DEPARTMENT OF CIVIL ENGINEERING

Course Structure and Syllabi

for

2-Year M.Tech. Course on Structural Engineering
(Effective from AY 2019-2020)

INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD
Dhanbad-826004, Jharkhand
March 2019

Highlights of the Course

The programme started in Monsoon Semester of the session 2015-16 with student strength of 25. The programme provides a strong theoretical/practical background necessary for Analysis and Design of various Structural Systems. This programme also imparts basic and advanced knowledge onStructural Dynamics, Finite Element Method, Theory of Elasticity and Plasticity, Bridge Engineering, Earthquake Resistant Design of Structures, Theory of Elastic Stability, Prestressed Concrete DesignAdvanced Design of Structures, Theory of Plate and Shell, Mechanics of Composite Materials etc. to cover wide spectrum of Structural Engineering Specialization. The Department is also furnished with basic and advanced equipments for laboratory investigations. On successful completion of the course, it is expected that students will acquire adequate knowledge and confidence to tackle challenging industrial as well as research problems.

Importance of the Course

Structural Engineering is one of the key specializations in the domain of Civil Engineering. The programme is expected to generate good Structural Engineer/Practitioner to tackle challenging infrastructural projects along with good researcher for innovative research.

Placement Opportunity

The students are expected to be recruited in various private/public sectors handling various infrastructure projects in thermal power plants, nuclear power plants, hydro projects, mining industries etc. Students may also pursue their career in higher studies.

Future/Recent Areas of Prominence

1. Multi-Scale Modelling of Structures
2. Blast and Fire Resistant Structures
3. Structural Health Monitoring
4. Smart Materials and Structures
5. Disaster Mitigation
6. Mechanics of Advanced Materials
7. Random Vibrations

8. Prefabricated and Modular Buildings
9. Energy Efficient Buildings

Programme Objectives

- ❖ Imparting specialized knowledge on various areas of Structural Engineering.
- ❖ Training of the students on professional Structural Engineering and preparing them for various challenges of the field.
- ❖ Enhancement of problem solving skills of students by covering basic concepts with advanced topics through theoretical/practical course works.
- ❖ Development and transfer of innovative technology based on dissertation works of the students for the benefit of society.

Strength of the Programme

- ❖ Faculty members having basic exposure to the emerging fields as-mentioned above.

Weakness of the Programme

- ❖ Research oriented Structural Engineering Laboratory is not yet fully developed.

COURSE STRUCTURE

Course No.	Course Name	L	T	P	C
	Semester - 1				
DC xxx	***Core Course 1***: Structural Dynamics	3	0	0	9
DC xxx	***Core Course 2***: Theory of Elasticity and Plasticity	3	0	0	9
DC xxx	***Core Course 3*****: Numerical Methods** Numerical Methods in Civil Engineering	3	0	0	9
DC xxx	***Core Course 4***: Advanced Design of Structures	3	0	0	9
DE xxx	***Core Course 5:*** Theory of Elastic Stability	3	0	0	9
DC xxx	***Practical 1:*** Structures Laboratory - I	0	0	3	3
DC xxx	***Practical 2:*** Structures Laboratory - II	0	0	2	2
	Total	**15**	**0**	**5**	**50**

Course No.	Course Name	L	T	P	C
	Semester -2				
DE xxx	***Departmental Elective 1***	3	0	0	9
DE xxx	***Departmental Elective 2***	3	0	0	9
DE xxx	***Departmental Elective 3***	3	0	0	9
OE xxx	***Open Elective 1***	3	0	0	9
OE xxx	***Open Elective 2***	3	0	0	9
DC xxx	***Practical 3:*** CAD Laboratory	0	0	3	3
DC xxx	***Practical 4:*** Term Project	0	0	2	2
	Total	**15**	**0**	**5**	**50**

Course No.	Course Name	L	T	P	C
Semester - 3					
DC xxx	**Thesis Unit 1**	0	0	0	9
DC xxx	**Thesis Unit 2**	0	0	0	9
DC xxx	**Thesis Unit 3**	0	0	0	9
DC xxx	**Thesis Unit 4**	0	0	0	9
	Total	**0**	**0**	**0**	**36**

Course No.	Course Name	L	T	P	C
Semester - 4					
DC xxx	**Thesis Unit 5**	0	0	0	9
DC xxx	**Thesis Unit 6**	0	0	0	9
DE xxx/ OE xxx	***Departmental Elective 4/ Open Elective 3***	3	0	0	9
DE xxx/ OE xxx	***Departmental Elective 5/ Open Elective 4***	3	0	0	9
	Total	**0**	**0**	**0**	**36**

LIST OF DEPARTMENTAL CORE SUBJECTS FOR MONSOON SEMESTER

Course No.	Course Name	L	T	P	C
DC xxx	Structural Dynamics	3	0	0	9
DC xxx	Theory of Elasticity and Plasticity	3	0	0	9
DC xxx	Numerical Methods in Civil Engineering	3	0	0	9
DC xxx	Advanced Design of Structures	3	0	0	9
DC xxx	Theory of Elastic Stability	3	0	0	9

LIST OF DEPARTMENTAL PRACTICAL SUBJECTS FOR MONSOON SEMESTER

Course No.	Course Name	L	T	P	C
DC xxx	Structures Laboratory - I	0	0	3	3
DC xxx	Structures Laboratory - II	0	0	2	2

LIST OF DEPARTMENTAL ELECTIVE SUBJECTS FOR WINTER SEMESTER

Course No.	Course Name	L	T	P	C
DE xxx	Finite Element Method	3	0	0	9
DE xxx	Experimental Stress Analysis	3	0	0	9
DE xxx	Earthquake Resistant Design of Structures	3	0	0	9
DE xxx	Bridge Engineering	3	0	0	9
DE xxx	Soil-Structure Interaction	3	0	0	9
DE xxx	Prestressed Concrete Structures	3	0	0	9

LIST OF DEPARTMENTAL PRACTICAL SUBJECTS FOR WINTER SEMESTER

Course No.	Course Name	L	T	P	C
DC xxx	CAD Laboratory	0	0	3	3
DC xxx	Term Project	0	0	2	2

LIST OF OPEN ELECTIVE SUBJECTS FOR WINTER SEMESTER

Course No.	Course Name	L	T	P	C
OE xxx	Mechanics of Composite Materials	3	0	0	9
OE xxx	Theory of Plates and Shells	3	0	0	9

SYLLABI OF DEPARTMENTAL CORE SUBJECTS OF MONSOON SEMESTER

DC xxx	Structural Dynamics	3-0-0

Course Philosophy:

The design of civil engineering structures has come to almost saturated stage under dead load and live load. Well lead design guidelines are existing. However, the issue becomes far more complicated while coming to dynamic loading like earthquake, wind, blast etc. This course may aim to address the basics for dealing with such loads.

Learning Outcome:

Students get aware of Dynamic of a system and building up basic for Earthquake resistant design philosophy.

UNIT I: [**4L**]
Vibrations and the nature of time dependent phenomena, inertia, dynamic equilibrium and mathematical models of physical systems; Energy storing and dissipation mechanisms.

UNIT II: [**14L**]
Dynamics of Single Degree of Freedom Systems, undamped and damped, free and forced vibrations; Steady-state and transient response, impulse response. Harmonic response and applications to vibration isolation.

UNIT III: [**6L**]
Concept of Response spectrum, Tripartite Spectrum for analysis due to generalized support motion.

UNIT IV: [**8L**]
Modal Analysis; Eigen value problem; Mode Shape; Orthogonality of mode shape. Shear Building model.

UNIT V: [**8L**]
Approximate Methods for Vibration Analysis, Rayleigh quotient, Rayleigh Ritz method. Introduction to Random Vibration.

Recommended Text Books:

1. Chopra, A. K. “Dynamics of Structures”, PHI Learning.

Recommended References:

2. Clough, R. W. and Penzien., J., “Dynamics of Structures”, 2nd edition, Mc-Graw Hill Book Company.
3. Dutta, S. C. ,and Mukhopadhya, P.(2012).Improving earthquake and cyclone resistance of structures: Guidelines for the Indian subcontinent.
4. Paz, M. “Structural Dynamics Theory and Computation”
5. Craig, R. R., Jr. and Kurdila, A., “Fundamentals of Structural Dynamics”, 2nd edition, John Wiley & Sons.
6. Villaverde, R., “Fundamental Concepts of Earthquake Engineering”, Taylor & Francis.

DC xxx	Theory of Elasticity and Plasticity	3-0-0

Course Philosophy:

The primary focus of this course is on theoretical background for computational methods for the modelling and simulation of the response of engineering materials. The range of material behaviour considered includes: small deformation in flexure and torsion, finite deformation elasticity and inelasticity, linear elastic fracture

Learning Outcome:

After studying this course, students should be able to:

- formulate numerical approximations to the equations of motion governing the large, possibly dynamic, deformations of continua.
- explain constitutive theory and apply it to the formulation of appropriate models of finite elasticity, plasticity and linear-elastic fracture mechanics
- formulate the Principle of Virtual Displacements for deforming continua,
- understanding features of various constitutive material models

UNIT I: [**7 L**]

Formulation of boundary value problems in elasticity: Introduction to Tensor, Two dimensional problems in Cartesian and Polar co-ordinate systems, Generalized Hook's Law, Strain-displacement relations, stress - strain transformation, stress invariants, equilibrium and compatibility equations, boundary conditions.

UNIT II: [**10L**]

Solution of boundary value problems in elasticity: Plane stress and plane strain analysis, Saint-Venant's principle, application of Fourier series for two dimensional problems. Airy's stress function, Three dimensional stress and strain analysis, Problems in flexure of prismatic bars

UNIT III: [**10L**]

Energy principles: Variational formulation and variational constitutive updates

Torsion problem: Torsion of rectangular bars including hollow sections, Solution with St.Venant's approach and Prandtl's approach, membrane analogy, Torsion of thin walled open and closed sections

UNIT IV: [**12L**]

Introduction to Plasticity and Fracture Mechanics: Concepts and assumptions, Fundamental Equations of Plasticity, Graphical Representations, yield criterions, Plastic Flow and Plastic stress strain relationship, Elastic plastic problems in bending, Concepts of Energy Release Rate and Linear Elastic Fracture Mechanics

Text Books:

1. Sadd, M. H. Elasticity: theory, applications, and numerics. Academic Press
2. Chakrabarty, J. Theory of plasticity. Elsevier.

References:

3. Timoshenko, S., & Goodier, J. N. Theory of Elasticity McGraw-Hill Book Co. Inc., New York.
4. Srinath, L. S. Advanced Mechanics of Solids. TataMcGra-Hill
5. Malvern, L. E. Introduction to the Mechanics of a Continuous Medium. Prentice-Hall Inc., Englewood Cliffs, New Jersey.
6. Shames, I. H., & Pitarresi, J. M. Introduction to solid mechanics. Pearson College Division.
7. Simo, J. C., & Hughes, T. J. Computational inelasticity. Springer Science & Business Media.
8. Chen, W. F., & Han, D. J. Plasticity for structural engineers. J. Ross Publishing.

DC xxx	Numerical Methods in Civil Engineering	3-0-0

Course Philosophy:

This course deals with the solution procedures to linear and nonlinear systems, partial differential equations and integral equations.

Learning Outcome:

After studying this course, students should be able to:

- Comprehend the fundamental principles of estimating errors and solving linear and nonlinear systems, partial differential equations and integral equations.
- Learn the computer-based techniques to utilize numerical methods in civil engineering applications.

UNIT I: [**5L**]

Sources of Errors, Truncation Error, Round-off Error, Order of Accuracy, Taylor series expansion.

UNIT II: [**10L**]

Gauss Elimination, Gauss Jordan Elimination, Pivoting, Factorization, Cholesky Decomposition, Jacobi Iteration, Gauss Seidel Iteration, Newton Raphson Iterations, Newton Iterations, Quasi Newton Iterations, Convergence Criteria.

UNIT III: [**10L**]

First and Second Order Equations, Examples, Strong and Weak form of differential equations, Galerkin method, Interpolation Functions, Lagrange Polynomials, Numerical Quadrature, Numerical Stability.

UNIT IV: [**8L**]

Difference Operators, Stability and Accuracy of Solutions, Finite Difference Operatorsto solve Initial and Boundary Value Problems, Fredholm Integral Equations, Fredholm's Alternative theorem, Newmark's Method, Wilson-theta.

UNIT V: [**6L**]

Programming-based Application of Numerical Methods in Civil Engineering Case Studies.

Recommended Text Books:

1. G. Dahlquist and A. Bork, Numerical Methods, Prentice-Hall, Englewood Cliffs.

Recommended References:

2. S.C. Chhapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, McGraw Hill Education.
3. J.H. Mathews and K.D. Fink, Numerical Methods using MATLAB, Pearson Publishing.

DC xxx	Advanced Design of Structures	3-0-0

Course Philosophy:
Advanced analysis and design of various concrete and steel structures including flat slab, ribbed slab, deep beam, gantry girder and industrial truss will be focussed in this course. Further, serviceability criteria and vibration control will also be emphasized.

Learning Outcome:
After studying this course, students should be able to:

- Have exposure towards inelastic design of beams and slabs.
- To design of the structures like compression member under biaxial bending, deep beam, flat slab, industrial truss etc.
- Estimate the serviceability requirement and have idea for vibration control.

UNIT I: [**12L**]
Introduction: Recapitulate the basics of RCC design, Plastic hinge and plastic rotation for RC element under bending, Redistribution of moments and moment rotation characteristics of RC member, Design of Compression members under Biaxial Bending, Design of Slender Columns.

UNIT II: [**10L**]
Limit state of Serviceability: Limit state of Serviceability: Deflection, crack width estimation and vibration control for RC beam and slab.

UNIT III: [**5L**]
Design of slab and Yield Line Analysis: Design of Flat slabs and Ribbed slabs. Yield line analysis and design of square and circular slabs for different support conditions by virtual work and equilibrium methods.

UNIT IV: [**6L**]
Design of Deep Beams: Design and detailing of simply supported and continuous RC deep beams.

UNIT V: [**6L**]
Gantry girder and Industrial Truss: Design of plate girder and gantry girder, Design of industrial truss.

Recommended Text Books:

1. Pillai, S. U. and Menon, D. (2014). Reinforced Concrete Design, Third Edition, Mc Graw Hill.
2. Subramanian, N. (2016). Design of Steel Structures-Limit States Method, Oxford University Press.
3. Varghese, P. C. (2005). Advanced Reinforced Concrete Design. PHI.

Recommended References:

4. Park, R., Paulay, T. Reinforced concrete structures, John Wiley & Sons.
5. Subramanian, N. (2014). Design of Reinforced Concrete Structures, Oxford University Press.

DC xxx	Theory of Elastic Stability	3-0-0

Course Philosophy:
The primary focus of this course is to understand the concept and importance of stability along with derivation of governing equations and analysis of stability behaviour of different structural elements

Learning Outcome:
After studying this course, students should be able to:

- Understand the importance of stability behaviour in design of modern light weight structures.
- Derive the governing equations for different structures.
- Analyse the stability characteristics of different structural elements under both static and dynamic loadings.

UNIT I: [**8L**]
Introduction and Fundamental Principles, Mechanical Models of Stability.

UNIT II: [**12L**]
Elastic Stability of Column and Beam-Column, Energy Criterion and Energy Based Method, Lateral Buckling of Beams, Combined Bending and Torsion

UNIT III: [**9L**]
Elastic Stability of Frames and Arches, Torsional Buckling of Thin-Walled Structures and Open Sections

UNIT IV: [**5L**]
Buckling and Post-Buckling of Plates and Shells Parametric Resonance, Mathieu Equations, Dynamic Stability of Simply Supported Column.

UNIT V: [**5L**]
Numerical Modelling and Analysis using ABAQUS/ANSYS: Column and Plate

Text Books:
1. Simitses, G.J and Hodges, D.H. (2006). Fundamental of Structural Stability, Elsevier.

References:
2. Timoshenko, S.P. and Gere, J.M. (2012). Theory of Elastic Stability, 2nd Edition, McGraw Hill.
3. Bazant, Z.P. and Cedolin, L. (2010). Stability of Structures, World Scientific.

SYLLABI OF DEPARTMENTAL PRACTICAL SUBJECTS OF MONSOON SEMESTER

DC xxx	Structural Laboratory I	0-0-3

Course Philosophy:

To understand the concrete mix design, fresh, hardened, durability properties, Non-destructive testing of concrete and behavior of concrete structures.

Learning Outcome:

Developing knowledge on material to structural level behaviour of concrete structures

Experiment	
1. Determination of Basic Properties: Specific gravity of sand, coarse aggregate and cement; Sieve analysis	**[1P]**
2. Concrete Mix Design by IS Code	**[1P]**
3. Casting of Test Samples and Workability Tests	**[1P]**
4. Design, Casting and Testing of Under-Reinforced Concrete Beam	**[1P]**
5. Design, Casting and Testing of Over-Reinforced Concrete Beam	**[1P]**
6. Compressive, Split-tensile and Flexural Strength of testing samples	**[1P]**
7. Test for Determination of Static Modulus of Elasticity of Concrete	**[1P]**
8. Non-Destructive Test of Concrete – Rebound Hammer	**[1P]**
9. Non-Destructive Test of Concrete - Ultrasonic Pulse Velocity Test	**[1P]**
10. Rapid Chloride Permeability Test of Concrete	**[1P]**
11. Accelerated Corrosion Test of Reinforcing Bar in Concrete	**[1P]**
Revision and Evaluation	**[2P]**

DC xxx	**Structural Laboratory II**	**0-0-2**

Course Philosophy:

To understand the buckling, torsion and dynamic behaviour of metal structures

Learning Outcome:

Developing knowledge on stress, strain, resonance and resistance of metal structures

Experiments	
1. Buckling of Columns: Variables- Length, Support Types and Materials	**[3P]**
2. Torsion Test: Circular and Non-circular (Rectangular) section	**[2P]**
3. Stress Analysis by Electric Resistance Strain Gauges and Stress Concentration	**[1P]**
4. Dynamic Properties of Structures: SDOF and MDOF, Resonance, Beam, Frame	**[2P]**
5. Photo elastic Experimental Determination of Stress Field: Stress Contour and Principal Stress Trajectories	**[2P]**
6. Testing of Structural Steel Beam	**[1P]**
Revision and Evaluation	**[2P]**

SYLLABI OF DEPARTMENTAL ELECTIVE SUBJECTS OF WINTER SEMESTER

DE xxx	Finite Element Method	3-0-0

Course Philosophy:
The main focus of this course is to solve engineering problems using numerical method. This method is based on mathematical concepts for obtaining an approximate solution of ordinary and partial differential equations of physical systems. The problem type consists of 1-D element, 2-D element, plane stress and plane strain problems.

Learning Outcome:
After studying this course, students should be able to:

- Formulate and solve various engineering problems by finite element method.
- Solve free vibration and eigen value problems through finite element approach.
- Acquire knowledge upon various finite element software as well.

UNIT I: **[6L]**
Introduction to finite element method: Introduction, Basic Steps in FEM Formulation, General Applicability of the Method, Variational Formulation, Rayleigh-Ritz Method. Derivation of Elemental Equations, Assembly, Imposition of Boundary Conditions, Solution of the Equations.

UNIT II: **[5L]**
Shape function and co-ordinate system: Basis Functions and Shape Functions, Convergence Criteria, h and p Approximations. Natural Coordinates, Numerical Integration, Gauss Elimination based Solvers.

UNIT III: **[10L]**
Problem solving for different element: FEM solution technique for 1-D Element, 2-D Element, Sub-parametric, Iso-parametric and Super-parametric Elements; Elements with C1 Continuity.

UNIT IV: **[12L]**
Plane stress, plane strain problems and eigen value problem: Plane Stress and Plane Strain Problems, Axisymmetric Problem, Free Vibration Problems, Formulation of Eigen Value Problem, Plate bending.

UNIT V: **[6L]**
Computer application in solving engineering problems using FEM: Computer implementation: Pre-processor, Processor, Post-processor.

Recommended Text Books:
1. Bathe, K.J. (1982), Finite Element Procedures in Engineering Analysis. Prentice-Hall, Inc.

Recommended References:
2. Zienkiewicz, O.C. and Taylor, R.L. (1989), The Finite Element Method. Vols. 1 & 2, 4th Edition, McGraw-Hill Book Company.
3. Reddy, J.N. (2005), An Introduction to the Finite Element Method, Third Edition, McGraw-Hill Book Company.
4. Logan, D. L. (2007), A First Course in the Finite Element Method, Fourth Edition by Nelson, a division of Thomson Canada Limited.
5. Shrikhande, M. (2014), Finite Element Method and Computational Structural Dynamics, PHI.

DE xxx	Experimental Stress Analysis	3-0-0

Course Philosophy:
Various experimental techniques involved for measuring displacements, stresses, strains in structural components during infinitesimal deformation and crack formation

Learning Outcome:
After studying this course, students should be able to:

- Knowledge of stress and strain measurements in loaded components.
- Acquiring information about the usage of strain gauges and photo elastic techniques of measurement.
- Working knowledge about wave propagation due to transient point load

UNIT I: [**11L**]

Elementary Elasticity And Fracture Mechanics: Revisit To Statistical Application, Displacement field from strain field, Field equations, Stress distribution in thin infinite plate with circular/elliptical hole, Westergaard stress function, stress intensity factors, crack-tip plasticity and crack instability, plastic processing zone

UNIT II: [**13L**]

Strain Measurement Method: Definition of strain and its relation to Experimental Determinations, properties of strain-gauge systems, Types of strain gauges, Mechanical and Optical strain gauges. Electrical Strain Gauges.

Strain Rosettes: Introduction, The three element rectangular Rosette - The delta rosette - Corrections for Transverse strain effects.

Stress Wave Propagation In A Half Plane Due To A Point Load: Stress wave propagation in a half plane loaded at an interior point, multiple spark gap camera recording the dynamic fringe patterns, The formation and development of the reflected waves from free boundary, principal stresses from dynamic fringe patterns associated with purely dilatational/distortional waves

UNIT III: [**15L**]

Optical Method For Stress Analysis: Introduction to photoelasticity, Temporary double refraction - The stress optic law - Effects of stressed model in a Polaris cope for various arrangements - Fringe sharpening, Brewster stress optic law. Isochromatic Fringe patterns, passage of light through plane Polariscope and circular Polariscope, Isoclinic fringe pattern - Compensation techniques - calibration methods, separation methods, scaling Model to Proto type stress- Materials for photo - elasticity, properties of photo elastic materials

Recommended Text Books:

1. Dally, J. W., & Riley, W. F. Experimental stress analysis. McGraw-Hili Book Co. New York.

Recommended References:

2. Srinath, L.S., Raghava, M.R., Lingaiah, K., Garagesha, G., Pant B., and Ramachandra, K. Experimental Stress Analysis. Tata McGraw Hill.
3. Sharpe, W. N. (Ed.). Springer handbook of experimental solid mechanics. Springer Science & Business Media
4. Pollock A.A., Acoustic Emission *in* Acoustics and Vibration Progress, Ed. Stephens R.W.B., Chapman and Hall.
5. Max Mark Frocht. Photo Elasticity. John Wiley and Sons Inc, New York.
6. Ramesh, K. Digital photoelasticity. Springer, New York.

DE xxx	Earthquake Resistant Design of Structures	3-0-0

Course Philosophy:

The course deals with special provisions and requirements of structures for their safety against earthquake forces.

Learning Outcome:

Students get aware of Earthquake Resistant Design Philosophy and provide keen interest to do further research in this field.

UNIT I: [**6L**]

Concepts of Earthquake Resistant Design: Force based vs. displacement based design; performance based design, seismic input characteristics and their effect on seismic design, comparative study of different national codes.

UNIT II: [**8L**]

Modelling and Analysis of Structures as per Performance Based Design: Structural and non-structural performance, quantification of performance, performance evaluation of structures, performance levels and limit states, services and equipment.

UNIT III: [**6L**]

Nonlinear Static Analysis (Push over Analysis): Back-bone curve, Idealized component models, estimation and modelling of stiffness, strength and ductility of a structures.

UNIT IV: [**6L**]

Secondary Effects: P-Delta effects; Torsion; Capacity design for direct displacement based design

UNIT V: [**8L**]

Seismic Evaluation of Existing Structures: Vulnerability Assessment for Earthquake; Rapid Visual Screening (RVS); Simplified Vulnerability Assessment (SVA); Detailed Vulnerability Assessment (DVA).

UNIT VI: [**6L**]

Hydrodynamic effect on liquid container: Modelling and analysis of liquid container, hydrostatic and hydrodynamic effects, earthquake resistant provisions.

Recommended Text Books:

1. Paulay, T. and Priestley, M.J.N. "Seismic Design of Reinforced Concrete and Masonry Buildings," John Wiley & Sons.
2. M.J.N. Priestley, F. Seible, and G.M. Calvi, "Seismic Design and retrofit of Bridges," John Wiley & Sons

Recommended References:

3. Dutta, S.C., and Mukhopadhyay, P.(2012).Improving earthquake and cyclone resistance of structures: Guidelines for the Indian subcontinent.
4. George G. Penelis and Andreas J. Kappos, "Earthquake Resistant Concrete Structures," E & FN Spon.
5. Skinner, R., Robinson, W.H., McVerry,G.H., "An Introduction to Seismic Isolation", John Wiley and Sons.
6. FEMA-356, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings," Federal Emergency management Agency.
7. FEMA-450, "NEHRP Recommended provisions for Seismic Regulations for New Buildings and Other Structures," Federal Emergency management Agency.
8. Priestley, M.J.N., Calvi, G.M. and Kowalsky, M.J., "Displacement Based Seismic Design of Structures," IUSS Press.

DE xxx	Bridge Engineering	3-0-0

Course Philosophy:

This course deals with the modelling, analysis, design, detailing, construction, damage, failure, maintenance and rehabilitation of bridges.

Learning Outcome:

After studying this course, students should be able to:

- Comprehend the fundamental principles, load transfer mechanisms, design guidelines, failure mechanisms of bridges.
- Develop an in-depth knowledge of analysis and design of a wide variety of bridges.
- Understand field-based construction, inspection, maintenance, repair and rehabilitation techniques of bridges.
- Learn computer-based modelling, analysis and detailing of a wide variety of bridges.

UNIT I: [**7L**]

Construction Materials, Load Transfer Mechanisms, Bridge Components, Classification of Bridges, Ideal Sites for Bridges, Loads on Bridges, Indian, British and AASHTO Standards for Highway Bridge Loading, Indian Railway Bridge Loading Standard, Influence Line Diagrams of Bridges.

UNIT II: [**7L**]

Design and Detailing of Masonry Arch Bridges, Forces and Moments on Reinforced Concrete Arch Bridges under Primary and Secondary Loading, Pylons, Cable Stays, Cable Sag, Aero-dynamic Stability of Cable-stayed and Suspension Bridges, Arrangement of Spans and Supports of Balanced Cantilever Bridges.

UNIT III: [**7L**]

Effective Width Method and Pigeud's Coefficient Method, Control of Cracking and Deflection in Bridge Decks, Orthotropic Plate Theory, Courbon's Method, Guyon-Massonet Method and Hendry-Jaegar Method, Ultimate and Serviceability Limit State Design of Slab Bridge Decks and Tee Beam-Slab Bridge Decks, Voided Slab Deck Bridges, Skew and Curved Bridges, Analysis and Design of Box Culverts.

UNIT IV: [**7L**]

Types of Bearings, Design of Bearings, Expansion Joints, Bed Block, Cut and Ease Water, Stability of Piers and Abutments, Approaches, Wing Walls, Parapets, Types of Foundations, Differential Support Settlement.

UNIT V: [**12L**]

Cantilever Construction, Staging Method, Progressive Placement, Incremental Launching, Bridge Inspection, Inspection Instrumentation, Repair and Rehabilitation Techniques, Case Studies of Damage, Failure, Repair and Retrofit of Bridges, Prominent Bridges across the world, Grillage Analysis, Finite Element Analysis, Numerical Modeling and Analyses of Bridges under Static and Dynamic Loading, Computer-based Detailing of Bridge Components.

Recommended Text Books:

1. N. Krishna Raju, Design of Bridges, Oxford & IBH Publishing Co. Pvt. Ltd.

Recommended References:

2. D.J. Victor, Essentials of Bridge Engineering, Oxford & IBH Publishing Co. Pvt. Ltd.
3. T.R. Jagadeesh and M.A. Jayaram, Design of Bridge Structures, PHI Learning Pvt. Ltd.
4. W.F. Chen, and L. Duan, Bridge Engineering Handbook, CRC Press, Taylor & Francis Group.

DE xxx	Soil-Structure Interaction	3-0-0

Course Philosophy:

- To provide basic concepts of soil-structure interaction and develop understanding of effectively simulating the soil-structure interaction problems.

Learning Outcome:

- Understanding of coupled behaviour of soil and structure systems under static and dynamic loading.
- Capability of analyses of SSI problems for practical cases such as building, bridges, nuclear reactor structures etc.

Unit-I: Introduction **[3L]**

Objectives, Practical significance, Structures on soft ground, Consideration of unbounded media

Unit-II: Static SSI **[14L]**

Discrete model: Winkler, Pasternak, Filoneko-Borodich, Hetenyi, Kerr, Rhines; Continuum model: Vlazov, Reissner, Biots, Gorbunov and Posadov, Modeling of boundaries. Beams and plates resting on elastic foundation and subjected to various loading conditions.

Unit-III: Dynamic SSI **[12L]**

Rational methods of analysis of substructure, Equation of motion for flexible and rigid base, Kinematic interaction, Inertial interaction and Modeling of unbounded domain, Effect of embedment, Dynamic stiffness of Surface foundation, Embedded foundation, Shallow (strip) foundation and Deep foundations.

Unit-IV: Nonlinear SSI Problems **[6L]**

Material nonlinearity of soil, Geometrical nonlinearity, Nonlinear soil-pile structure interaction problems, Liquefaction in soil structure interaction problems.

Unit-V: Application of SSI **[4L]**

Engineering applications of dynamic soil-structure interaction: Shallow footing, Concrete gravity dam, Soil-pile-structure interaction problem.

Recommended Text Books:

1. Hetenyi, M. (1979). Beams on Elastic Foundation: Theory with Applications in the Fields of Civil and Mechanical Engineering, The University of Michigan Press.
2. Wolf, J.P. (1985).Dynamic Soil-Structure Interaction,1st Edition, Prentice Hall, USA.

Recommended References:

3. Chowdhury, I. and Dasgupta, S.P. (2008). Dynamics of Structure and Foundation: A Unified Approach, Vol. 1 and 2, CRC Press.
4. Selvadurai, A.P.S. (1979). Elastic Analysis of Soil-Foundation Interaction, Elsevier Science.

DE xxx	**Prestressed Concrete Structures**	**3-0-0**

Course Philosophy:

This course deals with the contemporary professional aspects in the analysis, design and construction of Prestressed Concrete Structures along with the basic understanding of theories.

Learning Outcome:

After studying this course, students should be able to:

- Understand the basic concept and behaviour of Prestressed Concrete Structures.
- Develop knowledge on field-based contemporary design examples.

UNITI: [**14L**]

Basic concepts of Prestressing, Early Attempts of Prestressing, Development of Building Materials, Applications, High Strength Concrete and High-Tensile Steel, Tensioning Devices, Pre-tensioning and Post-tensioning Systems, Latest Indian, Eurocode and American Code, Nature of Losses, Elastic Deformation, Friction, Anchorage Slip, Shrinkage and Creep of Concrete, Relaxation of Steel, Pressure Line, Kern Point, Load Balancing Concept, Flexural resistance of Rectangular and Flanged sections, Shear and Principal Stresses, Types of Shear Cracks, Ultimate Shear Resistance, Shear Reinforcements, Design Rules for Torsion.

UNIT II: [**14L**]

Transmission Length, Bond Stresses, Transverse Tensile Stresses, End-Zone Reinforcements, Stress Distribution in End Block, Anchorage Zone Stresses and Reinforcements, Design Philosophy, Types of Members, Short-Term Deflections of Uncracked Members, Long-Term Deflections, Crack Width in Prestressed members, Design of Sections for Flexure, Prestress-cast-in-situ composites, Continuous Beams, Secondary Moments, Concordant Tendon Profile, Prestressed Concrete One-way and Two-way Slabs.

UNIT III: [**10L**]

Prestressed Concrete Pole, Design of Pre-tensioned Mast, Types of Prestressed Sleepers, Design of Sleepers, Prestressed Concrete Reactor and Containment Vessels, Circular Prestressing, Prestressed Concrete Pipes, Prestressed Concrete Tanks, Tank Floors, Circumferential Wire Winding Methods, Design of Post-tensioned Slab Bridge Deck, Precast Technology

UNIT IV: [**4L**]

Structural Forms, Planning concepts with Practical Examples, Construction Techniques, Maintenance, Inspection and Rehabilitation, Notable Prestressed Concrete Structures in the World, Computer Modelling and Analysis of Prestressed Concrete Structures

Recommended Text Books:

1. N. Krishna Raju, Prestressed Concrete, McGraw Hill Education (India) Private Limited

Recommended References:

2. T Y Lin and H Burns, Design of Prestressed Concrete, John Wiley and Sons
3. Arthur H Nilson, Design of Prestressed Concrete, John Wiley and Sons
4. Edward G Nawy, Prestressed Concrete: A Fundamental Approach, Prentice Hall
5. P Dayaratnam and P Sarah, Prestressed Concrete Structures, MEDTECH A Division of Scientific International

SYLLABI OF DEPARTMENTAL PRACTICAL SUBJECT OF WINTER SEMESTER

DC xxx	CAD Laboratory	0-0-3

Course Philosophy:

To able to model and analyze different structural elements using MATLAB and ABAQUS/ANSYS subjected to different loading conditions.

Learning Outcome:

Students will be able to model and analyze different structural elements under various loading conditions.

Experiment	
1. **Introduction to MATLAB:** Introduction; M-files, Script and Functions; Operating with Matrices; Conditionals, if and switch; Loops: for and while; Graphics: 2D Plots, 3D Plots, Examples.	**[1P]**
2. **Discrete Systems:** Springs and Bars, Equilibrium at nodes, Examples	**[1P]**
3. **Analysis of Bars:** Bar Element, Numerical Integration, Examples	**[1P]**
4. **Analysis of 2D Trusses:** 2D Trusses, Stiffness Matrix, Stresses at the Elements, Examples	**[1P]**
5. **Analysis of Beams:** Introduction, Static Problem, Free Vibration Problem, Buckling Analysis	**[1P]**
6. **Analysis of 2D Frames:** Introduction, Problems of 2D Frames	**[1P]**
7. **Plane Stress Analysis:** Displacement, Strains and Stresses; Example: Plate in Traction, Example: Beam in Bending	**[1P]**
8. **Analysis of Plates:** Plate in Bending, Free Vibration of Plate, Buckling Analysis of Plate, Examples of Laminated Plates, Stiffness Matrices	**[1P]**
9. **Introduction to ABAQUS/ANSYS:** Introduction and Toolbox	**[1P]**
10. **Benchmark Example:** Bending and Free Vibration of Beams	**[1P]**
11. **Benchmark Example:** Bending and Free Vibration of Plates	**[1P]**
Revision and Evaluation	**[2P]**

Recommended Text Books:

1. Ferreira, A.J.M (2014). MATLAB Codes for Finite Element Analysis, Springer.
2. ABAQUS/ANSYS User Manuals

Recommended References:

3. Moore, H. (2007). MATLAB for Engineers, 4^{th} Edition, Pearson.

SYLLABI OF OPEN ELECTIVE SUBJECTS OF

WINTER SEMESTER

OE xxx	Theory of Plates and Shells	3-0-0

Course Philosophy:

To know the behavior of plates and shells for different loading and boundary conditions

Learning Objectives:

Development of computer programme for analyzing plates and shells subjected to different loading and boundary conditions

UNIT I: [**6L**]

Classification of plates based on structural actions, Internal forces in various types of plate element, state of stress in elastic bodies, strain and displacement relation, governing differential equation equilibrium, Differential equation for plates in Cartesian coordinate system. Differential equation of circular plates.

UNIT II: **[14L]**

Small deflection theory of thin rectangular plates, Derivation of governing differential equation for thin plates, Plates with different boundary conditions, Simply supported plate under sinusoidal load: Navier's solution, Application to different cases of boundary conditions, Levy's solution for various boundary conditions and subjected to different loadings like uniform and hydrostatic pressure.

UNIT III: **[10L]**

Plates on elastic foundations: Rectangular and continuous plates on elastic foundation, plate carrying rows of equidistant columns. Equilibrium method and energy method for stability analysis of plate.

UNIT IV: **[8L]**

Introduction to different shell theories, membrane theory of cylindrical shells, Bending theory of cylindrical shells, DKJ (Donnel-Karman-Jenkins) theory.

Recommended Text Books:

Timoshenko, Stephen P., and Sergius Woinowsky-Krieger. *Theory of plates and shells*. McGraw-hill, 1959.

Recommended References:

Szilard, Rudolph. *Theories and applications of plate analysis: classical, numerical and engineering methods*. John Wiley & Sons, 2004.

OE xxx	Mechanics of Composite Materials	3-0-0

Course Philosophy:

To know the analysis of laminated composite plates

Learning Outcome:

Development of computer programme for analyzing laminated composite plates

UNIT I: [**6 L**]

Composite Fundamentals, Classification and characteristics of composite materials, Constituent Materials for Composites, Manufacturing Processes. Micromechanical analysis of composite strength and stiffness.

UNIT II: **[10L]**

Elastic properties of unidirectional lamina, stress strain relationship, transformation of stress and strain, derivation of reduced stiffness matrix. Analysis of laminated composite, determination of lamina stresses and strains, coupling effects, All type of laminate configurations and its analysis. Computer program for finding stiffness matrix of multi layered laminate.

UNIT III: **[14L]**

Analysis of laminated plates: Classical laminate plate theory for bending of composite plate. Navier's method of solution for analysing composite plates. Shear deformation theory for laminated plate: First order, higher order theory. Free vibration and stability analysis of laminated plates. Development of matlab programme for analyzing laminated plates.

UNIT IV: **[08 L]**

Failure theories and strength of a unidirectional lamina, Micromechanics of failure of unidirectional lamina. Anisotropic strength and failure theories: maximum stress theory, strain theory, Tsai-Hill criteria, Tsai-Wu criteria, Analysis of laminate strength.

Recommended Text Books:

Jones, R. M. (2014). *Mechanics of composite materials*. CRC press.

Recommended References:

Mukhopadhyay, M. (2005). *Mechanics of composite materials and structures*. Universities press