/ Projects/ Tutorials/ Quizzes/ Lab Evaluations)	40

## PCE104 STRUCTURAL MATERIALS

L	T	P	Cr
3	0	2	4

**Course Objectives:** To understand the mechanism of working of supplementary cementing materials in concrete for production of high performance concrete.

**Supplementary Cementing Materials:** Types of supplementary cementing materials such as fly ash, silica fume, rice husk ash, and metakaolin; their physical, chemical, mineralogical properties; Effects of these materials on the fresh properties; Strength properties; Durability properties.

**Fibre Reinforced Concrete:** Definition; types of fibres; Properties of fibres; Factors affecting FRC. Mixing and casting procedure; Composite materials approach; Effect of fibres on the workability, strength and durability of concretes; Applications of different types of fibres.

**High Volume Fly Ash Concrete:** Definition, Effect of types of fly ash in large quantities on the strength properties of concrete; Durability and abrasion resistance of HVFA; Applications of HVFA.

**Self-Compacting Concrete (SCC):** Definition, Advantages and disadvantages of SCC; Various mix design procedures; Tests for SCC; Applications for SCC.

**High Performance Concrete:** Definition of HPC; Material selection and its properties; Parameters for concrete being considered as HPC; Applications of HPC.

**Polymer Concrete Composites:** Definition; Types of monomers and polymers; Types of polymer concretes and their applications.

**Fibre Reinforced Plastics (FRP):** Types of FRP, their properties and effects on concrete elements under various loading conditions.

**Use of Waste Materials and By-products:** Types of waste materials and by-products such as waste glass, scrap tires, waste foundry sand, clean coal ash, etc. Effect of these materials on the various properties of mortar and concrete, Introduction of leachates from waste materials and their analysis.

**Behaviour of Concrete at High Temperature:** Definition of high temperature; Mechanism of concrete failure at high temperature; spalling characteristics; difference in the behaviour of normal concrete, High strength concrete and self-compacting concrete at high temperature.

**High Strength steel**

**List of Lab Experiments:**

- Study of stress-strain curve of high strength concrete, correlation between cube strength, cylinder strength, split tensile strength and modulus of rupture.
- Effect of cyclic loading on steel.
- Non-destructive testing of existing concrete members.
- Behavior of beams under flexure, shear and torsion.
- Effect of supplementary cementitious materials/industrial-byproducts/recycled waste additions on the properties of concrete.
- Behaviour of FRP-retrofitted reinforced concrete members.

**Course Outcomes (CO):** The students will be able to:

- Develop concrete using supplementary cementing materials in concrete.
- Formulate behaviour of properties of fly ash concrete, fibre reinforced concrete and high performance concrete.
- Apply waste materials and industrial by-products in the design for sustainable construction.
- Analysis of self-compacting concrete, polymer concrete, FRP and concrete at high temperature.

**Text Books:**

1. *Nevelly, A. M., Properties of Concrete, Prentice Hall of India (1995).*
2. *Siddique, R., Special Structural Concretes, Galgotia Publications (2000).*

**Reference Books:**

1. *Krishna Raju, N., Concrete Mix Design, CBS Publications (2002).*
2. *Gambhir, M. L., Concrete Technology, Tata-McGraw Hill, 3<sup>rd</sup> Edition (2008).*
3. *Siddique, R., Waste Materials and By-products in Concrete, Springer (2008).*

**Evaluation Scheme:**

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE204 STRUCTURAL DYNAMICS

L	T	P	Cr
3	2	0	4

**Course Objectives:** To be able to perform the dynamic analysis of SDOF and MDOF systems.

**Introduction:** Foundational objective of structural dynamic analysis, D'Alembert's principle, Rayleigh-Ritz method, Energy methods, Types of prescribed loadings, Basic structural concepts – ductility, Hysteresis, Rigid body dynamics, Vectorial representation.

**Basic Principles of Motion:** Simple harmonic motion, Fourier transformations, Damping properties, Mass properties, Free and forced vibrations.

**Single Degree Freedom Systems:** Dynamic response to time dependent transient and steady state, Forcing functions, Damped & un-damped response, Damping: vibration isolation, Response of time domain & Frequency domain.

**Multi Degree Freedom Systems:** Two degrees of freedom systems, Orthogonal properties – Rayleigh's method, Stodola-Vianolla Method, Method of matrix iterations, Lumped mass matrix, Multi degree freedom system, Determination of frequency and modes, Transfer matrix response determination.

**Dynamic analysis of systems with distributed properties:** Flexural vibration of uniform beams, Numerical Evaluation of Dynamic Response, Central Difference Method, New Mark method, Earthquake response of linearly elastic buildings and linearly inelastic buildings, Dynamics of base isolated buildings.

**Course Outcomes (CO):** The students will be able to:

- Develop the equations of motion for different types of structures.
- Perform analysis of single degree of freedom system.
- Perform analysis of multiple degree of freedom system.
- Perform dynamic analysis of various structures using numerical methods.

### **Text Books:**

1. Paz, M., *Structural Dynamics – Theory and Computation*, C.B.S. Publishers & Distributor, 2<sup>nd</sup> edition (2004).
2. Clough, R.W., Penzin, J., *Dynamics of Structures*, McGraw Hill International Editions (1993).

### **Reference Books:**

1. A.K. Chopra, *Earthquake Dynamics of Structures, a Primer*, Earthquake Engineering Research Institute; 2<sup>nd</sup> edition.

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE201 FINITE ELEMENT METHODS IN STRUCTURAL ANALYSIS

L	T	P	Cr
3	2	0	4

**Course Objectives:** To perform finite element analysis of structural elements.

**Introduction to Finite Elements:** Introduction, Direct formulation of finite element characteristics, Energy approach, Convergence criteria, Displacement functions with discontinuity between elements, Solution bounds, Extension of variational approach.

**Plane Stress and Plane Strain:** Introduction, Element characteristics, Assessment of accuracy, Some practical applications.

**Axis-Symmetric Stress Analysis:** Introduction, Element characteristics, Practical applications, Non-symmetrical loading.

**Some Improved Elements in 2-D Problems:** Introduction, Quadrilateral element, Characteristics derived from triangular elements, Conforming shape functions for a rectangle, Conforming shape functions for an arbitrary quadrilateral, Triangular element with size nodes.

**Nodes Dimensional Stress Analysis:** Introduction, Tetrahedral element characteristics, Composite elements with eight nodes, Improved displacement functions an element with eight arbitrary nodes, Tetrahedral element with ten nodes, Introduction to rectangular elements, Quadrilateral elements, Conforming functions for quadrilateral elements, Plate-bending elements, Introduction to non-linear Analysis-Material non-linearity and Performance non-linearity.

**Dynamic Analysis of Structures using FEM:** Beams and Frames.

**Course Outcomes (CO):** The students will be able to:

1. Develop stiffness matrix for one-dimensional bar and beam element.
2. Develop stiffness matrix for two-dimensional triangular and quadrilateral elements.
3. Formulate two-dimensional plane stress, plane strain and axis symmetric problems.
4. Analyse beams and frames using finite element method.
5. Perform dynamic analysis using finite element method.

**Text Books:**

1. *Gallagher, R. H., Finite Element Analysis: Fundamentals, Prentice Hall, Englewood Cliffs (1987).*
2. *Gere, James. M. and Weaver, Jr. W., Matrix Analysis of Framed Structures, CBS Publishers (1995).*

**Reference Books:**

1. McCormac, J. C. & Nelson, J. K., *Structural Analysis: A classical and Matrix Approach*, John Wiley and Sons (2004).
2. Pandit & Gupta, *Matrix Analysis of Structures*, Tata McGraw Hill Publications (2003).
3. Zienkiewicz, O. C., *The Finite Element Method in Engineering Science*, McGraw Hill Publications (1971).

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE202 PRE-STRESSED CONCRETE

<b>L</b>	<b>T</b>	<b>P</b>	<b>Cr</b>
<b>3</b>	<b>2</b>	<b>0</b>	<b>4</b>

**Course Objectives:** To analyse and design the pre-stressed concrete elements.

**Review:** Definition, Basic Principles, External and internal pre-stressing, Linear and circular pre-stressing, Systems of pre-stressing, Partial pre-stressing, Loss of pre-stress, Materials used, Advantages and disadvantages.

**Working Stress Design of Simple Beams:** Critical load condition, Permissible stresses, Various suggested methods of design, Dimensionless design variables, Solution of equations, Design Procedure based on flexure, Minimum weight design, Cable layout and profile of tendons, Design by load balancing method, Code provisions.

**Pre-stressed Concrete Composite Beams:** Allowable stress considerations, Non-dimensional allowable stress equations and their solution, Shrinkage stresses.

**Continuous Beams:** Two span continuous beams and their analysis, Two span continuous beam with eccentricities at outer supports, Fixed and bending moment, Application of moment distribution method, Design of continuous beams, Continuous beams with variable section.

**Pre-stressed Concrete Slabs:** One-way and two-way slabs, Beam and slab construction, Flat Slabs.

**Shear and Bond in Pre-stressed Concrete:** Principal Stresses, Failure due to shear, Combined bending and shear, Bond in pre-tensioned Construction, Bond in post tensioned construction.

**Anchorage in Pre-stressing Classes:** Post tensioned Construction, Pre-stressing cable at the centroidal axis, Symmetric multiple cable, Cable with eccentricity, Inclined cables, Spalling and bursting stresses.

**Limit State Design:** Introduction, Strength limit state in flexure, Limit state of strength in shear, Torsion, Limit state strength of transfer condition, Limit state of serviceability, Durability limit state, Design of short span, medium span and long span beams, Partially pre-stressed Concrete beams.

**Miscellaneous Structures:** Compression members, Tension members, Pre-stressed Concrete Pavements, Folded plates and Shells, Arches, Dams, Rigid frames, Cylindrical tanks.

**Course Outcomes (CO):** The students will be able to:

- Characterize the materials required for prestressed concrete structures and various methods of pre-stressing.
- Calculate losses and deflection in pre-stressed members.
- Analyse prestressed concrete members for flexure, shear and torsion.
- Design various prestressed concrete structures for bending, axial tension, bond and bearing.

**Text Books:**

1. *I.S.: 1343 – 1980 Indian Standard Code of Practise for Pre-stressed Concrete (1980).*
2. *Krishna Raju, N., Pre-stressed Concrete, Tata McGraw Hill (1998).*

**Reference Books:**

1. *Lin, T. Y. et al, Design of Pre-stressed Concrete Structures, John Wiley and Sons (1981).*
2. *Nilson, A. H., Design of Pre-stressed Concrete, John Wiley (1978).*

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE301 EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

L T P Cr  
3 2 0 4

**Course Objectives:** To design earthquake resistant structures as per IS guidelines.

**Past Earthquakes:** Review of damage in past earthquakes.

**Earthquake response of structures,** Idealization of structures, Response spectrum analysis, Equivalent lateral force concepts, Torsionally coupled systems, Orthogonal effects, Nonlinear, Pushover and Time history analysis.

**Philosophy of earthquake resistant design:** Ductility, Redundancy & Over strength, Damping, Base Isolation Supplemental Damping, Codal Provisions.

**Seismic behaviour of Structures:** Concrete structures, Steel and masonry structures, Material properties, Analysis of members under cyclic loads, Detailing provisions, Concepts of structural control.

**Course Outcomes (CO):** The students will be able to:

- Evaluate seismic forces for various structures as per relevant Indian standards guidelines.
- Design the various structural elements resisting earthquake forces as per Indian standard codes.
- Exercise ductile detailing of reinforced concrete structures as per codal provisions considering seismic forces.
- Practice ductile detailing of masonry buildings as per codal provisions.

### **Text Books:**

1. Clough, Ray W. and Penzien, Joseph, *Dynamics of Structures*, McGraw Hill (1975).
2. Den Hartog, J. P., *Mechanical Vibrations*, McGraw Hill Book Co. (1989).

### **Reference Books:**

1. Timoshenko, S. P., *Vibration Problems in Engineering*, D. Van Nostrand Company Inc. (2007).
2. Aggarwal, P., ShriKhande, M., *Earthquake Resistant Design of Structures*, McGraw Hills (2003).

### **Evaluation Scheme:**

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE211 ADVANCED BRIDGE DESIGN

L	T	P	Cr
3	2	0	4

**Course Objectives:** To analyse and design various types of bridges.

**General:** Bridge System, Considerations in alignment, Planning, Economic consideration, Aesthetics and selection of type of bridge (Review).

**Loading Standards:** Standards followed in U.K., U.S.A. and Europe.

**Super Structure Analysis:** Bridge deck analysis using different methods, Load distribution theories – Courbon specifications for loading, Geometrical proportioning etc. of road, rail-cum-road bridges, Indian Road Congress (IRC) and Indian Railway Loading standards and their comparison with loading, Hendry-Jaegar, Morris-Little (Orthotropic plate theories) methods, Stiffness method, Finite difference method, Folded Plate method, Finite strip method and Finite Element method (General treatment), Limit analysis, Design of bridge decks.

**Continuous Bridges:** Introduction to IRC 112: Provisions of Earthquake Resistant Design of Bridges.

**Connections:** Design of different connections, Bearings and joints.

**Substructure Analysis and Design:** Piers, Abutments, Wing walls and other appurtenant structures.

**Foundations:** Well foundations and pile foundation, Design and construction and field problems.

**Construction & Maintenance:** Erection of bridge super structure, Maintenance, Rating and Strengthening of existing bridges.

**Dynamics Behaviour:** Behaviour of bridges under dynamic loads, Discussion of code provisions for design of bridges for wind and earthquake forces.

**Long Span Bridges:** General discussion of suspension and cable stayed bridges.

**Course Outcomes (CO):** The students will be able to:

- Demonstrate the key concepts of planning of bridges and investigations.
- Analyse and design superstructures for various types of reinforced concrete bridges.
- Analyse and design connections and substructures of bridges.
- Design well and pile foundation for bridges.

**Text Books:**

1. Bakht, B. and Jaeger, L.G., *Bridge Analysis Simplified*, McGraw-Hill Book Company (1985).
2. Cusens, A.R. and Parma, R.P., *Bridge Deck Analysis*, John Wiley & Sons Ltd. (1975).
3. Hambly, E.C., *Bridge Deck Behaviour*, Chapman and Hall. (1991).

**Reference Books:**

1. Krishna Raju, N., *Design of Bridges*, Oxford and IBH Publications (1998).
2. Ponnuswamy, R., *Bridge Engineering*, Tata McGraw Hill (1997).
3. *Relevant Road & Railway Codes for Bridges*.
4. Raina, V K , *Concrete Bridge Practice*, Tata McGraw Hill Publications(1991).

**Evaluation Scheme:**

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE212 TALL BUILDINGS

L T P Cr  
3 2 0 4

**Course Objectives:** To be able to analyse and design of tall structural systems.

**Principles of Planning of Tall Buildings:** Technological Planning, Mechanical systems, Fire rating, Local considerations, Structures elements, Types of structural systems for tall buildings, Shear Walls and their arrangement.

**Loads on Tall Buildings:** Gravity loads, Live loads, Wind loads and seismic loading, Code Provisions, Discussion of relevant codes of practices and loading standards, Fire Tender Loading.

**Analysis of Tall Buildings (With and Without Shear Walls):** Approximate analysis for gravity loads, Lateral loads, Analysis of tube-in-tube constructional and 3-Dimensional analysis of shear core buildings, Stability, Stiffness and fatigue, Factor of safety and load factor.

**Design of Tall Buildings:** Procedures of elastic design, Ultimate strength design and Limit state design of super structures including structural connections, soil structure interaction.

### Introduction to dampers

**Course Outcomes (CO):** The students will be able to:

- Plan tall buildings considering structural systems, fire rating, local considerations etc.
- Evaluate loading for tall structures.
- Analyse and design of tall structural systems including structural connections.
- Analyse tube-in-tube construction and 3-dimensional analysis of shear core building.

### Text Books:

1. *Smith, Byran Stafford and Coull, Alex, Tall Building Structures: Analysis and Design, John Wiley and Sons (1991).*
2. *Taranath, B. S., Analysis and Design of Tall Buildings, Tata McGraw Hill Limited (1988).*

### Reference Books:

1. *Symposium on Tall Buildings with particular reference to Shear Wall Structures, held at University of Southampton (1996).*

### Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE213 WIND EFFECT ON STRUCTURES

L	T	P	Cr
3	2	0	4

**Course Objectives:** To evaluate the wind forces for various structures using relevant Indian standards and to design structures for wind resistance.

**Introduction:** Nature of windstorm, Design wind speed, Atmospheric boundary layer and Wind turbulence.

**Basic Bluff body aerodynamics:** Flow around bluff bodies, Pressure & force coefficients flow around flat plates, Walls, Prismatic shapes.

**Wind effects on Low Buildings:** Low buildings with different roof shapes and multi-span buildings.

**Wind effects on Tall Buildings:** Along wind effects, Across wind effects and vortex shedding.

**Wind effects on Bridges:** Basic force coefficients for bridges, Nature of dynamic response of long span bridges, Flutter instability, Buffeting of long span bridges. Cable suspended structures.

**Role of Wind Tunnel:** Flow simulation, Modelling, Flow measurement, Pressure measurement, Deformation measurement.

### Introduction to tensile and membrane structures

**Course Outcomes (CO):** The students will be able to:

- Assess the wind effects on low as well as tall buildings.
- Evaluation of wind forces for various structures using relevant Indian standards.
- Evaluate dynamic response of bridges due to wind loads
- Perform wind tunnel modeling for various structures.

### Text Books:

- Simiu, E., Scanlan, Robert H., *Effects on Structures*, Dover Publications, (1996).
- Sachs, P., *Wind Forces in Engineering*, Pergamon Press (1972).

### Reference Books:

- Holmes, J.D., *Wind Loading of Structures*, Taylor & Francis (2007).

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE214 SOIL STRUCTURE INTERACTION

L	T	P	Cr
3	2	0	4

**Course Objectives:** To give basic concepts of dynamic soil structure interaction analysis and to illustrate the usage of finite element techniques in soil structure interaction analysis of buildings, and structures.

**Introduction:** Critical study of conventional methods of foundation design, nature and complexities of soil structure interaction.

**FEM Analysis:** Application of advanced techniques of analysis such as FEM and finite difference method.

**Soil-structure Interaction:** Relaxation and interaction for the evaluation of soil structure interaction for different types of structure under various conditions of loading and subsoil characteristics.

**Sub-grade Reaction:** Preparation of comprehensive design oriented computer programs for specific problems, interaction problems based on theory of sub grade reaction such as beams, footings, rafts etc.

**Frame Structures:** Analysis of different types of frame structures founded on stratified natural deposits with linear and non-linear stress-strain characteristics.

**Piles:** Determination of pile capacities and negative skin friction, action of group of piles considering stress-strain characteristics of real soils, anchor piles and determination of pullout resistance.

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

- Analyse soil structure interaction concept and complexities involved.
- Evaluate soil structure interaction for different types of structure under various conditions of loading and subsoil characteristics.
- Prepare comprehensive design oriented computer programs for interaction problems based on theory of sub grade reaction such as beams, footings, rafts etc.
- Analyse different types of frame structure founded on stratified natural deposits with linear and non-linear stress-strain characteristics.
- Evaluate action of group of piles considering stress-strain characteristics of real soils.

### **Reference Books:**

1. *Analytical and Computer Methods in Foundation*, Bowels J.E., McGraw Hill Book Co., New York, 1974.
2. *Numerical Methods in Geotechnical Engineering*, Desai C.S. and Christian J.T., McGraw Hill Book Co., New York, 1977.
3. *Soil Structure Interaction - The real behaviour of structures*, Institution of Structural

*Engineers, 1989.*

4. *Elastic Analysis of Soil Foundation Interaction, Developments in Geotechnical Engg. Vol-17, Elsevier Scientific Publishing Company, 1979.*
5. *Elastic Analysis of Soil-Foundation Interaction, Selvadurai A.P.S., Elsevier Scientific Publishing Company, 1979.*
6. *Analysis & Design of substructures, Swami Saran, Oxford & IBH Publishing Co. Pvt. Ltd, 2006.*
7. *Design of Foundation System- Principles & Practices, Kurian N. P., Narosa Publishing, 2014.*

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE321 ADVANCED DESIGN OF FOUNDATIONS

L	T	P	Cr
3	2	0	4

**Course objective:** To understand the concepts of bearing capacity of soil so as to have deeper understanding in the design of foundations

**Shallow foundations:** Terzaghi's bearing capacity equation, General bearing capacity equation, Meyerhof's Vesic theory, Effect of water table, Special footing problems, I.S. Codes, Footing pressure for settlement on sand, Soil pressure at a depth, Boussineq's & Westergaard's methods, Computation of settlements, Inclined and Eccentric Loads.

**Pile foundations:** Timber, Concrete, Steel piles, Estimating pile capacity by dynamic formula, by wave equation and by static methods, Point bearing piles, Pile load tests, Negative skin friction, Modulus of sub-grade reaction for laterally loaded piles, Lateral resistance, Pile group considerations, Efficiency, Stresses on underlying strata, Settlement of pile groups, Pile caps, Batter piles, Approximate and Exact analysis of pile groups, I.S. Codes.

**Well foundations:** Types (open end, closed or box, Pneumatic, Drilled), Shapes, Bearing capacity and settlements, Determination of grip length by dimensional analysis, Stability of well foundations by IRC Method, Construction, Tilts & shifts.

**Machine foundations:** Types, Analysis and design by Barkans method, Determination of coefficient of uniform elastic compression, and Design of a machine foundation, I.S. Method of design.

**Introduction to geotechnical earthquake engineering:** Ground Shaking, Liquefaction, Evaluation, Mechanism, Effects of liquefaction.

**Sheet pile structures:** Types, Cantilever, Anchored sheet, Design by free earth & fixed earth method, Anchored braced sheeting, Cofferdams, Stability of cellular cofferdam, Instability due to heave of bottom.

**Course Outcomes (CO):** The students will be able to:

- Calculate the bearing capacity for shallow foundations.
- Evaluate the load carrying capacity of pile and well foundations.
- Perform geotechnical analysis of machine foundations.
- Analyse the liquefaction potential of a site.

### **Text Books:**

1. Bowles, Joseph E. , *Foundation Analysis and Design*, Tata McGraw Hill (2001).
2. Coduto, Donald P., *Foundation Design: Principles and Practice*, Prentice Hall (2001).
3. Dass, B. M. , *Principles of Foundation Engineering*, Thomson Learning (2006).

**Reference Books:**

1. Kramer, Steven L., *Geotechnical Earthquake Engineering*, Pearson Education (2003).
2. Murthy, V.N.S., *Advanced Foundation Engineering*, C.B.S. Publishers (2007).

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE322 RELIABILITY BASED DESIGN

L T P Cr  
3 2 0 4

**Course Objective:** To understand the basic concepts related to reliability analysis of structures and to design the structures for various reliability indices.

**Basic Probability and Statistics:** Events, random variables, Discrete and Continuous distributions, Functions of random variables and moments.

**Statistics:** General statistics, Mean, Median, Mode, Higher moments, Empirical distribution, Sampling, Estimation theory and order statistics, Bayes theorem, Entropy and its property, Principle of maximum entropy, Vague prior, Reproducing density and Utility.

**Reliability and Design under Uncertainty:** Methods of finding reliability, Weakest link structures, Single members, Several load conditions, Multi-member multi-load condition, Fail-safe structure, First and second moment semi probabilistic design, Simple and extended optimisation.

**Course Outcomes (CO):** The students will be able to:

- Solve problems on probabilistic analysis of structures.
- Solve problems on the concepts of reliability analysis of structures.
- Design the structures for various reliability indices.

### **Text Books:**

1. Ditlevsen, O. and Madsen, H.O. , *Structural Reliability methods*, John Wiley & Sons (2007).
2. Madsen, H.O., Krenk, S. and Lind, N.C, *Methods of structural safety*, John Wiley & Sons (1999).

### **Reference Books:**

1. Melchers, Robert E., *Structural Reliability Analysis and Prediction*, John Wiley and Sons (1999).

### **Evaluation Scheme:**

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE323 INDUSTRIAL STRUCTURES

L	T	P	Cr
3	2	0	4

**Course Objective:** To analyse and design various industrial buildings.

**Review of Plastic Design:** Concept of minimum weight design.

**Design of Industrial Buildings:** General, Framing, Crane girders & columns, Analysis of trussed bents, Design of industrial frame.

**Design of Storage Structures:** Design of containers like bunkers, silos.

**Design of Space Structures:** Transmission towers, Steel domes, Pre-cast building components.

**Design using Light Gauge Sections:** Structural use of pressed sections and light gauge sections, Aluminium as a material of construction for industrial structures and design of such structures, Tubular structures and Sandwich plate construction.

**Aluminium structures:** Introduction, Permissible stresses, Tension members, Compression members, Design of beams, Local buckling of compression elements, Riveted and bolted construction, Design of chimneys, Load analysis, Design of steel supporting chimney, Chimney foundation.

**Construction Practices:** Shop practice in steel construction, Fabrication erection and production.

**Course Outcomes (CO):** The students will be able to:

- Carry out plastic design of structural elements.
- Analyse and design industrial buildings.
- Analyse and design of storage structures and space structures.
- Analyse and design structures using light gauge sections.
- Analyse and design aluminium structures.

### **Text Books:**

1. *Ajmani, A. L. and Arya, A. S., Design of Steel Structures, Nem Chand and Brothers (2000).*
2. *Dunham, C.W., Planning of Industrial Structures, John Wiley and Sons (2001).*

### **Reference Books:**

1. *Gary, W., Steel Designer's Manual, Prentice Hall (2008).*
2. *Glower, F., Structural Pre-cast Concrete, Oxford Publishers (2008).*

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE324 STRUCTURAL HEALTH MONITORING AND RETROFITTING

L	T	P	Cr
3	2	0	4

**Course Objective:** To clearly understand the risk and reliability assessment of structures.

**Structural Health:** Factors affecting health of structures, causes of distress, regular maintenance.

**Structural Health Monitoring:** Concepts, various measures, structural safety in alteration.

**Structural Audit:** Assessment of health of structure, collapse and investigation, investigation management, SHM Procedures.

**Static Field Testing:** Types of static tests, simulation and loading methods, sensor systems and hardware requirements, static response measurement.

**Dynamic Field Testing:** Types of dynamic field test, stress history data, dynamic response methods, hardware for remote data acquisition systems, remote structural health monitoring.

**Introduction to Repairs and Rehabilitations of Structures:** Case studies (site visits), piezo-electric materials and other smart materials, electro-mechanical impedance (EMI) technique, adaptations of EMI technique.

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

- Diagnose the distress in the structure understanding the causes and factors.
- Assess the health of structure using static field methods.
- Assess the health of structure using dynamic field tests.
- Suggest repairs and rehabilitation measures of the structure.

### **Reference Books:**

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

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE203 PLATES AND SHELLS

L	T	P	Cr
3	2	0	4

**Course Objectives:** To analyse and design plate and shell structures.

**Pure Bending of Plates:** Slopes and curvatures, Relations between bending moment and curvature, Strain energy.

**Symmetrical Bending of Circular Plates:** Differential equation in Polar co-ordinates, Uniformly loaded circular plate with or without hole at the centre and with various edge conditions.

**Rectangular Plates:** Differential equation of the deflection surface (Small deflection theory only), Fourier Series expansion for various types of loads, Rectangular plates with various loading and edge conditions, Navier's & Levy's methods.

**Introduction to Shell Structures:** Development of shell structures, Advantages and disadvantages of shell structures, Forms of shells, Mathematical equations of various curves connected with shells, I.S. code provisions on folded plates and shell structures.

**Analysis of Shell Structures:** Structural behaviour of cylindrical shells, Shell dimensions and allowances, Methods of analysis, Approximate analysis covering beam action, Arch action, Membrane action, Design of cylindrical shells by approximate method, Skylight in a shell, Reinforcement details.

**Membrane Analysis of Shells:** General theory, Derivation of expressions for membrane forces for various directrices, for self weight and snow load, Perturbational stresses for shells with edge beams and shells without edge beams, Effect of concentrated live load, Design by membrane theory.

**Folded Plate Structures:** General, Various shapes, Advantages and Disadvantages, Structural action of a folded plate structure, Methods of analysis, Design by any one method.

**Introduction to Grid Structures:** Various methods for analyzing grids for roofs and bridges.

**Course Outcomes (CO):** The students will be able to:

- Analyse plate and shell structures using equilibrium theory
- Perform critical analysis and design of cylindrical shell structures
- Analyse and design folded plate roofs
- Analyse grid structures for roofs and bridges

**Text Books:**

1. IS. : 2210-1982: *Indian Standard Criteria for the Design of R.C.C. Shell Structures and Folded Plates* (1982).
2. *Jai Krishna and Jain, O.P., Vol.-II, Plain and Reinforced Concrete, Nem Chand and Bros, Roorkee* (1983).

**Reference Books:**

1. *Ramaswamy, G.S., Design Construction of Concrete Shell Roofs, CBS Publishers* (1986).
2. *Timoshenko, S. P. et al, Theory of Plates and Shells, Tata McGraw Hill* (1990).

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE326 THEORY OF STRUCTURAL STABILTY

L T P Cr  
3 2 0 4

**Course Objectives:** To develop an understanding on investigating the elastic and inelastic stability of static and dynamic systems.

**Criteria for Design of Structures:** Stability, strength, and stiffness, classical concept of stability of discrete and continuous systems, linear and nonlinear behaviour.

**Stability of Columns:** Axial and flexural buckling, lateral bracing of columns, combined axial, flexural and torsion buckling.

**Stability of Frames:** Member buckling versus global buckling, slenderness ratio of frame members.

**Stability of Beams:** Lateral torsion buckling.

**Stability of Plates:** Axial flexural buckling, shear flexural buckling, buckling under combined loads.

### Introduction to Inelastic Buckling and Dynamic Stability.

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

- Determine the stability of columns and frames.
- Determine the stability of beams and plates.
- Use the stability criteria and concepts for analysing discrete and continuous systems.

### Reference Books:

1. *Theory of elastic stability, Timoshenko and Gere, Tata McGraw Hill, 1981.*
2. *Principles of Structural Stability Theory, Alexander Chajes, Prentice Hall, New Jersey, 1974.*
3. *Structural Stability of columns and plates, Iyengar, N. G. R., Eastern west press Pvt. Ltd, 1988.*
4. *Buckling Strength of Metal Structures, Bleich F., Tata McGraw Hill, New York, 1985.*

### Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE327 ANALYSIS OF LAMINATED COMPOSITE PLATES

<b>L</b>	<b>T</b>	<b>P</b>	<b>Cr</b>
<b>3</b>	<b>2</b>	<b>0</b>	<b>4</b>

**Course Objectives:** To analyse the laminated plates using analytical methods.

**Introduction:** Displacement field approximations for classical laminated plate theory (CLPT) and first order shear deformation theory (FSDT), analytical solutions for bending of rectangular laminated plates using CLPT.

**Governing Equations:** Navier Solutions of Cross-Ply and Angle-Ply Laminated Simply-Supported Plates, Determination of Stresses. Levy Solutions for Plates with Other Boundary Conditions, Analytical Solutions for Bending of Rectangular Laminated Plates Using FSDT.

**Finite Element Solutions** for Bending of Rectangular Laminated Plates using CLPT.

**Introduction to finite element method**, rectangular elements, formation of stiffness matrix, formation of load vector, numerical integration, post computation of stresses.

**Finite Element Solutions** for bending of rectangular laminated plates using FSDT. Finite element Model,  $C^0$  element formulation, post computation of stresses.

**Analysis of rectangular composite plates using analytical methods.**

**Course outcomes:** At the end of the course, students will be able to:

- Analyse the rectangular composite plates using the analytical methods.
- Analyse the composite plates using advanced finite element method.
- Develop the computer programs for the analysis of composite plates.

**Reference Books:**

1. *Mechanics of Laminated Composites Plates and Shells*, Reddy J. N., CRC Press, 2003.

**Evaluation Scheme:**

<b>Sr. No.</b>	<b>Evaluation Elements</b>	<b>Weightage (%)</b>
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE328 STRUCTURAL OPTIMIZATION

L	T	P	Cr
3	2	0	4

**Course Objectives:** To develop mathematical models and efficient numerical optimization methods for structures.

**Introduction:** Simultaneous failure mode and design, classical external problems.

**Calculus of Variation:** Variational principles with constraints.

**Programming:** Linear programming, integer programming, nonlinear programming, dynamic programming, geometric programming and stochastic programming.

**Applications:** Structural steel and concrete members, trusses and frames.

**Design:** Frequency Constraint, Design of Layouts.

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

- Use variational principle for optimization
- Apply optimization techniques to structural steel and concrete members.
- Design using frequency constraint.

**Reference Books:**

1. *Elements of Structural Optimization*, Haftka, Raphael T., Gürdal, Zafer, Springer Netherlands, 1992.
2. *Variational methods for Structural optimization*, Cherkaev Andrej, Springer-Verlag New York, 2000.

**Evaluation Scheme:**

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

## PCE391 SEMINAR

L T P Cr  
- - - 4.0

**Course Objectives:** To expose students to extensive literature review on the area of their research interest or the emerging technologies in the civil engineering industry.

The seminar is carried out on one topic by each student so as to have state-of-the art knowledge on that area and to define the gray area in that topic so as to carry out further research in that area. Those students who have opted for one-year industrial project in industry can do the extensive review of emerging technologies in the industry. They shall be evaluated on the basis of project report and viva-voce examination.

**Course Outcomes (CO):** After the completion of this course the student will be able to:

- Identify domain specific scholarly research area or the detailed review of recent emerging technologies in industry.
- Investigate and tabulate details and history about the selected topic
- Enhance technical report writing and presentation skills.

### Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Internal Evaluation	40
2	Report	10
3	External Evaluation	50

## PCE392 MINOR DESIGN PROJECT

L T P Cr  
- - - 4.0

**Course Objectives:** This course is designed to encourage design projects where students take what they have learned throughout the course of their ME program and apply it to examine a specific idea.

**Course Outcomes (CO):** After the completion of this course the students will be able to:

4. Investigate and identify the real world problems
5. Design, develop and implement a domain specific design/research problem.
6. Develop acumen for higher education and research.
7. Enhance technical report writing skills.

### Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Internal Evaluation	40
2	Report	10
3	External Evaluation	50

## PCE091 DISSERTATION

L T P Cr  
- - - 16.0

**Course Objectives:** To expose students to research work in the area of their interest.

Extensive research / research projects with some industry specific problem is carried out on one topic by each student by conducted experiments in the lab / industry or by developing analytical models by using various software's. They shall be evaluated on the basis of dissertation / project report and viva-voce examination.

**Course Outcomes (CO):** The students will be able to:

- Design and implementation of identified research problem or industrial projects.
- Develop acumen for higher education and research.
- Write technical reports and publish the research work in referred journals, national and international conferences of repute.
- Foresee how their current and future work will influence/impact the economy, society and the environment.

### Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Evaluation by panel of examiners based on subject matter, presentation, usefulness of work & viva-voce	40
2	Supervisor & External Examiner evaluation based upon subject matter, literature review, presentation, discussion of result & conclusions	50
3	Overall perception/ Paper writing (Evaluated by Chairman, evaluation committee)	10

## PCE092 INDUSTRIAL PROJECT

L T P Cr  
- - - 16.0

**Course Objectives:** To expose students to detailed industrial design along with certain innovations & solutions to the industrial problems.

Extensive industrial design & research projects with some industry specific problem is carried out on one topic by each student by conducted experiments in the lab / industry or by developing analytical models by using various software's. They shall be evaluated on the basis of dissertation / project report and viva-voce examination.

**Course Outcomes (CO):** The students will be able to:

- Design and implementation of identified research problem or industrial projects.
- Develop acumen for higher education and research.
- Write technical reports and publish the research work in referred journals, national and international conferences of repute.
- Foresee how their current and future work will influence/impact the economy, society and the environment.

### Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Evaluation by Industry Coordinator	30
2	Evaluation by Faculty Coordinator	30
3	Evaluation by panel of examiners based upon project report, presentation & viva voce examinations	40