Course Structure

3. Course Structure for M. Tech (Civil Engg.) in Structural Engineering

Prog.	CCMT Code	Group	Sem	Course code	Course Title	L	T	P	Credits	FM
CEPG	CESTR	Core	1	PGCE1301	Advanced Structural Analysis	3	0	0	3	100
CEPG	CESTR	Core	1	PGCE1302	Theory of Elasticity and Plasticity	3	0	0	3	100
CEPG	CESTR	EL-1	1	PGCE13xx	Elective – I	3	0	0	3	100
CEPG	CESTR	EL-2	1	PGCE13xx	Elective – II	3	0	0	3	100
CEPG	CESTR	EL-3	1	PGCE13xx	Elective – III / Open Elective	3	0	0	3	100
CEPG	CESTR	Lab	1	PGCEL1301	Advanced Structural Engineering Lab – I	0	0	6	4	100
CEPG	CESTR		1		**Total Semester Credit**	**15**		**6**	**19**	**600**

Prog	CCMT Code	Group	Sem	Course code	Course Title	L	T	P	Credits	FM
CEPG	CESTR	Core	2	PGCE2301	Structural Dynamics	3	0	0	3	100
CEPG	CESTR	Core	2	PGCE2302	Finite element analysis	3	0	0	3	100
CEPG	CESTR	EL-4	2	PGCE23xx	Elective – IV	3	0	0	3	100
CEPG	CESTR	EL-3	2	PGCE23xx	Elective – V	3	0	0	3	100
CEPG	CESTR	EL-6	2	PGCE23xx	Elective – VI / Open Elective (Intellectual Property Rights)	3	0	0	3	100
CEPG	CESTR	Lab	2	PGCEL2301	Advanced Structural Engineering Lab – II	0	0	6	4	100
CEPG	CESTR		2		**Total Semester Credit**	**15**		**6**	**19**	**600**

Prog	CCMT Code	Group	Sem	Course code	Course Title	L	T	P	Credits	FM
CEPG	CESTR	Lab	3	*PGCEL3301	Seminar and Technical report Writing(work to start in the end semester break-summer)	0	0	3	2	100
CEPG	CESTR	EL-7	3	PGCEL33XX	Online course (MOOCs/NPTEL/SWAYAM)	3	0	0	3	100
CEPG	CESTR	Lab	3	PGCEL3302	Dissertation (to be continued in 4th Sem)	0	0	12	8	100
CEPG	CESTR		3		**Total Semester Credit**	**3**	0	**15**	**13**	**300**

Prog	CCMT Code	Group	Sem	Course code	Course Title	L	T	P	Credits	FM
CEPG	CESTR	Lab	4	PGCEL4302	Dissertation	0	0	21	12	100
CEPG	CESTR		4		**Total Semester Credit**			**21**	**12**	**100**
CEPG	CESTR				**Cumulative Total Credit**				**63**	**1600**

*Evaluation to be done in beginning of 3rd semester.

List of Electives – 1st semester

CEPG	CESTR	EL-x		PGCE1303	Theory of Plates and Shells	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1304	Prestressed Concrete	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1305	Bridge Engineering	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1306	Mechanics of Composite Materials	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1307	Machine Learning Methods	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1308	Earthquake Resistant Design of Structures	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1309	Applied Probability and Statistics	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1310	Fracture Mechanics	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1311	Optimization Techniques in Civil Engineering	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1312	Design of Masonry Structures	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1313	Advanced design of concrete structures	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE1314	Numerical methods in Engineering	3	0	0	3	100

List of Electives – 2nd semester

CEPG	CESTR	EL-x		PGCE2303	Advanced Concrete	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2304	Structural Stability	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2305	Design of advanced steel structures	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2306	Reliability Engineering	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2307	Structural Health Monitoring	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2308	Nonlinear Structural Analysis	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2309	Construction technology and management	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2310	Advanced Prestressed Concrete Structures	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2311	Fuzzy Logic and Artificial Intelligence in Civil	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2312	Computational plasticity	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2313	Random Vibration Analysis	3	0	0	3	100
CEPG	CESTR	EL-x		PGCE2314	Advanced Finite Element	3	0	0	3	100

Advanced Structural Analysis (PGCE1301)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended a course of Structural Analysis.

Objective: The objective of the course is to provide the student learn advanced methods to analyse structures

Detailed Course Outline

1. Review of the concepts: Basic concepts of structural analysis; Basis for principle of virtual work **8 Lectures**
2. Principle of virtual forces - standard and matrix formulation; Force method for analyzing skeletal structures, System to Member Force transformation.

   10 Lectures
3. Principle of virtual displacements - standard and matrix formulation; Displacement method for analyzing skeletal structures; Transformation of system displacement to member displacement. **10 Lectures**
4. Extension of Displacement Method to the Generalized stiffness method; Transformations of Stiffness Matrix, Applications on Beams and Arches,

   6 Lectures
5. Non-linear stiffness matrix analysis.

   8 Lectures

Reference Books:

1. Matrix Analysis of Framed Structures, W Weaver and J M Gear, Von Nastrand
2. Matrix Methods of Structural Analysis, M B Kanchi, Wiley Eastern New Delhi
3. Basic Structural Analysis, C S Reddy Tata Mc Graw Hill New Delhi
4. Theory of Matrix Structural Analysis, J S Przemiencky, Dover Pub., New York.
5. Matrix, Finite Element, Computer and Structural Analysis, M Mukhopadhayaya, Oxford and IBH Pub Co. Ltd New Delhi

Expected Outcome: The student will be able to analyses structures with advanced methods.

Theory of Elasticity and Plasticity (PGCE1302)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended a course of Mechanics of Solids and Structural Analysis.

Objective: The objective of the course is to provide the students in-depth concept in elastic and plastic analyses for design of structures.

Course contents:

1. **Analysis of Stress**: Traction Vector, State of Stress at a Point, Stress Components on an Arbitrary Plane, Equations of Equilibrium, Transformation of Stress w.r.t. another Coordinate, Principal Stresses in 3D, Stress Invariants, Octahedral Stresses, Mohr's Circle of Stresses, Hydrostatic and Deviatorial Stress components, Equations of Equilibrium Cylindrical Coordinates. Other Special Cases of Stresses **9 Lectures**

2. **Analysis of Strain:** Deformation in the Neighborhoods of a Point, Magnification of a line, Definition of Strain, Strain Tensor, Large and Small Deformations and Strains, Change in Angle between two lines, Principal Strains, Strain Transformation, Dilatation, Different Special Cases, Compatibility Relations, Strain Rossets.

   9 Lectures

3. **Stress-Strain Relation for Linear Elastic Bodies**: General Theory of Constitutive equations; Stress-strain Relations for Linear Elastic Solids, Types of Elastic problems for Isotropic solids. Displacement Equations of Equilibrium

   6 Lectures

4. **Torsion**: Torsion of thin walled Tubes, Torsion of Noncircular Section: Saint Venanat's Method, Prandtl Stress Function Method, Membrane Analogy, Torsion of Multiply Connected Sections, Centre of Twist and Flexure Centre.

   6 Lectures

5. **Plasticity:** Different plastic behaviours, Basic Concepts, Different Theories of Failure and Yield Criteria, Yield Locus and Yield Surfaces, Bauschinger's Effect, Isotropic and Kinematic Hardening, Flow Rules, Pi- plane, Prandtle-Reuss Equations and other Equations of Plasticity, Elasto-Plastic analysis of Torsion and Bending Problems, Residual Stresses.

   8 Lectures

6. **Axi-symmetric Problems**: Thick Walled Cylinders Subjected to Internal and External Pressure, Problems of Spherical and Axial Symmetry, Bending of Curved Beams. **4 Lectures**

Reference Books

1. Advanced Mechanics of Solids, L.S. Srinath, Tata Mc Graw Hill Pub.Co., New Delhi
2. Solid Mechanics, S M A Kazimi, Tata Mc Graw Hill Pub.Co., New Delhi
3. Advanced Mechanics of Materials, A. P Boresi and R J Schmidt, John Wiley and Sons Inc.
4. Theory of Elasticity, S P Timoshenko and J. H. Goodier, Mc Graw Hill Book Co.,
5. Classical and Computational Solid Mechanics, Y C Fung and P Tong, World Scientific, Singapore.
6. Introduction to the Theory of Plasticity for Engineers, O H Hoffmann, and G Sachs, Mc Graw Hill Book Co. New York.

Expected Outcome: The Student will be able to perform elastic and plastic analyses of structures.

Theory of Plates and Shells (PGCE1303)

L-T-P-CR: 3-0-0-3

Prerequisite: Student should have attended course on structural analysis.

Objective: The objective of the course is to make the student learn basics of design of plate and shell structures.

Detailed Course Outline:

1. Plate: Classification- Thin and thick plates, small and large deflections, Assumptions in theory of thin plates with small deflection, Governing Differential equation in Cartesian coordinates, moment curvature relations, stress resultants. **8 Lectures**
2. Rectangular plates: Navier solution for plates with all edges simply supported, Distributes loads. Point loads, rectangular patch load, Green function, Rectangular plates: Levy's method, Distributed load, line load. Energy method: Minimum potential theorem Rayleigh-Ritz approach for simple cases. **8 Lectures**
3. Circular Plates: Governing Differential equation in Polar coordinates, Axisymmetric situation, moment curvature relations, simply supported and fixes edge, distributes load, line load, linearly varying load. **8 Lectures**
4. Introduction to thin shell theory, classification on shell geometry, equation to shell surfaces, stress resultants, stress- displacement relations, compatibility Conditions, equilibrium equations, Circular cylindrical shells: Membranes theory, Bending theory for circular-cylindrical shell, design procedure. **10 Lectures**
5. Shells of revolution: membrane theory, spherical and conical shells with axisymmetric loading, Simple methods of analysis and design for conoidal and hyperbolic paraboloidal shells. **10 Lectures**

Books:

1. S. P. Timoshemkoo& W. Kriger: Theory of Plates and Shells
2. Jaeger: Theory of Plates
3. Szilard: Theory and Analysis of Plates
4. Flugge: Analysis of Shells
5. G. Ramaswami: Theory and Design of RC Shells

Expected Outcome: It is expected that the student will understand behaviour of plate and shell structures.

Pre-stressed Concrete Structures (PGCE1304)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on concrete structures.

Objective: The objective of the course is to understand the mechanical behavior, analysis and design of prestressed concrete elements.

Detailed Course Outline:

Introduction to basic concepts and general principles of pre-stressed concrete, materials used in prestressed concrete and methods and techniques of prestressing, prestressing systems.
5 Lectures

Analysis of prestressed concrete sections for flexure considering loading stages, computation of sectional properties, critical sections under working loads for pretensioned and post tensioned members, load balancing method of analysis of prestressed concrete beams, losses in prestress, application to simply supported beams and slabs.
5 Lectures

Design philosophy of prestressed concrete sections, permissible stresses in concrete and steel, design approaches using working stress method as per IS 1143 – 1980, limit state of collapse – flexure and shear as applied to prestressed concrete beams, kern points, choice and efficiency of sections, cable profile and layouts, cable zone, deflection of prestressed concrete sections.
8 Lectures

End zone stresses in prestresses concrete members, pretension transfer bond, transmission length, end block of post tensioned members. **5 Lectures**

Design of simply supported pre-tensioned and post tensioned slabs and beams. Design of bridge girders as per IRC. **8 Lectures**

Analysis and design of composite prestressed concrete structures **8 Lectures**

Introduction to application of prestressing to continuous beams, linear transformation and concordancy of cables **5 Lectures**

Reference Books/Material:

1. Raju, N. K. (2006). Prestressed concrete. Tata McGraw-Hill Education
2. Lin, T. Y., & Burns, N. H. (1981). Design of prestressed concrete structures.
3. Park, R. (1977). Design of Prestressed Concrete Structures. University of Canterbury.

Course Outcomes:

At the completion of this course, the student shall acquire knowledge and ability,
i. to understand basic properties of pre-stressed concrete structures
ii. to analyze and design pre-stressed concrete structures as per IS codes

Bridge Engineering (PGCE1305)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on concrete structures at UG level.

Objective:

The objective of the course is to provide basics in design of bridge structures.

Course contents:

Module-I **8Lecture**

Introduction, historical review, engineering and aesthetic requirements in bridge design. Introduction to bridge codes. Economic evaluation of a bridge project. Site investigation and planning;. Scour - factors affecting and evaluation.

Module-II **12Lecture**

Bridge foundations - open, pile, well and caisson. Piers, abutments and approach structures; Superstructure - analysis and design of right, skew and curved slabs. Girder bridges - types, load

distribution, design. Orthotropic plate analysis of bridge decks.

Module-III **10Lecture**

Introduction to long span bridges - cantilever, arch, cable stayed and suspension bridges. Methods of construction of R.C Bridges,

Module-IV **12Lecture**

Prestressed concrete bridges and steel bridges Fabrication, Lounching & creation. Design and construction of construction joints

Texts

1. D. J. Victor, Essentials of Bridge Engineering, Oxford IBH, 1980.
2. V. K. Raina, Concrete Bridge Practice Analysis Design and Economics, Tata McGraw Hill, 2nd Ed, 1994.

References

1. N. Rajagopalan, Bridge Superstructure, Narosa Publishing House, 2006.
2. W. F. Chen and L. Duan, Bridge Engineering Handbook, CRC press, 2003.
3. B. Bakht and L.G. Jaeger, Bridge Analysis Simplified, McGraw Hill, 1987.
4. E. J. O'Brien, and D. L. Keogh, Bridge Deck Analysis, Taylor and Francis, 1999.
5. H. Eggert and W. Kauschke, Structural Bearings, Ernst &Sohn, 2002.
6. T. Y. Lin and N. H. Burns, Design of Prestressed Concrete Structures, John Wiley and Sons, 1981.

Expected Outcome: It is expected that the student can design bridges using indian codal provisions.

Mechanics of Composite Materials (PGCE1306)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on structural analysis.

Objective: The objective of the course is to provide basics of mechanics of composite materials.

Detailed Course Outline

1.	Introduction to Composites	**4 Lectures**
2.	Basic constituent materials in Composites	**4 Lectures**
3.	Behaviour of a Laminae.	**8 Lectures**
4.	Laminated Composites:	**6 lectures**
5.	Strength and Failure theories	**4 Lectures**
6.	Design Concepts	**4 Lectures**
7.	Manufacturing Processes	**6 Lectures**
8.	Creating Special Topics, Engineering Applications, Civil Engineering Applications	**6 Lectures**

Texts/References

1. R. M. Jones, Mechanics of Composite Materials, McGraw Hill, 1988.
2. J.N. Reddy, Mechanics of Laminated Composite Plates, CRC Press, 1999.
3. B.D. Agrawal and Broutman, Analysis of Performance of Fibre Composites, John Wiley and Sons, 1990.
4. Autar K. Kaw, Mechanics of Composite Materials, CRC Press, 2005.

Expected Outcome: The Student will be able to understand basics involved in mechanics of composite materials.

Machine Learning Methods (PGCE1307)

LTP: 3-0-0 (3 Cr.)

Perquisite: NIL

Objective: The objective of the course is to equip the student analyses of structures by machine learning methods.

Detailed Course Outline:

Part I: Introduction **5 Lectures**

What is Machine Learning? An Overview.

Intro to Supervised Learning: KNN

Part II: Computational Foundations **5 Lectures**

Using Python, Anaconda, IPython, Jupyter Notebooks

Scientific Computing with NumPy, SciPy, and Matplotlib

Data Preprocessing and Machine Learning with Scikit-Learn

Part III: Tree-Based Methods **5 Lectures**

Decision Trees

Ensemble Methods

Part IV: Evaluation **5 Lectures**

Model Evaluation 1: Introduction to Overfitting and Underfitting

Model Evaluation 2: Uncertainty Estimates and Resampling

Model Evaluation 3: Model Selection and Cross-Validation

Model Evaluation 4: Algorithm Selection and Statistical Tests

Model Evaluation 5: Performance Metrics

Part V: Dimensionality Reduction **8 Lectures**

Feature Selection

Feature Extraction

Part VI: Bayesian Learning **8 Lectures**

Bayes Classifiers

Text Data & Sentiment Analysis

Naive Bayes Classification

Part VII: Regression **5 Lectures**

Intro to Regression Analysis

Part VIII: Unsupervised Learning **5 Lectures**

Intro to Clustering

Reference Books:

6. Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, The MIT Press
7. Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies, John D. Kelleher , Brian Mac Namee , Aoife D'Arcy , The MIT Press

Expected Outcome: The Student will be able to analyse structures with advanced methods of by machine learning.

Earthquake Resistant Design of Structures (PGCE1308)

Prerequisite: Student should have attended course on concrete and steel structures.

Objective: The objective of the course is to provide basics of earthquake resistant design of structures.

Detailed Course Outline

Theory:

1. **Earthquakes and Ground Motion:** Causes and Consequences of Earthquakes, Seismic Waves, Measurement of Ground Motion, Seismic Zoning.
4 Lectures

2. **Introduction to Dynamics of Structures and Seismic Response:** Modelling of Structures, Equation of Motion, Dynamic/Seismic Response of SDOF Structures, Systems with Multi-Degree of Freedom Systems, Periods and Modes of MDOF Systems; Elastic, Inelastic and Design Spectra, Damping. **8 Lectures**

3. **Earthquake Resistant Planning and Design Of Buildings:** Functional Planning: Simplicity and Symmetry, Stiffness and Strength, Twisting of Building, Ductility Provisions, Framing Systems, Introduction to IS Codes, Philosophy of Design: Seismic Co-efficient Method, Response Spectrum Method, Introduction to Time- History Method. Seismic Isolators.
9 Lectures

4. **Seismic Design of Masonry Buildings:** Box Action and Provision of Bands, Restoration and Strengthening Methods.
3 Lectures

5. **Seismic Design of RC Buildings:** Soft And Weak Storeys, Vertical and Horizontal Irregularities, Reinforcement Detailing Requirements, Ductility Provision in R.C Buildings, Confining

Reinforcements, Design Example, Frame Members Subjected to Bending and Axial Loads. **8 Lectures**

6. Design of steel timber structures **5 Lectures**

7. Design considerations for building appurtenance **4 Lectures**

Reference Books:

1. Elements of Earthquake Engineering: Jai Krishna, A.R. Chandrashekaran, Brajesh Chandra, South Asian Publishers Pvt. Ltd., New Delhi
2. Earthquake Resistant Design of Structures: S.K.Dugal, Oxford University Press, New Delhi
3. Earthquake Resistant Design of Structures, P.Agarwal and M. Shrikhande, Prentice Hall, New Delhi.
4. Dynamics of Structures: A.K. Chopra, Prentice hall, Englewood cliffs, New Jersey.
5. Limit State Design of Steel Structures, S K Duggal, Tata Mc Graw Hill, New Delhi.

Expected Outcome: The student should be able to design earthquake resistant structures.

Applied Probability and Statistics (PGCE1309)

L-T-P-CR: 3-0-0-3

Pre-requisite: Basic knowledge of Probability and Statics at intermediate level.

Objectives: To apply knowledge of probability and statics for analysis.

Detailed Course Outline:

1. Treatment of data: Pareto Diagrams; Frequency distributions; Graphs; Descriptive measures; Software applications; Excel; SPSS; MATLAB.
(**4 Lectures**)

2. Probability: Samples spaces and events; Axioms of probability; Theorems; Conditional Probability; Mathematical expectations and decision making.
(**15 Lectures**)

3. Probability Distributions: Random variables; Binomial and hypergeometric distributions; Mean and variance; Chebyshev's theorem; Poisson distribution; Multinomial distribution. (**5 Lectures**)

4. Probability Densities: Continuous random variables; Normal distribution; Uniform, LogNormal, Gamma, Beta, Weibull distributions; Joint distributions - Discrete and continuous.
(**5 Lectures**)

5. Inference: Inference about Means; Inference about variances; Inference about Proportions; Bayesian estimation.
(**13 Lectures**)

Recommended Books:

1. Milton. J. S. and Arnold. J.C., "Introduction to Probability and Statistics", Tata McGraw Hill, 4 th Edition, 2007.
2. Johnson. R.A. and Gupta. C.B., "Miller and Freund"s Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, 2007.
3. Papoulis. A and Unnikrishnapillai. S., "Probability, Random Variables and Stochastic Processes " McGraw Hill Education India , 4th Edition, New Delhi , 2010.

Expected outcome: To apply the knowledge in the real field situations related to statistical computations of civil engineering problems.

Fracture Mechanics (PGCE1310)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on Structural analysis.

Objective: The objective of the course is to provide basics of fracture mechanics in different type of materials.

Detailed Course Outline:

1. Historical perspective and Basic Concepts, Brittle and Ductile Fracture, Modes of Fracture, Surface Energy, Griffith's Concept, Energy Release Rate, Load and Mixed Mode Crack Propagation, Load and Displacement Control, Compliance, Crack-Resistance, Thin vs. Thick Plate. **6 Lectures**
2. Linear Elastic Fracture Mechanics: Stress and Displacement Field, Stress Intensity Factor, Westergaard's Approach, Co-linear Cracks, Application of Principle of Superposition Edge and Embedded Cracks, Relation Between G1 and k1.

   6 Lectures
3. Elastic Plastic Fracture Mechanics: Crack-tip Singularity, Approximate Shape and Size of Plastic Zone For Plane Stress and Plane Strain Cases, Effective Crack Length, Irwin's Approach, Dugdale's Approach, Effects of Plate Thickness.

   6 Lectures
4. J-integral and its Definition, Numerical Evaluation of J-integral, Toughness of Ductile Materials, Crack-tip Opening Displacement, Relation between CTOD, K_1 and G_1, Equivalence between CTOD and J-integral.

   8 Lectures
5. Test methods to determine K_{IC}, J_{IC}, G_{IC} and G_{IIC}, Determination of Critical CTOD, Computational Fracture Mechanics. **4 Lectures**
6. Fatigue Failure, S-N Curve, Environmental effects, Crack Initiation, Propagation and Closure, Crack under Variable amplitude Loading, Mixed Mode Crack, Low and High Cycle fatigue, Estimation of Fatigue Life, High and Low Temperature Fatigue, Corrosion Fatigue.

   8 Lectures

Texts

1. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers,1999.
2. T.L. Anderson, Fracture Mechanics – Fundamentals and Applications, CRC press, 1995.

References

1. M.F. Kanninen and C.H. Popelar, Advanced Fracture Mechanics, Oxford Engineering Science Series, 1985.

2. S.P. Shah, S.E. Swartz, Fracture Mechanics of Concrete: Applications of Fracture Mechanics to Concrete, Rock and Other Quasi-Brittle Materials, John Wiley and Sons Inc., 1995.

3. S. Suresh, Fatigue of Materials, Cambridge University Press, 1998.

4. D.R.J. Owen, and A.J. Fawkes, Engineering Fracture Mechanics: Numerical Methods and Applications, Pineridge Press Ltd., 1983.

Expected Outcome: The students will be able to understand phenomena of Fracture Mechanics under different load conditions of member.

Optimization Techniques in Civil Engineering (PGCE1311)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course in engineering mathematics.

Objective: The objective of the course is to provide optimal solutions to a particular problem.

Detailed Course Outline:

1. **System Engineering:** Definition of a system, systems approach, linear, non-linear, deterministic and stochastic systems. **8 Lectures**
2. **Optimization:** Introduction, definitions, system variables, objective functions, constraints. **6 Lectures**
3. **Linear programming** formulations, standard form, graphical solution, simplex algorithm, duality, primal-dual algorithm, Integer linear programming. **8 Lectures**
4. **Non-linear programming**, convex and concave functions, unconstrained optimization, uni-variate method, Powell's method, Gradient Method. **8 Lectures**
5. **Constrained problems** by unconstrained optimization, interior and exterior penalty functions, direct method of constrained optimization, Lagrange Multipliers, Kuhn Tucker conditions. **8 Lectures**
6. **Quadratic Programming**, Introduction to Dynamic programming, geometric and stochastic programming. **4 Lectures**

Text/ReferenceBooks

1. Taha, Hamdy A., Operation Research: An Introduction, Prentice Hall.
2. Vedula and Mujumdar Water Resources System Analysis TMH.
3. Rao S.S, Engineering Optimization, theory and practice, New age International
4. LjungLennant, System identification: theory for the users, Prentice Hall, India
5. Deb Kalyanmony, Optimization for engineering design, Prentice Hall, India

Reference Book:

1. E Polak, Computational Methods in Optimization, Academic Press, New York
2. P E Gill, W Murray and M H Wright, Practical Optimization, Academic Press, New York
3. S J Gass, Linear Programming, Mc Graw Hill Book Co. New York

Expected Outcome: The Student will be able to develop optimal solution to a particular problem.

DESIGN OF MASONRY STRUCTURES (PGCE1312)

LTP: 3-0-0 (3 Cr.)

Pre-requisite: NIL

Objective: The objective of the course is to equip students with the design and the use of (i) Reinforced Masonry, (ii) Composite Masonry (iii)Confined Masonry and (iv) 'In filled frames', their advantages and disadvantages.

Course contents:

Brick, stone, and block masonry units – Strength, modulus of elasticity and water absorption of masonry materials- classification and properties of mortars, selection of mortars. Defects and errors in masonry construction, cracks in masonry, types, reasons for cracking and remedial methods. Strength and stability of concentrically loaded masonry walls, effect of unit strength, mortar strength, joint thickness, rate of absorption, effect of ageing, workmanship, strength formulae and mechanism of failure of masonry subjected to direct compression.

8 Lectures

Permissible compressive stresses, stress reduction and shape reduction factors, increase in permissible stresses for eccentric vertical and lateral loads, permissible tensile and shear stresses. Load considerations for masonry: walls carrying axial load, eccentric load with different eccentric ratios—walls with openings and free standing wall. **8 Lectures**

Design considerations: Effective height of walls and columns, opening in walls, effective length, effective thickness, slenderness ratio, eccentricity, load dispersion, arching action and lintels.

8 Lectures

Design of load bearing masonry walls for building up to 3storeys using IS 1905 and SP20 procedure. **8 Lectures**

Reinforced masonry and its application, flexural and compression elements of reinforced masonry, shear walls. Composite masonry walls, composite wall beam elements, infilled frames**.**

8 Lectures

TEXT BOOKS:

1. Henry,A.W (1990), "Structural masonry", Macmillan Education Ltd.
2. Dayarathnam.P (1987), "Brick and reinforced brick structures", Oxford & IBH Publication.

REFERENCE BOOKS:

1. Sinha, B.P and Davies, S.R (1997), "Design of Masonry Structures", E & FN spon.
2. IS 1905-1987 (3rd revision), "Code of practice for structural use of unreinforced masonry", BIS, New Delhi.
3. SP 20 (S& T) 1991, "Hand book on Masonry Design and Construction (1st revision)",
BIS, New Delhi

Course Outcomes:

Students will understand the concept of reinforced masonry and its applications, and how to bring flexural and compression elements (beams and columns) of reinforced masonry shear walls. They also understand the concept of composite wall beam elements and in filled frames. They will know how to design these masonry structures.

Advanced Design of Concrete Structures (PGCE1313)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on structural analysis.

Course Objectives: To develop the conceptual understanding of the advanced concrete design

Detailed Course Outline:

1. Basic Design Concepts: Limit state method - Design of beams- Short-term and long-term deflection of reinforced concrete beams and slab- Estimation of crack width in reinforced concrete members **4 Lecture**

2. Frame Analysis and Design, Static and dynamic loading of structures **4 Lecture**

3. Inelastic Behaviour of Concrete Beams, Moment curvature relationship – plastic hinge formation-moment redistribution in continuous beams **5 Lecture**

4. Deep Beams and Corbels, Strut and tie method of analysis for corbels and deep beams, Design of corbels, Design of deep beams **5 Lecture**

5. Flat Slab, Design of flat slabs and flat plates according to IS method – Check for shear - Design of spandrel beams - Yield line theory and Hillerborg's strip method of design of slabs - Grid floor **5 Lecture**

6. Slender Columns, Design of slender columns subjected to combined bending moment and axial force using IS 456-2000 and SP 16 **5 Lecture**

7. Shear Wall, Analysis and design of shear wall framed buildings **8 Lecture**

8. Design of water tank, bunkers and silos **8 Lecture**

Text Book(s):

1. Subramanian. N., (2013), Design of Reinforced Concrete Structures, Oxford University Press, New Delhi.
2. Gambhir.M.L., (2012),Design of Reinforced Concrete Structures, Prentice Hall of India, New Delhi.
3. Varghese. P.C., (2011), Advanced Reinforced Concrete Design, PHI Learning Pvt. Ltd., New Delhi. 3. IS 456 Plain and Reinforced Concrete - Code of Practice
4. IS 13920 Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces -Code of Practice

Expected Course Outcome:

- Analyse and design the deep beams
- Design shears wall buildings and flat slabs
- Design slender columns, Design of water tanks, bunkers and silos

Advanced Structural Engineering Lab-I (PGCEL1301)

LTP: 0-0-6 (4 Cr.)

PREREQUISITE: The student should have attended course of concrete structures and engineering mechanics.

OBJECTIVE: To provide practical skill and the application in civil constructions.

List of experiments:

1. Mix proportioning for high strength concrete, use of admixture/plasticizer;
2. Nondestructive evaluation of strength of concrete/steel specimens;
3. Study of loading and response measuring systems;
4. Testing of beams subjected to transverse (static/dynamic) loading;
5. Testing of prestressed concrete beams;
6. Testing of slab –study of flexural and punching failure;
7. Free and forced vibration studies
8. Loading and deflection measurement in a space truss system;
9. Natural frequencies and mode shapes of structures;
10. Evaluation of structural damping.

Texts/References

1. H.G. Harris and G.M. Sabnis, Structural Modeling and Experimental Techniques, 2nd Ed, CRC Press, 1999.
2. E. Bray and R. K. Stanley, Non Destructive Evaluation, CRC Press, 2002.
3. J.W. Dally and W.F. Riley, Experimental Stress Analysis, McGraw Hill, 3rd Ed, 1991.
4. J.F. Doyle, Modern Experimental Stress Analysis, John Wiley and Sons, 2004.
5. P.C. Aitcin, High-Performance Concrete, E & FN SPON, 1998.

Course outcome: Student will get knowledge of practical aspects of structures.

Structural Dynamics (PGCE2301)

L-T-P-CR: 3-0-0-3

Prerequisite:

Student should have attended course on structural analysis.

Objective:

The objective of the course is to provide basics of dynamics in structures.

Detailed Course Outline:

1. Introduction to dynamic load and response, stiffened and damping in series and parallel, Degree of freedom, damped and undamped free vibrations of SDOF, critical damping, logarithmic decrement. **6 Lectures**

2. Response of SDOF to harmonic excitation, frequency response function , half power band method for damping ratio, base isolation, transmissibility, frequency domain analysis for periodic loading, seismic instruments. **8 Lectures**

3. Response of SDOF: response to impulsive and different pulse loads, Duhamel and convolution integrals, numerical methods eg. Approximation of excitation constant and linear acceleration method, newmark-Beta method, Wilson-theta method. **9 Lectures**

4. Multi-degree freedom system, stiffness and flexibility approaches, Lumped-mass matrix, free vibrations fundamental Frequencies and mode shapes, Eigen value problem, Rayleigh quotient, orthogonally of modes, numerical schemes to find mode shapes and frequencies. **6 Lectures**

5. Multi degree freedom systems, response to dynamic loading, Formulations of equations of motion, normal coordinates, mode superposition method, modal matrix, numerical scheme of Wilson and Newmark. **8 Lectures**

6. Distributed systems: free vibration of uniform bars and beams, BCS in such problems, assumed mode method, Hamilton's method, langrage method, generalized parameters. **6 Lectures**

7. Structural response to earthquake, wind and ground motion characteristics Response spectrum design earth quake, IS code provisions for multistory frames. **8 Lectures**

BOOKS:

1. R. W. Clough:, J. Penzian: Dynamics of Structures
2. J. M. Biggs: Structural Dynamics

3. L. S. Jacobsen R. S. Arye: Engineering Vibrations
4. S. P. Timoshenkoo: Vibration Problems in Engineering
5. G. B. Warburden: The Dynamical Behaviour of Structures

Expected Outcome: The Student will be able to analyse problems related to dynamics of structures.

FINITE ELEMENT ANALYSIS (PGCE2302)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on mathematics.

Course Objectives: The objectives of this course are to introduce concepts of finite element method for analysis of structures

Detailed Course Outline:

Introduction to Finite Element Analysis: Introduction, Basic Concepts of Finite Element Analysis, Introduction to Elasticity, Steps in Finite Element Analysis. **4 Lectures**

Finite Element Formulation Techniques: Virtual Work and Variational Principle, Galerkin Method, Finite Element Method: Displacement Approach, Stiffness Matrix and Boundary Conditions **5 Lectures**

Element Properties: Natural Coordinates, Triangular Elements, Rectangular Elements Lagrange and Serendipity Elements, Solid Elements, Iso-parametric Formulation, Stiffness Matrix of Iso-parametric Elements, Numerical Integration: One Dimensional; Numerical Integration: Two and Three Dimensional **9 Lectures**

Analysis of Frame Structures: Stiffness of Truss Members, Analysis of Truss, Stiffness of Beam Members, Finite Element Analysis of Continuous Beam, Plane Frame Analysis, Analysis of Grid and Space Frame. **6 Lectures**

FEM for Two and Three Dimensional Solids: Constant Strain Triangle, Linear Strain Triangle, Rectangular Elements, Numerical Evaluation of Element Stiffnes, Computation of Stresses, Geometric Nonlinearity and Static Condensation, Axisymmetric Element, Finite Element Formulation of Axi-symmetric Element, Finite Element Formulation of Axi-symmetric Element, Finite Element Formulation for 3Dimensional Elements. **10 Lectures**

FEM for Plates and Shells: Introduction to Plate Bending Problems, Finite Element Analysis of Thin Plate, Finite Element Analysis of Thick Plate, Finite Element Analysis of Skew Plate, Introduction to Finite Strip Method **5 Lectures**

Additional Applications of FEM: Finite Elements for Elastic Stability, Finite Elements in Civil Engineering, Dynamic Analysis. **3 Lectures**

Texts

1. J.N. Reddy, An Introduction to the Finite Element Method, Tata McGraw Hill, 2nd Ed, 2003.
2. C.S. Krishnamoorthy, Finite Elements Analysis: Theory and Programming, Tata McGraw Hill, 2nd Ed, 1994.

References

1. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and Applications of Finite ElementAnalysis, John Wiley & Sons, 4th Ed, 2002.
2. O.C. Zienkiewicz, R.L. Taylor and J.Z. Zhu, Finite Element Method Its Basis andFundamentals, Elsevier, 6th Ed, 2005.
3. S.S. Rao, Finite Element Method in Engineering, Butterworth Heinemann, 3rd Ed, 1999.
4. M.B. Kanchi, Matrix Method of Structural Analysis, Wiley Eastern Limited, 2nd Ed, 1993.
5. K.J. Bathe, Finite Element Procedures, Prentice Hall of India Pvt. Ltd., 2002.

Expected Outcome: The Student will be able to analyse complex problems in structural engineering.

Advanced Concrete Technology (PGCE2303)

LTP: 3-0-0 (3 Cr.)

Prerequisite: NIL

Objective: The objective of the course is to introduce advance concrete technology.

Detailed Course Outline

Theory:

1. Concrete as a composite material; Rheological properties of concrete; Microstructure studies in concrete, techniques for measurement of porosity **5 Lectures**
2. Reinforcement corrosion: an electrochemical process, techniques for corrosion monitoring, corrosion protection measures, application of coatings on rebar, corrosion inhibitors in concrete **5 Lectures**
3. Use of industrial waste and their influence on physical, mechanical and durability properties of concrete; Fiber reinforced concrete: mechanism of fiber reinforcement, types of fibers, properties of fiber reinfor **6 Lectures**
4. High strength concrete: constituents, mix proportioning, properties at fresh and hardened state; Reactive powder concrete; Macro Defect Free (MDF) cement **5 Lectures**
5. Self-compacting concrete; Roller compacted concrete; Ferro cement composites; Polymers in construction, polymer concrete composites; Chemical testing of concrete **5 Lectures**
6. Non-destructive evaluation of reinforced concrete by surface hardness techniques, wave propagation techniques, penetration resistance techniques, electrochemical and electromagnetic techniques. **6 Lectures**
7. Fracture mechanics of concrete **4 Lectures**
8. Repairs and rehabilitation of old concrete. **6 Lectures**

Texts

1. P. K. Mehta and P. J. M. Monteiro, Concrete: Microstructure, Properties and Materials, McGraw-Hill, 3rd Ed., 2006.
2. J. Newman and B. S. Choo, Advanced Concrete Technology: Processes, Elsevier, Butterworth-Heinemann, 2003.

References

1. A. M., Neville and J. J. Brooks, Concrete Technology, Pearson Education, 4th Indian reprint, 2004.
2. M. S. Mamlouk and J. P. Zaniewski, Materials for Civil and Construction Engineers, Pearson, Prentice Hall, 2nd Ed., 2006.
3. P. C. Aitcin, High Performance Concrete, E &FnSpon, 1998.

4. J. Newman and B. S. Choo, Advanced Concrete Technology: Concrete properties, Elsevier, Butterworth-Heinemann,2003.
5. E. G. Nawy, Fundamentals of High-Performance Concrete, John Wiley & Sons Inc., 2nd Ed., 2001.

Expected Outcome: The student will have understanding of current advances in Concrete technology.

Structural Stability (PGCE2304)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course in structural analysis.

Objective: The objective of the course is to provide basics involved in stability of structures.

Detailed Course Outline:

1. **Beam Columns:** Differential equation for beam columns - Beam column with concentrated loads - Continuous lateral load - Couples - Beam column with built in ends - Continuous beams with axial load. **6 Lectures**
2. **Elastic Buckling of Bars:** Elastic buckling of straight columns - Effect of shear stress on buckling - Eccentrically and laterally loaded columns - Energy methods - Buckling of a bar on elastic foundation-Buckling of bar with intermediate compressive forces and distributed axial loads-Buckling of bars with change in cross section-Effect of shear force on critical load-Built up columns. **6 Lectures**
3. **Inelastic Buckling:** Buckling of straight bars-Double modulus theory-Tangent modulus theory. **6 Lectures**
4. **Mathematical Treatment of Stability Problems:** Buckling problem - Orthogonality relation-Ritz method-Timoshenko method and Galerkin method. **6 Lectures**
5. **Torsional Buckling:** Pure torsion of thin walled bar of open cross section-Non-uniform torsion of thin walled bars of open cross section-Torsional buckling-Buckling by Torsion and Flexure. **6 Lectures**
6. **Lateral Buckling of Simply Supported Beams:** Beams of rectangular cross section subjected to pure bending. **6 Lectures**
7. **Buckling of Simply Supported Rectangular Plates:** Derivation of equation of plate subjected to constant compression in two directions and one direction, finite element method. **6 Lectures**

Text Books:

1. Stephen P. Timoshenko and James M. Gere., " Theory of Elastic Stability",McGraw Hill Book company.

Reference Books :

1. Blunch- "Stability of Metallic Structure", Mc Graw Hill.
2. Chem. &Atsute "Theory of Beam Columns, Vol I " Mc Graw Hill.
3. Smitses, " Elastic Stability of Structures" ,Prentice Hall.

4. Brush and Almorth, “Buckling of Bars, Plates and Shells” , Mc Graw Hill book company.
5. Chajes,A., “ Principles of Structural StabilityTheory”, Prentice Hall.
6. Ashwini Kumar, “ Stability theory of Structures” , Tata Mc Graw Hill Publishing company Ltd, New Delhi.
7. Bleaigh“ Elastic Stability”, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.

Expected Outcome: The Student will understand basics involved in stability of structures

Design of Advanced Steel Structures (PGCE2305)

LTP: 3-0-0 (3Cr)

Perquisites: Student should have attended course in steel structures at undergraduate level.

Course Objectives:
To introduce method for design of steel structures with loading standards as per code provisions

Detailed Course Outline:

1) Elements of a plate girder, design of a plate girder, curtailment of flanges, various type of stiffeners. **8 Lecture**

2) Design of steel foot bridge with parallel booms and carrying wooden decking, using welded joints. **10 Lecture**

3) Complete design of an industrial shed including:

i) Gantry girder

ii) Column bracket

iii) Mill bent with constant moment of inertia

iv) Lateral and longitudinal bracing for column bent **12 Lecture**

4) Design of single track railway bridge with lattice girders having parallel chords (for B.G.)

i) Stringer

ii) Cross girder

iii) Main girders with welded joints

iv) Portal sway bracings

v) Bearing rocker and rollers **12 Lecture**

References:

1) Limit state design of steel structures: S K Duggal
2) Design of steel structures: N Subramanian
3) Design of steel structures (Vol. 2): Ram Chandra
4) Design of steel structures: L S Negi
5) Design of steel structures (by limit state method as per IS: 800-2007): S S Bhavikatti

Course Outcomes: At the completion of this course, the student shall acquire knowledge and ability,
i. to understand methods of structural steel design,
ii. to design various types of steel structures

Reliability Engineering (PGCE2306)

LTP: 3-0-0 (3 Cr.)

Pre-requisite: NIL

Objective: The objective of the course is to impart knowledge of modelling techniques incorporating uncertainty.

Detailed Course Outline:

1. **Concept of variability** in design parameters, applications of statistical principles to deal with randomness in basic variables, statistical parameters and their significance. Characteristic strength and characteristic load, probability modeling of strength, geometrical dimensions, material properties and loading. Description of various probability distributions – Binomial, Poisson, Normal, Lognormal, Beta, Gama distributions. **6 Lectures**
2. **Testing of goodness** – of – fit of distributions to the actual data using chi-square method and K.S Method. Statistical regression and correlation using least – square and chi – square methods. Statistical Quality control in Civil Engineering, -Application problems. **6 Lectures**
3. **Mean value method and its applications** in structural designs, statistical inference comparison of various acceptance and rejection testing. **8 Lectures**
4. **The Random variable, operation on one Random variable, expectation, multiple random variables, reliability distributions** – basic formulation, the hazard function, Weibull distribution. Introduction to safety assessment of structures – reliability analysis using mean value theorem – I, II and III order Reliability formats. **6 Lectures**
5. **Simulation techniques, reliability index** - reliability formulation in various limit states, reliability based design, application to design of RC, PSC and steel structural elements **10 Lectures**

Texts/References

1. P. Thoft-Christensen and M.J. Baker, Structural Reliability Theory and its Applications, Springer Verlag, 1982.
2. R.E. Melchers and Ellis Horwood, Structural Reliability and Prediction, John Wiley and Sons Ltd., 1987.
3. A.H.S. Ang and W. H. Tang, Probability Concepts in Engineering Planning and Design, Vol. II, John Wiley and Sons, New York, 1984.
4. P. Thoft-Christensen and Y. Murotsu, Applications of Structural Systems Reliability Theory, Springer Verlag, 1986.

Expected Outcome: The student should be able to do Probabilistic Analysis of Structures.

Structural Health Monitoring (PGCE2307)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on concrete and steel structures.
Objective: The objective of the course is to provide details of techniques for health monitoring of structures.

Detailed Course Outline:

1. Concept of structural health monitoring, sensor systems and hardware requirements, global and local techniques, **10 Lectures**
2. Computational aspects of global dynamic techniques, experimental mode shapes, Damage localization and quantification **8 Lectures**
3. Piezo-electric materials and other smart materials, Electro-mechanical impedance (EMI) technique, low cost adaptations **8 Lectures**
4. Fatigue life assessment, Integration of global and EMI techniques **8 Lectures**
5. Shear lag models **8 Lectures**

Text Books and References:

1. Ewins, D. J. (2000), Modal Testing: Theory, Practice and Applications, 2nd edition, Research Studies Press Ltd., Baldock.
2.Inman, D. J., Farrar, C.R., Steffan, V. and Lopes, V. (2005), Damage Prognosis -For Aerospace, Civil and Mechanical Systems, John Wiley & Sons, Ltd., Chichester, UK.
3.Soh, C. K, Yang Y. W. and Bhalla S. (2011), Smart Materials in Structural Health Monitoring, Control and Bio – mechanics, Springer.
4.Hixon, E.L. (1988), "Mechanical Impedance", Shock and Vibration Handbook, edited by C. M. Harris, 3rd ed., Mc Graw Hill Book Co., New York, pp. 10.1-10.46.
5.Ikeda, T. (1990), Fundamentals of Piezoelectricity, Oxford

Expected Outcome: The objective of the course is to provide details of techniques used for health monitoring of structures.

Nonlinear Structural Analysis (PGCE2308)

LTP: 3-0-0 (3 Cr.)

Pre-requisite: Basic knowledge of linear structural analysis course.

Objectives: To understand nonlinear structural behavior and apply knowledge for analysis.

Detailed Course Outline:

1. Introduction to nonlinear structural analysis; Overview, Sources of nonlinearities, types of structural analysis (1st order elastic, 1st order inelastic, 2nd order elastic, and 2nd order inelastic), overview of solution strategies for nonlinear structures **2 Lectures**

2. Principles of computational plasticity; overview, yield criterion, flow rule, hardening rule, loading/unloading criterion. Some commonly used uniaxial material models; elastic material, elastic-perfectly plastic material, bilinear steel material with kinematic and isotropic hardening, Ramberg-Osgood steel material model, Giuffre-Menegotto-Pinto model with isotropic strain hardening, Kent-Scott-Park concrete material model, Visco-elastic material model, Bouc-Wen model. **8 Lectures**

3. Member section analysis; fiber section discretization; moment-curvature response; force-deformation response; Material nonlinear beam-column element formulation; lumped plasticity models (beam with hinges formulation), distributed nonlinearity models; displacement-based nonlinear beam-column element; force-based nonlinear beam-column element. **8 Lectures**

4. Geometrically nonlinear analysis; simplified 2nd order P-Δ analysis, co-rotational formulations of truss and beam elements. **8 Lectures**

5. Solution strategies for nonlinear system of equations; incremental single-step methods; Euler method, second-order Runge-Kutta methods, incremental-iterative methods, load control, displacement control, work control, arc-length control; Nonlinear structural dynamic analysis; semi-discrete equations, of motion, explicit time integration, implicit time integration, dissipative integration algorithms, stability and accuracy. **8 Lectures**

6. Application to hybrid simulation; overview, sub-structuring in hybrid simulation; application to modeling analytical substructures, solution of time discretized equations of motion **8 Lectures**

Recommended Books:

1. Bassam A. Izzuddin "Nonlinear Structural Analysis for Engineers", CRC Press, New Delhi, 2013.
2. Leszek Gasinski, Nikolaos S. Papageorgiou "Nonlinear Analysis" Chapman and Hall/CRC, New Delhi, 2005.

Expected outcome: To apply the knowledge in the real field of structural engineering problems.

Construction Technology and Management (PGCE2309)

LTP: 3-0-0 (3 Cr.)

Perquisite: NIL

Objective: Student shall learn about concept of a project and Quality & Safety concern in construction. Apply various Networking & Optimization Techniques for planning a project. Prepares budget of a project and also prepares construction cost estimates.

Course Contents:

1.Concept of a Project: Characteristic features – Project life cycle – Phases – Project Management – Effects of project risks on organization – Organization of project participants – Traditional designer – Construction sequence – Professional construction management – Owner - builder Operation – Turnkey operation – Leadership and Motivation for the Project Team – Interpersonal behaviour in project organizations - Perceptions of owners and contractors.

4 lectures

2. 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.

4 lectures

3. 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 tradeoff.

8 lectures

4. 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.

8 lectures

5. Cost Control Problem: 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.

8 lectures

6. Costs Associated With Construction 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.

8 lectures

Text Books:

1. Chitkara, K.K, "*Construction Project Management: Planning, Scheduling and Control*", Tata Mc Graw Hill Publishing company, New Delhi.

Reference Books:

1. Prasanna Chandra, "*Project Planning Analysis, Selection, Implementation and Review*". Tata Mc Graw Hill Publishing Company, New Delhi.
2. Sengutha. B.and Guha.H, "Construction *Management and Planning*", Tata Mc Graw Hill Publishing company, New Delhi.
3. Feigenbaum.L., "*Construction Scheduling with Primavera Project Planner*", Prentice Hall Inc.
4. Halpin,D.W., "*Financial and Cost Concepts for Construction Management*", John Wiley & Sons New York.
5. Choudhury.S, "Project *Management*", Tata Mc Graw Hill Publishing Company, New Delhi.
6. A.K.Datta, "*Materials Management*". Prentice Hall, India.

Expected Outcome: After completion of this course, the student shall understand

(i) The concept of a project along with Quality & Safety concerns in Construction

(ii) Plan a project using various Networking Techniques and Optimization Techniques

(iii) Prepare budget of a project and construction cost estimates.

Advanced Pre-stressed Concrete Structures (PGCE2310)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on concrete structures**.**

Objective: The objective of the course is to make the student learn basics and design of pre-stressed concrete and industrial structures.

Detailed Course Outline:

1. **Anchorage Zone Stresses In Post-Tensioned Members:** Introduction to PSC, stress distribution in end block, investigations on anchorage zone stresses, Magnel and Guyon's methods, Comparative analysis, anchorage zone reinforcement. **5 Lectures**
2. **Shear And Torsional Resistance:** Shear and principal stresses, ultimate shear resistance, design of shear reinforcement, torsion, design of reinforcement for torsion. **6 Lectures**
3. **Composite Beams**: Introduction, types of composite beams, analysis for stresses, differential shrinkage, serviceability limit state. Design for flexural and shear strength. **6 Lectures**
4. **Tension Members:** Introduction, ties, pressure pipes – fabrication process, analysis, design and specifications. Cylindrical containers - construction techniques, analysis, design and specifications. **5 Lectures**
5. **Compression Members:** Introduction, columns, short columns, long columns, bi-axially loaded columns, prestressed concrete piles. **6 Lectures**
6. **Slab And Grid Floors:** Types of floor slabs, design of one way, two way and flat slabs. Distribution of prestressing tendons, analysis and design of grid floors. **4 Lectures**
7. **Precast Elements:** Introduction, prestressed concrete poles, manufacturing techniques, shapes and cross sectional properties, design loads, design principles. Railway sleepers-classification and manufacturing techniques, design loads, analysis and design principles. Precast bridge girders and segmental constructions. External prestressing. **10 Lectures**

References:

1. Lin T.Y. and H. Burns, Design of Prestressed concrete structures - - John Wiley &Sons, 1982.
2. N. Krishna Raju, Prestressed Concrete- - Tata McGraw-Hill, 3rd edition, 1995.
3. P. Dayaratnam, Prestressed Concrete Structures- - Oxford & IBH, 5th Edition, 1991.
4. G.S. Pandit and S.P. Gupta, Prestressed Concrete-– CBS Publishers, 1993.
5. Guyon, Prestressed concrete, Contractors Record Books, 19636. IS: 1343:1980.

Expected Outcome: It is expected that the Student will able to analyse prestressed concrete structures behaviour and design.

Fuzzy Logic and Artificial Intelligence in Civil Engineering (PGCE2311)

Prerequisite: Nil

Objective:

The objective of the course is to impart knowledge of modelling techniques incorporating uncertainty.

Theory:

Introduction - Classification of artificial intelligence-expert systems. **4 lectures**

Artificial neural networks-basic concepts, uses in functional approximation and optimization. **8 lectures**

Applications in the design and analysis, building construction. **10 lectures**

Fuzzy logic - basic concepts – problem formulation using fuzzy logic. **10 lectures**

Applications of fuzzy logic in civil engineering. **10 lectures**

Texts/References

1. D.E. Rumelhart and J.L. McClelland, Parallel Distributed Processing, Vol. 1, MIT Press, 1986.

2. M.J. Patyra and D.J. Mlynek, Fuzzy Logic Implementation and Applications, Wiley Teubner, 1996.

Expected Outcome: The student should be able to apply fuzzy logic and artificial intelligence in Civil Engineering problems.

Computational Plasticity (PGCE2312)

LTP: 3-0-0 (3 Cr.)

Prerequisite: The student should have attended a course on finite element method.

Objective: To learn the computational techniques in plasticity approach to problem.

Course Contents:

1. Experimental behaviour of metals and other materials under monotonic and cyclic loading

   4 Lectures
2. One dimensional mathematical modeling and its computational implementation

   4 Lectures
3. Yield criteria for different materials in multiaxial conditions

   8 Lectures
4. Elastoplastic boundary value problem. Finite element analysis of elastoplastic boundary value problems

   6 Lectures
5. Integration of constitutive relations

   6 Lectures
6. Consistent tangent modulus, Kinematics of plastic deformation at finite strain

   6 Lectures
7. Finite element formulation at large strain, recent development in cyclic plasticity and its computational implementation.

   8 Lectures

Texts/References

1. J. C. Simo and T.J.R. Hughes, Computational Inelasticity, Springer, 1998.

2. J. Lemaitre and J.L. Chaboche, Mechanics of Solid Materials, Cambridge University Press, Cambridge 1990.

3. Akhatar S. Khan and Sujian Huang, Continuum theory of plasticity, John Wiley & sons Inc. 1995.

4. I. H. Shames and F.A. Cozzarelli, Elastic and inelastic stress analysis, Prentice hall,

Englewood Cliffs, New Jersey 1992.

Expected Outcome: The student will be able to use computational techniques in plasticity approach to problem.

RANDOM VIBRATION ANALYSIS (PGCE2313)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on mathematics.

Course Objectives

This course covers the basic principles of random variables and stochastic processes and applications to the response of systems subjected to random vibrations.

Course contents:

1. Basic Theory: Meaning and axiom of probability, events, random variables, discrete and continuous distribution, some examples; Functions of random variables, expectations, characteristic functions; Orthogonality principles, sequence of random variables.
   10 Lecture

2. Stochastic Processes: Counting process, random walk, Markov chain, Gaussian process, filtered point process, Markov process and non-stationary Gaussian process; Stochastic continuity and differentiation, integral, time average, ergodicity; Correlation and power spectrum; Threshold crossing, peak, envelope distribution and first passage problem.
   10 Lecture

3. Response of Linear Systems to Random Vibrations: Linear response of single and multiple-degree of freedom systems subjected to random inputs; Linear response of continuous systems.
   10 Lecture

4. Response of Nonlinear Systems to Random Vibrations: Response of nonlinear systems to random inputs; Equivalent linearization and Gaussian closure technique.
   12 Lecture

Reference Books/Material

1. Nigam, N. C., & Saunders, H. (1986). Introduction to Random Vibration.
2. Preumont, A. (2013). Random Vibration and Spectral Analysis/Vibrations aléatoiresetanalyse spectral (Vol. 33). Springer Science & Business Media.
3. Lin, Y. K., &Cai, G. Q. (2004). Probabilistic structural dynamics: advanced theory and applications. Mcgraw-hill Professional Publishing.
4. C. W. (2011). Nonlinear random vibration: Analytical techniques and applications. CRC Press.
5. Wirsching, P. H., Paez, T. L., & Ortiz, K. (2006). Random vibrations: theory and practice. Courier
Corporation.
6. Robson, J. D. (1964). An introduction to random vibration, Edinburgh University Press.

Expected course outcome:

At the completion of this course, the student shall acquire knowledge and ability to random variables and stochastic processes and applications to the response of systems subjected to random loading

Advanced Finite Element Method (PGCE2314)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on finite element method.

Objective: To provide basics to analyze complex structures using numerical methods.

Theory:

1. Energy principles in mechanics: Weak form and variational principles. Isoparametric Finite Element formulation and its properties, Finite Element Basics. **4 Lectures**
2. Concepts of locking in finite element and constrained minimal problems. Shear locking, membrane locking and incompressible locking in solid and structural problems. **4 Lectures**
3. Locking free finite element methods: Field consistent formulation, Assumed strain and assumed stress methods, Incompatible modes and the enhanced strain formulation. **6 Lectures**
4. Nonlinear Finite Element Basics **5 Lectures**
5. Nonlinear Bending of Beams **5 Lectures**
6. Nonlinear Bending of Plates and Shells: Basic Linear Plate and Shell Elements, Nonlinear Plates and Shells, Time-dependent Deformation of Shells. **6 Lectures**
7. Nonlinear Finite Elements of Solids: Material Nonlinearities, Objective Rates, Nonlinear Elasticity, Plasticity, Viscoplasticity, Viscoelasticity. **6 Lectures**
8. Solution techniques for nonlinear equations, Newton-Raphson method and quasi-Newton schemes. Equilibrium path tracing strategies, Arc length schemes, Formulations of contact problems, Error analysis in linear and nonlinear FEM. **7 Lectures**
9. Introduction to advanced Topics: Dynamic Fracture, Stochastic Finite Elements, Contact, Mesh Generation, Multi-scale Methods, Multi-physics Problems. **4 Lectures**

Texts/References

1. O. C. Zienkiewicz, R. L. Taylor and J.Z. Zhu, The Finite Element Methods Its Basis and Fundamentals, Butterworth-Heinemann, 6th Ed., 2005.
2. L.E. Malvern (1969), Introduction to the Mechanics of a Continuous Medium,
3. Prentice-Hall.T. J. R. Hughes, The Finite Element Method Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
4. J. N. Reddy (1993), An Introduction to the Finite Element Method, McGraw-Hill.
5. K-J. Bathe (1996), Finite Element Procedures, Prentice-Hall.

Expected Outcome: The student will be able to analyse complex structures.

Numerical methods in Engineering (PGCE2314)

LTP: 3-0-0 (3 Cr.)

Prerequisite: Student should have attended course on mathematics.

Objective: The objective of the course is to empower students with programming skill and application of various numerical methods to solve large scale computation heavy problems

Detailed Course Outline:

Computer programming Fortran /MATLAB–Programming fundamentals, Introduction to algorithm development, Computer Implementation of Matrices, Guidelines for development of a large sized problem.

8 Lectures

Numerical methods-Solution of Linear Simultaneous equations – Method of Gauss Elimination, Cholesky''s, Jacobi iteration, Gauss – Seidel method of Iteration, Numerical Integration – Trapezoidal, Simpson's and other Newton – Cotes formulae, Method of Gauss Quadrature.
Interpolation (Lagrange Interpolation, Taylor series expansion, Extrapolation), curve fitting, regression

8 Lectures

Initial and boundary value problem, Euler's, Runge-kutta, Milne's etc, Computer oriented Algorithms.

8 Lectures

Solution of nonlinear Equations: Newton-based method for solving sparse nonlinear equations

8 Lectures

Eigen value and Eigen vectors. Problems associated with choice and implementation of solution techniques in the eigen solution of large problems arising in dynamic systems (determinant search, subspace iteration and Lanczos method) .

12 Lectures

Reference Books/Material

1. Scarborough J. B., "Numerical Mathematical Analysis", Oxford and IBH publishers, 1966.
2. Gerald C. F., "Applied Numerical Analysis", Addison – Wesley Publishing Company, 1970.
3. Jain M. K., Iyengar S. R. K. and Jain R. K, "Numerical Methods for Scientific and Engineering
Computations", John Wiley – New Age International Limited, 1993.
4. Balgurusamy E., "Numerical Methods", Tata McGraw Hill, New Delhi, Fifth Edition, 2001.
5. Rajaraman, V., "Fortran-95", Prentice Hall of India, 1988.

Course Outcomes:

At the completion of this course, the student shall acquire knowledge and ability,

i. to understand various numerical techniques for solving problems in structural engineering
ii. to develop codes/software for solution using numerical techniques