SYLLABUS
M.Tech- STRUCTURAL ENGINEERING

ADVANCED DESIGN OF RC STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	19CSE11	**CIE**	50
Number of Lecture Hours/Week	04	**SEE**	50
Total Number of Lecture Hours	52	**Exam Hours**	03

CREDITS – 04

Course objectives:

The objective of this course is to make students to learn principles of Structural Design, To design different types of structures and to detail the structures. To evaluate performance of thestructures

Modules	Teaching Hours	RBT Level
Module -1		
Yield line method of design of slabs. Introduction, fundamental concepts of yield line theory, location of yield lines for standard cases, internal force in yield lines, methods of yield line by equilibrium approach, yield line analysis of one way and two way rectangular slab, circular slab and rectangular slab supported on three sides. Yield line design of one way and two way rectangular slab.	**11 Hours**	**L_1, L_2, L_3, L_4, L_5**
Module -2		
Design of grid floors andDesignof flat slabs. Introduction, analysis and design of grid floors by approximate method. Design of flat slab	**11 Hours**	**L_1, L_2, L_3, L_4, L_5**
Module -3		
Design of continuous beams with redistribution ofMoments Introduction, effective span and calculation of bending moment and shear force, redistribution of moments, design of continuous beam by limit state method, reinforcement detailing.	**10 Hours**	**L_1, L_2, L_3, L_4, L_5**
Module -4		
Design of silos, bunkers and chimneys.	**10 Hours**	**L_1, L_2, L_4, L_5**
Module -5		
Art of detailing earthquake resistant structures, general ductile detailing reinforcement, ductile detailing of beam column joint, expansion and contraction joints	**10 Hours**	**L_1, L_2**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of StructuralDesign
- Design and develop analyticalskills.
- Summarize the principles of Structural Designand detailing
- Understands the structuralperformance.

Question paper pattern:

- The question paper will have tenquestions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS:

1. N Krishna raju "Design of advance R C structure" CBS publication, New delhi
2. A.K.Jain "Limit state method of design neemchand and bros roorkee
3. Park and pandey "Reinforced concrete" john witney and bros
4. B.C Punmia , Ashokkumar and Jain A K Jain – "Limit state design of reinforced concrete" laxmi publication new delhi
5. V. Ram Krishnan and P.D Arthm "Ultimate strength design of structural concrete" Wheeler books Allahabad
6. IS 456-2000, SP-16

COMPUTATIONAL STRUCTURAL MECHANICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	19CSE12	**CIE**	50
Number of Lecture Hours/Week	04	**SEE**	50
Total Number of Lecture Hours	52	**Exam Hours**	03

CREDITS – 04

Course objectives:

The objective of this course is to make students to learn principles of Structural Analysis, To implement these principles through different methods andtoanalysevarioustypesofstructures.Toevaluatetheforceanddisplacement parameters of thestructures.

Modules	Teaching Hours	RBT Level
Module -1		
Fundamental concepts: Static and Kinematic indeterminacy, Concepts of stiffness and flexibility. Energy concepts. Principle of minimum potential energy and minimum complementary energy. Development of element flexibility and element stiffness matrices for truss, beam and gridelements.	**12 Hours**	**L_1, L_2, L_4, L_5**
Module -2		
Analysis using Flexibility method: Force- transformation matrix using Flexibility method, Development of global flexibility matrix for continuous beams, plane trusses and rigid plane frames (having not more than six co-ordinates – 8x8flexibility matrix) Analysis of continuous beams, plane trusses and rigid plane frames by flexibility method (Only 2D)	**10 Hours**	**L_1, L_2, L_3 L_4, L_5**
Module -3		
Analysis using Stiffness Method: Displacement- transformation matrix using Stiffness Method, Development of global stiffness matrix for continuous beams, plane trusses and rigid plane frames (having not more than six co-ordinates – 8x8 stiffness matrix) Analysis of continuous beams, plane trusses and rigid plane frames by stiffness method (Only 2D)	**10 Hours**	**L_1, L_2, L_3 L_4, L_5**
Module -4		
Effects of temperature change and lack of fit: Related numerical problems by flexibility and stiffness method as in Module 2 and 3	**10 Hours**	**L_1, L_2, L_3 L_4, L_5**

Module -5		
Solution techniques: Solution techniques including numerical problems for simultaneous equations, Gauss elimination and Cholesky method. Bandwidth minimization technique.	**10 Hours**	**L_1, L_2, L_4, L_5**

Course outcomes:

On completion of this course, students are ableto:

- Achieve Knowledge of design and development of problem solvingskills.
- Understand the principles of StructuralAnalysis
- Design and develop analyticalskills
- Summarize the Solutiontechniques
- Understand the concepts of structuralbehavior

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Rajasekaran, "**Computational Structural Mechanics**", PHI, New Delhi 2001.
2. F.W.Beaufait et al., "**Computer methods of Structural Analysis"**, Prentice Hall,1970.
3. W.Weaver and J.H.Gere, "**Matrix Analysis of Framed Structures"**, Van Nastran,1980.
4. H.KardeStuncer, "**Elementary Matrix Analysis of Structures"**, McGraw Hill1974.
5. A.K.Jain "**Advanced Structural Analysis with ComputerApplication"** Nemchand and Brothers, Roorkee, India.
6. M.F.Rubinstein "**Matrix Computer Methods of Structural Analysis**"Prentice – Hall.
7. C.S.Reddy "**Basic Structural Analysis**" Tata McGraw Hill – 1996
8. M.Mukhopadyaya "**Matrix Finite Element ,Compute and Strength Analysis**" OxFord& IBW – 1984.
9. G.S.Pandit & S.P.Gupta "**Structural Analysis A Matrix Approach"** TataMcGraw Hill – 1981

DESIGN OF MASONRY STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	19CSE 13	**CIE**	50
Number of Lecture Hours/Week	04	**SEE**	50
Total Number of Lecture Hours	52	**Exam Hours**	03

CREDITS – 04

Course objectives:
The objective of this course is to make students tolearn performance of masonry structures, To design the masonry structures for earthquake resistance. To evaluate the strength and stability of the masonrystructures.

Modules	Teaching Hours	RBT Level
Module -1		
Introduction, Masonry units, materials and types and masonry construction: History of masonry Characteristics of Brick, stone, clay block, concrete block, stabilized mud block masonry units – strength, modulus of elasticity and water absorption. Masonry materials – Classification and properties of mortars, selection ofmortars, defects and errors in masonry construction, cracks in masonry, types, reason for cracking.	**10 Hours**	**L_1, L_2**
Module -2		
Strength of Masonry in Compression: Behaviour of Masonry under compression, strength and elastic properties, influence of masonry unit and mortar characteristics, effect of masonry unit height on compressive strength, influence of masonry bonding patterns on strength, prediction of strength of masonry in Indian context, Failure theories of masonry under compression. Effects of slenderness and eccentricity, effect of rate of absorption, effect of curing, effect of ageing, workmanship on compressivestrength	**10 Hours**	**L_1, L_2, L_4**
Module -3		
Flexural and shear bond, flexural strength and shear strength: Bond between masonry unitand mortar, tests for determining flexural and shear bond strengths, factors affecting bond strength, effect of bond strength on compressive strength, orthotropic strength properties of masonry in flexure, shear strength of masonry, test procedures for evaluating flexural and shearstrength	**10 Hours**	**L_1, L_2, L_4**

Module -4		
Design of load bearing masonry buildings: Permissible compressive stress, stress reduction and shape reduction factors, increase in permissible stresses for eccentric vertical and lateral loads, permissible tensile and shear stresses, Effective height of walls and columns, opening in walls, effective length, effective thickness, slenderness ratio, eccentricity, load dispersion, arching action, lintels; Wall carrying axial load, eccentric load with different eccentricity ratios, wall with openings, freestanding wall; Design of load bearing masonry for buildings up to 3 to 8 storeys using BIS codal provisions, Applications of load bearing in masonry building	**12 Hours**	**L_1, L_2, L_3, L_4**
Module -5		
Earthquake resistant masonry buildings: Behaviour of masonry buildings during earthquakes, concepts and design procedure for earthquake resistant masonry, BIS codal provisions. Masonry arches, domes and vaults: Components and classification of masonry arches, domes and vaults, historical buildings, construction procedure	**10 Hours**	**L_1, L_2, L_4**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of design and construction of masonry structures
- Design and develop analyticalskills.
- Summarize the masonryCharacteristics.
- Evaluatethestrengthandstabilityofthemasonrystructures.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Hendry A.W., "Structural masonry"- Macmillan Education Ltd.,2nd edition
2. SinhaB.P&DavisS.R.,"DesignofMasonrystructures"-E&FNSpon
3. DayaratnamP,"BrickandReinforcedBrickStructures"-Oxford&IBH
4. Curtin,"DesignofReinforcedandPrestressedMasonry"-ThomasTelford
5. Sven Sahlin, "Structural Masonry"-PrenticeHall
6. Jagadish K S, Venkatarama Reddy B V and Nanjunda Rao K S, "Alternative Building Materials and Technologies"-New Age International, New Delhi &Bangalore
7. IS 1905, BIS, NewDelhi.
8. SP20(S&T),NewDelhi

STRUCTURAL DYNAMICS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	19CSE14	**CIE**	50
Number of Lecture Hours/Week	04	**SEE**	50
Total Number of Lecture Hours	52	**Exam Hours**	03

CREDITS – 04

Course objectives:
The objective of this course is to make students to learn principles of Structural Dynamics, To implement these principles through different methods and to apply the same for free and forced vibration of structures. To evaluate the dynamic characteristics of thestructures

Modules	Teaching Hours	RBT Level
Module -1		
Introduction: Introduction to Dynamic problems in Civil Engineering, Concept of degrees of freedom, D'Alembert'sprinciple, principle of virtual displacement and energy principles Dynamics of Single degree-of-freedom systems: Mathematical models of Single-degree-of-freedom systems system, Free vibration response of damped and undamped systems.	**12 Hours**	**L_1, L_2, L_5**
Module -2		
Response of Single-degree-of-freedom systems to harmonic loading (rotation unbalance, reciprocating unbalance) including support motion, vibration isolation, transmissibility, Numerical methods applied to Single-degree-of-freedom systems – Duhamel integral,	**10 Hours**	**L_3, L_4, L_5**
Module -3		
Two degrees of freedom system: free and forced vibration of undamped freedom system, viscous damping in free vibration, co-ordinate coupling, vibration absorber of two-degree of freedom system.Forced vibration of damped two degrees of freedom system.	**10 Hours**	**L_1, L_2, L_4, L_5**
Module -4		

Dynamics of Multi-degree freedom systems: multi-degree-of-freedom systems, Shear building concept, free vibration of undamped multi-degree-of-freedom systems – Natural frequencies and mode shapes – orthogonalitypropertyof modes.	**10 Hours**	**L_3, L_4, L_5**
Module -5		
Approximate methods: Rayleigh's method Dunkarley's method, Stodola's method. Dynamics of Continuous systems: Free longitudinal vibration of bars, flexural vibration of beams with different end conditions, lumped mass and consistence mass system.	**10 Hours**	**L_2, L_4**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of StructuralDynamics
- Design and develop analyticalskills.
- Summarize the Solution techniques for dynamics of Multi-degree freedom systems
- Understand the concepts of damping instructures.

Question paper pattern:

- The question paper will have tenquestions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four subquestions) from eachmodule.
- Each full question will have sub questions covering all the topics under a module.
- Thestudentswillhavetoanswer5fullquestions,selectingonefull question from each module.

REFERENCE BOOKS:

- Dynamics of Structures – Theory andApplication to Earthquake Engineering"- 2nd ed., Anil K.Chopra, PearsonEducation.
- Earthquake Resistant Design of Building Structures, Vinod Hosur, WILEY(india)
- Vibrations, structural dynamics- M. Mukhopadhaya:OxfordIBH publishing co-pvt.ltd. New Delhi.
- Structural Dynamics- Mario Paz: CBSpublishers.
- Structural Dynamics- Clough &Penzien:TMH
- Vibration Problems in Engineering Timoshenko, S, Van-NostrandCo

ADVANCED DESIGN OF PRE-STRESSED CONCRETE STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	19CSE151	**CIE**	50
Number of Lecture Hours/Week	03	**SEE**	50
Total Number of Lecture Hours	40	**Exam Hours**	03

CREDITS – 03

Course objectives: This course will enable students to

1. Design pre-stressedelements
2. Understand the behavior of pre-stressedelements.
3. Understand the behavior of pre-stressedsections

Modules	Teaching Hours
Module -1	
Losses of Prestress:general concepts of stress, pre-tensioning system, post tensioning system, resultant compressive line, load bearing concepts Loss of prestress in pre-tensioned and post- tensioned members due to various causes like elastic shortening of concrete, shrinkage of concrete, creep of concrete, relaxation of steel, slip in anchorage, bending of member and frictional loss – Analysis of sections under axial load and for flexure.	**8 Hours**
Module -2	
Design of Section for Flexure: Allowable stresses, Elastic design of simple beams having rectangular and I-section for flexure, kern lines, cable profile and cablelayout. **Design of Sections for Shear**: Shear and Principal stresses, Improving shear resistance by different prestressing techniques- horizontal, sloping and vertical prestressing, Analysis of rectangular and I–beam, Design of shear reinforcement,Indian code provisions.	**8 Hours**
Module -3	
Deflections of Prestressed Concrete Beams: Short term deflections of uncracked members, Prediction of long-term deflections, load–deflection curve for a PSC beam, IS code requirements for maximumdeflections.	**8 Hours**
Module -4	
Transfer of Prestress in Pretensioned Members : Transmission of prestressing force by bond, Transmission length, Flexural bond stresses,IScodeprovisions,Anchoragezonestressesinpost tensioned members, stress distribution in End block, Anchorage zone reinforcements.	**8 Hours**
Module -5	
Statically Indeterminate Structures: Advantages and disadvantages of continuous PSC beams, Primary and secondary moments,PandClines,Lineartransformation,concordantand non-concordant cable profiles, Analysis of continuous beams.	**8 Hours**

Course outcomes:

After studying this course, students will be able to:

- Analyse , Design and detail PSCelements

Question paper pattern:

- The question paper will have Ten questions, each full question carrying 10marks.
- There will be two full questions (with a maximum Three sub divisions, if necessary) from eachmodule.
- Each full question shall cover the topics under amodule.
- The students shall answer Five full questions selecting one full question from each module.
- Ifmorethanonequestionisansweredinmodules,bestanswerwillbeconsidered for the award of marks limiting one full question answer in each module.

REFERENCE BOOKS:

1. Sadhu Singh.L.S.,AdvancedMechanicsofSolids,TataMcGraw-HillPublishingColtd.,New Delhi
1. Krishna Raju, "Prestressed concrete", Tata McGraw Hill Book – Co ., NewDelhi.
2. T.Y. Lin and Burn, "Design of prestress concrete structures", John Wiley, NewYork.
3. S. Ramamrutham, "Prestressed concrete", DhanpatRai& Sons,Delhi.
4. IS1343-2007

SPECIAL CONCRETE

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	19CSE152	**CIE**	50
Number of Lecture Hours/Week	03	**SEE**	50
Total Number of Lecture Hours	40	**Exam Hours**	03

CREDITS – 03

Course objectives:

The objective of this course is to make students to learn principles of Concrete mix design, To differentiate between different types of concrete. To characterize the high Performanceconcrete.

Modules	Teaching Hours	RBT Level
Module -1		
Components of modern concrete and developments in the process and constituent materials: Role of constituents, Development incements and cement replacement materials, pozzolona, fly ash, silica fume, rice husk ash, recycled aggregates, chemical admixtures. Mix proportioning of Concrete: Principles andmethods.	**8 Hours**	**L_1, L_2, L_5**
Module -2		
Light Weight concrete: Introduction, classification, properties, strength and durability, mix proportioning and problems. High density concrete: Radiation shielding ability of concrete, materials for high density concrete, mix proportioning, properties in fresh and hardened state, placementmethods.	**8 Hours**	**L_1, L_2**
Module -3		
Ferro cement: Ferrocement materials, mechanical properties, cracking of ferrocement, strength and behaviour in tension, compression and flexure, ferrocement constructions, durability, andapplications. Self Compacting Concrete, Reactive powder concrete, and bacterialconcrete	**8 Hours**	**L_1, L_2, L_5**
Module -4		
Fibre reinforced concrete: Fibre materials, mix proportioning, distribution and orientation, interfacial bond, properties in fresh state, strength and behavior in tension, compression and flexure of steel fibre reinforced concrete, mechanicalproperties, crack arrest and toughening mechanism,applications.	**8 Hours**	**L_1, L_2, L_5**

Module -5		
High Performance concrete: constituents, mix proportioning, properties in fresh and hardened states, applications and limitations. Ready Mixed Concrete-QCI-RMCPC scheme requirements.	**8 Hours**	**L_1, L_2**

Course outcomes:

On completion of this course, students are ableto:

- Achieve Knowledge of design and development of problem solvingskills.
- Understand the principles of Concrete mixdesign
- Design and develop analyticalskills.
- Summarize the Light Weight concrete, Fibre reinforced concrete and High Performanceconcrete
- Understand the concepts of high Performanceconcrete

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCES:

1. Neville A.M, "Properties of Concrete" Pearson Education Asia,2000
2. P. Kumar Mehta, Paul J.N. Monterio, CONCRETE:Microstructure, Properties and Materials", Tata McGrawHill
3. A.R.Santhakumar, (2007) "Concrete Technology"-Oxford University Press, New Delhi,2007
4. Gambhir "Concrete Technology"TMH.
5. Short A and Kinniburgh.W, "Light Weight Concrete"- Asia Publishing House,1983
6. Aitcin P.C. "High Performance Concrete"-E and FN, Spon London1998
7. Rixom.R. and Mailvaganam.N., "Chemical admixtures in concrete"- E and FN, Spon London1999
8. Rudnai.G.,"LightWeightconcrete"-Akademiaikiado,Budapest,1983
9. http://qcin.org/CAS/RMCPC/

DESIGN OF PRECAST AND COMPOSITE STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	19CSE153	**CIE**	50
Number of Lecture Hours/Week	03	**SEE**	50
Total Number of Lecture Hours	40	**Exam Hours**	03

CREDITS – 03

Course objectives: This course will enable students to

1. Understand the concepts and techniques of precast construction and Select or design precast elements suitable for project specific requirements
2. Design precast systems to ensure integrity and safety of the structure and to avoid progressive collapse and Design composite floors and beam elements

Modules	Teaching Hours
Module -1	
Concepts , components, Structural Systems and Design of precast concrete floors Need and types of precast construction, Modular coordination, Precast elements- Floor, Beams, Columns and walls. Structural Systems and connections. **Design of precast Concrete Floors:**Theoretical andDesign Examples of Hollow core slabs,. Precast Concrete Planks, floor with composite toppings with and without props.	**8 Hours**
Module -2	
Design of precast reinforced and prestressed Concrete beams Theoretical andDesignExamples of ITB – Full section precast, SemiPrecast,proppedandunproppedconditions.DesignofRC Nibs	**8 Hours**
Module -3	
Design of precast concrete columns and walls Design of braced and unbraced columns with corbels subjected to pattern and full loading. Design of Corbels Design of RC walls subjected to Vertical, Horizontal loadsand moments, Design of vertical ties and horizontal joints.	**8 Hours**
Module -4	
Design of Precast Connections and Structural Integrity Beam bearing, Beam half Joint,Steel Inserts, Socket Connection, Structural integrity, Avoidance of progressive collapse, Design of Structural Ties.	**8 Hours**
Module -5	

Design of Steel Concrete Composite Floors and Beams Composite Floors: Profiled Sheeting with concrete topping, Design method, Bending and Shear Resistance of Composite Slabs, Serviceability Criteria, DesignExample	**8 Hours**
Composite Beams: Elastic Behaviour, Ultimate Load behavior of Composite beams, Stresses and deflection in service and vibration, Design Example of Simply Supported beams.	

Course outcomes:

After studying this course, students will be able to:

Graduate Attributes (as per NBA)

Question paper pattern:

- The question paper will have Ten questions, each full question carrying 10marks.
- There will be two full questions (with a maximum Three sub divisions, if necessary) from eachmodule.
- Each full question shall cover the topics under amodule.
- The students shall answer Five full questions selecting one full question from eachmodule.
- If more than one question is answered in modules, best answer will be considered for the award of marks limiting one full question answer in eachmodule.

REFERENCES:

1. Hass A.M. – Precast Concrete – Design and applications Applied Science,1983.
2. David Sheppard – "Plant cast, Precast and Prestressed concrete– McGraw Hill;1989
3. NBC – 2005 (Part I to Part VII) BIS Publications, New Delhi, IS 15910- 2011,IS 11447,IS5241 – I andIII
4. R.P.Johnson: Composite Structure of Steel and Concrete (Volume 1), Blackwell Scientific Publication (Second Edition), U.K.,1994.
5. IS: 11384-1985, Code of Practice for Composite Construction in Structural Steel andConcrete.
6. INSDAG Teaching Resource Chapter 21 to 27:www.steel-insdag.org

RELIABILITY ANALYSIS OF STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	19CSE154	**CIE**	50
Number of Lecture Hours/Week	03	**SEE**	50
Total Number of Lecture Hours	40	**Exam Hours**	03

CREDITS – 03

Course objectives:

The objective of this courseis to make students to learn principles of reliability, To implement the Probability Concepts for the ReliabilityAnalysis.
To evaluate different methods of reliability analysis.

Modules	Teaching Hours	RBT Level
Module -1		
Preliminary Data Analysis: Graphical representation- Histogram, frequency polygon, Measures of central tendency- grouped and ungrouped data, measures of dispersion, measures of asymmetry. Curve fitting and Correlation: Fitting a straight line, curve of the form $y = ab^x$, and parabola, Coefficient ofcorrelation.	**8 Hours**	**L_1, L_2, L_3, L_4**
Module -2		
Probability Concepts: Random events-Sample space and events, Venn diagram and event space, Measures of probability-interpretation, probability axioms, addition rule, multiplication rule, conditional probability, probability tree diagram, statistical independence, total probability theorem and Baye's theorem	**8 Hours**	**L_1, L_2, L_4**
Module -3		
Random variables: Probability mass function, probability density function, Mathematical expectation, Chebyshev'stheorem. Probability distributions: Discrete distributions- Binomial and poison distributions, Continuousdistributions- Normal, Log normal distributions.	**8 Hours**	**L_1, L_2, L_4**
Module -4		
Reliability Analysis: Measures of reliability-factor of safety, safety margin, reliability index, performance function and limiting state. Reliability Methods-First Order Second Moment Method (FOSM), Point Estimate Method (PEM), and Advanced First Order Second Moment Method (Hasofer-Lind'smethod)	**8 Hours**	**L_1, L_2, L_3, L_4**
Module -5		

System reliability: Influence of correlation coefficient, redundant and non-redundant systems- series, parallel and combined systems, Uncertainty in reliability assessments- Confidence limits, Bayesian revision of reliability. Simulation Techniques: Monte Carlo simulation- Statistical experiments, sample size and accuracy, Generation of randomnumbers- random numbers with standard uniform distribution, continuous random variables, discrete random variables	**8 Hours**	**L_1, L_2, L_4**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles ofreliability.
- Design and develop analyticalskills.
- Summarize the Probabilitydistributions
- Understands the concept of Systemreliability.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Ranganathan, R. (1999). "Structural Reliability Analysis and design"- Jaico publishing house, Mumbai,India.
2. Ang, A. H. S., and Tang, W. H. (1984). "Probability concepts in engineering planninganddesign"-Volume–I,JohnWileyandsons,Inc,NewYork.
3. Ang, A. H. S., and Tang, W. H. (1984). "Probability concepts in engineering planning and design"-Volume –II, John Wiley and sons, Inc, NewYork.
4. Milton, E. Harr(1987). "Reliability based design in civil engineering"- McGraw Hill bookCo.
5. Nathabdndu, T., Kottegoda, and Renzo Rosso(1998). Statistics, "Probability and reliability for Civil and Environmental Engineers"- McGraw Hill international edition,Singapore.
6. AchintyaHaldarand SankaranMahadevan(2000). "Probability, Reliability and Statistical methods in Engineering design"- John Wiley and Sons.Inc.
7. Thoft-christensen, P., and Baker, M., J., (1982), "Structural reliability theory and its applications"- Springer-Verlag, Berlin,NewYork.
8. Thoft-christensen, P., and Murotsu, Y. (1988). "Application of structural systems reliability theory"- Springer-Verlag, Berlin,NewYork

DISASTER MITIGATIONANDMANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	19CSE155	**CIE**	50
Number of Lecture Hours/Week	03	**SEE**	50
Total Number of Lecture Hours	40	**Exam Hours**	03

CREDITS – 03

Course objectives:

- To introduce various environmental hazards anddisasters.
- To understand various concepts, principles to manage disaster.
- Toappraisevariousenvironmentalpoliciesandprogramsin Indiafordisaster management.

Modules	Teaching Hours	RBT Level
Module -1		
Environmentalhazards,EnvironmentalDisastersandEnvironmentalstress-Meaning and concepts. Vulnerability and disasterpreparedness.	**8 Hours**	**L_1, L_2, L_3, L_4**
Module -2		
NaturalhazardsandDisasters-VolcanicEruption,Earthquakes,Tsunamis, Landslides,Cyclones,Lightning,Hailstorms,Floods,Droughts,Coldwaves, Heat waves andFire. Man induced hazards & Disasters - Soil Erosion, Chemical hazards, Population Explosion.	**8 Hours**	**L_1, L_2, L_4**
Module -3		
EmergingapproachesinDisasterManagement-Preparinghazardzonation maps,Predictability/forecasting&warning,Preparingdisasterpreparedness plan, Land use zoning,Communication. Disaster resistant house construction, Population reduction in vulnerable areas, Awareness Rescue training for search & operation at national & regionallevelImmediaterelief,Assessmentsurveys,PoliticalAdministrative Aspect, Social Aspect, Economic Aspect, Environmental Aspect.	**8 Hours**	**L_1, L_2, L_4**
Module -4		
ProvisionofImmediatereliefmeasurestodisasteraffectedpeople,Prediction of Hazards & Disasters, Measures of adjustment to naturalhazards.	**8 Hours**	**L_1, L_2, L_3, L_4**
Module -5		

A regional survey of Land Subsidence, Coastal Disaster,Cyclonic Disaster & Disaster in Hills with particular reference to India. Ecological planningfor sustainability&sustainabledevelopmentinIndia, Sustainablerural development: A Remedy to Disasters, Role of Panchayats in Disaster mitigations, Environmental policies &programmes in India- Institutions & NationalCentersforNaturalDisasterreduction,EnvironmentalLegislations in India, Awareness, Conservation Movement, Education &training.	**8 Hours**	**L_1, L_2, L_4**

Course outcomes:*On completion of this course, students are ableto:*

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the environmental hazards anddisasters.
- Design and develop analyticalskills.
- To understand various concepts, principles to manage disaster.
- Toappraisevariousenvironmentalpoliciesandprogramsin Indiafordisaster management.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. R.B.Singh (Ed), Environmental Geography, Heritage Publishers New Delhi,1990.
2. Savinder Singh, Environmental Geography, PrayagPustakBhawan,1997.
3. Kates,B.I& White, G.F., The Environment as Hazards, Oxford, New York, 1978.
4. R.B.Singh(Ed),DisasterManagement,RawatPublication,NewDelhi,2000.
5. H.K. Gupta (Ed), Disaster Management, University Press, India,2003.
6. R.B. Singh, Space Technology for Disaster Mitigation in India (INCED), University of Tokyo,1994
7. Dr.Satender, Disaster Management in Hills, Concept Publishing Co.,New Delhi,2003.
8. R.K. Bhandani, An overview on Natural &Man made Disaster & their Reduction, CSIR, NewDelhi.
9. M.C. Gupta, Manuals on Natural Disaster management in India, National Centre for Disaster Management, IIPA, New Delhi,2001.

STRUCTURAL ANAYSIS AND DESIGN LAB-I

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	19CSEL16	**CIE**	50
Number of Lecture Hours/Week	03	**SEE**	50
Total Number of Lecture Hours	42	**Exam Hours**	03

CREDITS – 02

Course objectives:
The objective of this course is to make students to learn principles of design of experiments, To investigate the performance of structural elements. To evaluate the different testing methods andequipments.

Modules	Teaching Hours	RBT Level
1. Static and Dynamic analysis and design of Multistory Building structures using software(ETABS / STAADPRO) 2. Preparation of EXCEL sheets for structuraldesign.	**42**	**L_1, L_2, L_3, L_4**

Course outcomes:
On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofexperimentingskills.
- Understand the principles of design ofexperiments
- Design and develop analyticalskills.
- Summarize the testing methods andequipments.

ADVANCED DESIGN OF STEEL STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	19CSE21	IA Marks	50
Numberof Lecture Hours/Week	04	Exam Marks	50
Total Number of Lecture Hours	52	Exam Hours	03

CREDITS – 03

Course objectives: This course will enable students to

1. Understand the background to the design provisions for hot-rolled and cold-formed steel structures, including the main differences between them.
2. Proficiency in applying the provisions for design of columns,beams, beam-columns
3. Design structural sections for adequate fireresistance

Modules	**Teaching Hours**
Module -1	
Laterally Unrestrained Beams: Lateral Buckling of Beams, Factors affecting lateral stability, IS 800 code provisions, Design Approach. Lateral buckling strength of Cantilever beams, continuous beams, beams with continuous and discretelateralrestraints,Mono-symmetricandnon-uniform beams – Design Examples. Concepts of -Shear Center, Warping, Uniform and Non-Uniform torsion.	**12 Hours**
Module -2	
Beam- Columns in Frames: Behaviour of Short and Long Beam - Columns, Effects of Slenderness Ratio and Axial Force on Modes of Failure, Biaxial bending, Strength of Beam Columns, Sway and Non-Sway Frames, Strength and Stability of rigid jointed frames, Effective Length of Columns-, Methods in IS 800 – Examples	**10 Hours**
Module -3	
Steel Beams with Web Openings: Shape of the web openings, practical guide lines, and Force distribution and failure patterns, Analysis of beams with perforated thin and thick webs, Design of laterally restrained castellated beams for given sectional properties, Vierendeel girders (design for given analysis results)	**10 Hours**

Module -4	
Cold formed steel sections: Techniques and properties, Advantages, Typical profiles, Stiffened and unstiffened elements, Local buckling effects, effective section properties, IS 801&811 code provisions- numerical examples, beam design, column design.	**10 Hours**
Module -5	
Fire resistance: Fire resistance level, Period of Structural Adequacy, Properties of steel with temperature, Limiting Steel temperature, Protected and unprotected members, Methods of fire protection, Fire resistance ratings- Numerical Examples.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

Graduate Attributes (as per NBA)

Question paper pattern:

- The question paper will have Ten questions, each full question carrying 10 marks.
- There will be two full questions (with a maximum Three sub divisions, if necessary) from eachmodule.
- Each full question shall cover the topics under amodule.
- The students shall answer Five full questions selecting one full question from eachmodule.
- If more than one question is answered in modules, best answer will be considered for the award of marks limiting one full question answer in each module.

REFERENCE BOOKS:

1. N. Subramanian, “Design of Steel Structures”, Oxford,IBH
2. Duggal S.K, “Design of Steel Structures” TataMcGraw-Hill 3. IS 1031, 1032,1033
3. IS 800: 2007,
4. IS 811
5. INSDAG Teaching Resource Chapter 11 to 20:www.steel-insdag.org

THEORY OF PLATES AND SHELLS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	19CSE 22	IA Marks	50
Number of Lecture Hours/Week	03	Exam Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

The objective of this course is to make students to learn different methods of analysis and design of plates and shells, To critically detail the plates, folded plates and shells. To evaluate the performance of spatial structures.

Modules	Teaching Hours	RBT Level
Module -1		
Introduction to plate theory, Small deflectionof laterally loaded thin rectangular plates for pure bending. Navier'sand Levy's solution for various lateral loading and boundary conditions (No derivation), Numericalexamples.	**8 Hours**	**L_1, L_2**
Module -2		
Energy methods for rectangular and circular plates with clamped edges subjected to symmetric loadings.	**8 Hours**	**L_2, L_3**
Module -3		
Introduction to curved surfaces and classification of shells, Membrane theory of spherical shells, cylindrical shells, hyperbolic paraboloids, elliptic paraboloidandconoids	**8 Hours**	**L_2, L_3**
Module -4		
Axially symmetric bending of shells of revolution, Closed cylindrical shells, water tanks, spherical shells and Geckler's approximation. Bending theory of doubly curved shallowshells.	**8 Hours**	**L_2, L_3**

Module -5		
Design and detailing of folded plates with numerical examples Design and Detailing of simple shell problems – spherical domes, water tanks, barrel vaults and hyperbolic paraboloidroofs	**8 Hours**	**L_2, L_3, L_4**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of Analysis andDesign
- Design and develop analyticalskills.
- Summarize the performance ofshells
- Understand the concepts of energyprinciple.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Timoshenko, S. and Woinowsky-Krieger, W., "Theory of Plates and Shells" 2nd Edition, McGraw-Hill Co., New York,1959
2. Ramaswamy G.S. – "Design and Constructions of Concrete Shell Roofs" – CBS Publishers and Distributors – New Delhi –1988.
3. Ugural, A. C. "Stresses in Plates and Shells", 2nd edition, McGraw-Hill,1999.
4. R. Szilard, "Theory and analysis of plates - classical and numerical methods", PrenticeHall,1994
5. Chatterjee.B.K. – "Theory and Design of Concrete Shell", – Chapman & Hall, New York-third edition,1988

FINITE ELEMENT METHOD OF ANALYSIS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	19CSE23	IA Marks	50
Number of Lecture Hours/Week	04	Exam Marks	50
Total Number of Lecture Hours	52	Exam Hours	03

CREDITS – 03

Course objectives:

The objective of this course is to make students to learn principles of Analysis of Stress and Strain, To apply the Finite Element Method for the analysis of one and two dimensional problems. To evaluate the stress and strain parameters and their inter relations of thecontinuum.

Modules	Teaching Hours	RBT Level
Module -1		
Basic concepts of elasticity – Kinematic and Static variables for various types of structural problems – approximate method of structural analysis – Rayleigh – Ritz method – Finite difference method – Finite element method. Variation method and minimization of Energy approach of element formulation. Principles of finite element method – advantages &disadvantages – Finite element procedure. Finite elements used for one, two & three dimensional problems – Element aspect ratio – mesh refinement vs. higher order elements – Numbering of nodes to minimize bandwidth.	**12 Hours**	**L_1, L_2**
Module -2		
Nodal displacement parameters – Convergence criterion – Compatibility requirements – Geometric invariance – Shape function – Polynomial form of displacement function. Generalized and Natural coordinates – Lagrangianinterpolation function – shape functions for one, two & three dimensional elements.	**10 Hours**	**L_1, L_2, L_4, L_5**
Module -3		
Isoparametric elements, Internal nodes and higher order elements, Serendipity and Lagrangianfamily of Finite Elements, Sub-parametric and Super- parametric elements, Condensation of internal nodes, Jacobian transformation Matrix. Development of strain-displacement matrix and stiffness matrix, consistent load vector, numericalintegration.	**10 Hours**	**L_1, L_2, L_4, L_5**
Module -4		
Application of Finite Element Method for the analysis of one & two dimensional problems, Analysis of simple beams and plane trusses, Application to planestress / strain / axisymmetric problems using CST & Quadrilateral Elements	**10 Hours**	**L_1, L_2, L_3, L_4, L_5**

Module -5		
Application to Plates & Shells, Choice of displacement function (C^0, C^1 and C^2 type), Techniques for Non – linear Analysis.	**10 Hours**	**L_1, L_2**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of stress-strain behaviour ofcontinuum
- Design and develop analyticalskills.
- Describe the state of stress in acontinuum
- Understand the concepts of elasticity andplasticity.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. KrishnamoorthyCS,"FiniteElementAnalysis"-TataMcGrawHill
2. Desai C and Abel J F, "Introduction to the Finite Element Method"- East West Press Pvt. Ltd.,1972
3. Bathe K J, "Finite Element Procedures in Engineering Analysis"- Prentice Hall
4. Rajasekaran. S, "Finite Element Analysis in Engineering Design"-Wheeler Publishing
5. Cook R D, Malkan D S &Plesta M.E, "Concepts and Application of Finite Element Analysis" - 3rd Edition, John Wiley and Sons Inc.,1989
6. ShamesIHandDymCJ,"EnergyandFiniteElementMethodsin Structural Mechanics"- McGraw Hill, New York, 1985

EARTHQUAKE RESISTANT STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	19CSE24	IA Marks	50
Number of Lecture Hours/Week	04	Exam Marks	50
Total Number of Lecture Hours	52	Exam Hours	03

CREDITS – 03

Course objectives:

The objective of this course is to make students to learn principles of engineering seismology, To design the reinforced concrete buildings for earthquakeresistance.Toevaluatetheseismicresponseofthestructures

Modules	Teaching Hours	RBT Level
Module -1		
Introduction to engineering seismology, Geological and tectonic features of India, Origin and propagation of seismic waves, characteristics of earthquake and its quantification – Magnitude and Intensity scales, seismic instruments. Earthquake Hazards in India, Earthquake Risk Evaluation and Mitigation. Structural behavior under gravity and seismic loads, Lateral load resisting structural systems, Requirements of efficient earthquake resistant structural system, damping devises, base isolation systems.	**12 Hours**	**L_1, L_2**
Module -2		
The Response history and strong motion characteristics. Response Spectrum – elastic and inelastic response spectra, tripartite (D-V-A) response spectrum, use of response spectrum in earthquake resistant design. Computation of seismic forces in multi-storied buildings – using procedures (Equivalent lateral force and dynamic analysis) as perIS-1893.	**10 Hours**	**L_2, L_3, L_4, L_5**
Module -3		
Structural Configuration for earthquake resistant design, Concept of plan irregularities and vertical irregularities, Soft storey, Torsion in buildings. Design provisions for these in IS-1893. Effect of infill masonry walls on frames, modeling concepts of infill masonry walls. Behaviour of masonry buildings during earthquakes, failure patterns, strength of masonry in shear and flexure,	**10 Hours**	**L_2, L_4, L_5**

Slenderness concept of masonry walls, concepts for earthquake resistant masonry buildings – codalprovisions.		
Module -4		
Design of Reinforced concrete buildings for earthquake resistance- Load combinations, Ductility and energy absorption in buildings. Confinement of concrete for ductility, design of columns and beams for ductility, ductile detailing provisions as per IS- 1893. Structural behavior, design and ductile detailing ofshearwalls.	**10 Hours**	**L_2, L_4, L_5**
Module -5		
Seismic response control concepts – Seismic demand, seismic capacity, Overview of linear and nonlinear procedures of seismic analysis. Performance Based Seismic Engineering methodology,Seismic evaluation and retrofitting ofstructures.	**10 Hours**	**L_2, L_5, L_8**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of engineeringseismology
- Design and develop analyticalskills.
- SummarizetheSeismicevaluationandretrofittingofstructures.
- Understand the concepts of earthquake resistance of reinforced concrete buildings.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Dynamics of Structures – Theory and Application to Earthquake Engineering- 2nd ed. – Anil K. Chopra, PearsonEducation.
2. EarthquakeResistantDesignofBuildingStructures,VinodHosur,WILEY(india)
3. EarthquakeResistantDesignofStructures,Duggal,OxfordUniversityPress
4. Earthquake resistant design of structures - Pankaj Agarwal, Manish Shrikande - PHIIndia
5. IS – 1893 (Part I): 2002, IS – 13920: 1993, IS – 4328: 1993, IS-13828: 1993
6. Design of Earthquake Resistant Buildings, Minoru Wakabayashi, McGraw Hill Pub.
7. SeismicDesignofReinforcedConcreteandMasonryBuildings,TPaulayandMJN Priestley, John Wiley and Sons

DESIGN OF TALL STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	19CSE251	IA Marks	50
Number of Lecture Hours/Week	03	Exam Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

The objective of this course is to make students to learn principles of stability of tall buildings, To design the tall buildings for earthquake and wind resistance. To evaluate the performance of tall structures for strength and stability

Modules	Teaching Hours	RBT Level
Module -1		
Design Criteria: Design philosophy, loading, sequential loading, and materials – high performance concrete, fiber reinforced concrete, lightweight concrete, design mixes. Loading and Movement: Gravity loading: Dead and live load, methods of live load reduction, Impact, Gravity loading, Construction loads	**8 Hours**	**L_1, L_2**
Module -2		
Wind loading: static and dynamic approach, Analytical and wind tunnel experimentation method. Earthquake loading: Equivalent lateral force, modal analysis, combinations of loading, working stress design, Limit state design, Plasticdesign.	**8 Hours**	**L_1, L_3, L_4, L_5**
Module -3		
Behavior of Various Structural Systems: Factors affecting growth, Height and structural form; High rise behavior, Rigid frames, braced frames, in-filled frames, shear walls, coupled shear walls, wall-frames, tubular, cores, Futigger – braced and hybrid mega system.	**8 Hours**	**L_2, L_3**
Module -4		
Analysis and Design: Modeling for approximate analysis, accurate analysis and reduction techniques, analysis of building as total structural system considering overall integrity and major subsystem	**8 Hours**	**L_2, L_3, L_4**

interaction, analysis for member forces; drift and twist, computerized general three dimensional analyses.		
Module -5		
Stability of Tall Buildings: Overall buckling analysis of frames, wall frames, approximate methods, second order effects of gravity of loading, P-Delta analysis, simultaneous first order and P-Delta analysis, Transnational, Torsional instability, out of plum effects, stiffness of member in stability, effect of foundation rotation. Structural elements: sectional shapes, properties and resisting capacities, design, deflection, cracking, pre-stressing, shear flow. Design for differential movement, creep and shrinkage effects, temperature effects andfire	**8 Hours**	**L_2, L_3, L_4, L_5**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of strength andstability
- Design and develop analyticalskills.
- Summarize the behavior of various structuralsystems.
- Understand the concepts of P-Deltaanalysis

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Taranath B.S, "Structural Analysis and Design of Tall Buildings"- McGrawHill
2. Wilf gang Schuller, "High rise building structures"- JohnWiley
3. Bryan Stafford Smith &Alexcoull, "Tall building structures Analysis and Design"- JohnWiley
4. T.Y Lin &D.Stotes Burry, "Structural concepts and system for Architects and Engineers"- JohnWiley
5. Lynn S.Beedle, "Advances in Tall Buildings"- CBS Publishers andDistributors.
6. Dr. Y.P. Gupta – Editor, "Proceedings National Seminar on High Rise Structures- Design and Construction practices for middle level cities"- New Age InternationalLimited

REPAIR AND REHABILITATION OF STRUCTURES

[As per Choice Based Credit System (CBCS) scheme] SEMESTER – II

Subject Code	19CSE 252	IA Marks	50
Number of Lecture Hours/Week	03	Exam Marks	50
Total Numberof Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

The objective of this course is to make students to investigate the cause of deterioration of concrete structures, To strategize different repair and rehabilitation of structures. To evaluate the performance of the materials for repair

Modules	Teaching Hours	RBT Level
Module -1		
General: Introduction, Cause of deterioration of concrete structures, Diagnostic methods &analysis, preliminary investigations, experimental investigations using NDT, load testing, corrosion mapping, core drilling and other instrumental methods, Quality assurance for concrete construction, as built concrete properties strength, permeability, thermal properties andcracking.	**8 Hours**	**L_3, L_5**
Module -2		
Influence on Serviceability and Durability: Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, and cathodicprotection.	**8 Hours**	**L_3, L_4, L_5**
Module -3		
Maintenance and Repair Strategies: Definitions: Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance, Preventive measures on various aspects. Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration, testingtechniques	**8 Hours**	**L_2, L_3, L_5**

Module -4		
Materials for Repair: Special concretes and mortars, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, Ferro cement, Fiber reinforced concrete. Techniques for Repair: Rust eliminators and polymers coating for rebar during repair foamed concrete, mortar and dry pack, vacuum concrete, Gunite and Shot Crete Epoxy injection, Mortar repair for cracks, shoringand underpinning.	**8 Hours**	**L_2**
Module -5		
Examples of Repair to Structures: Repairs to overcome low member strength, Deflection, Cracking, Chemical disruption, weathering wear, fire, leakage, marine exposure, engineered demolition techniques for dilapidated structures - casestudies	**8 Hours**	**L_2, L_5**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the cause of deterioration of concretestructures.
- Design and develop analyticalskills.
- Summarizetheprinciplesofrepairandrehabilitationofstructures
- Understands the concept of Serviceability and Durability.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Sidney, M. Johnson "Deterioration, Maintenance and Repair ofStructures".
2. Denison Campbell, Allen & Harold Roper, "Concrete Structures – Materials, Maintenance and Repair"- Longman Scientific andTechnical
3. R.T.Allen and S.C. Edwards, "Repair of Concrete Structures"-Blakie andSons
4. Raiker R.N., "Learning for failure from Deficiencies in Design, Constructionand Service"- R&D Center (SDCPL

STABILITY OF STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	19CSE 253	IA Marks	50
Number of Lecture Hours/Week	03	Exam Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

The objective of this course is to make students to learn principles of stability of structures, To analyse the structural elements for stability. To evaluate the use of strain energy in plate bendingand stability.

Modules	Teaching Hours	RBT Level
Module -1		
Beam – column – Differential equation. Beam column subjected to (i) lateral concentrated load, (ii) several concentrated loads, (iii) continuous lateral load. Application of trigonometric series, Euler's formulation using fourth order differential equation for pined – pined, fixed – fixed, fixed – free and fixed – pinnedcolumn.	**8 Hours**	**L_1, L_2**
Module -2		
Buckling of frames and continuous beams. Elastic Energy method: Approximate calculation of critical loads for a cantilever. Exact critical load for hinged – hinged column using energy approach. Buckling ofbar on elastic foundation. Buckling of cantilever column under distributed loads. Determination of critical loads by successive approximation. Bars with varying cross section. Effect of shear force on critical load. Column subjected to non – conservative follower and pulsatingforces.	**8 Hours**	**L_2, L_3**
Module -3		
Stability analysis by finite element approach – deviation of shape function for a two nodded Bernoulli – Euler beam element (lateral and translation of) – element stiffness and element geometric stiffness matrices – assembled stiffness and geometric stiffness matrices for a discretised column with different boundary condition – calculation of critical loads for a discretised (two elements) column (both endsbuilt	**8 Hours**	**L_2, L_3, L_4**

in). Buckling of pin jointed frames (maximum of two active DOF) – symmetrical single bay portal frame.		
Module -4		
Lateral buckling of beams – differential equation – pure bending – cantilever beam with tip load – simply supported beam of I section subjected to central concentrated load. Pure Torsion of thin – walled bars of open cross section. Non – uniform Torsion of thin – walled bars of open crosssection.	**8 Hours**	**L_1, L_2, L_3**
Module -5		
Expression for strain energy in plate bending with in plate forces (linear and non – linear). Buckling of simply supported rectangular plate – uniaxial load and biaxial load. Buckling of uniformly compressed rectangular plate simply supported along two opposite sides perpendicular to the direction of compression and having various edge conditionalong the other two sides	**8 Hours**	**L_1, L_2, L_3**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of strength andstability
- Design and develop analyticalskills.
- Appraise the Stability analysis by finite elementapproach.
- Understand the concepts of Lateral buckling ofbeams.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Stephen P.Timoshenko, James M Gere, "Theory of Elastic Stability"-2nd Edition, McGraw – Hill, NewDelhi.
2. Robert D Cook et.al, "Concepts and Applications of Finite Element Analysis"-3rd Edition, John Wiley and Sons, NewYork.
3. S.Rajashekar, "Computations and Structural Mechanics"-Prentice – Hall,India.
4. Ray W Clough and J Penzien, "Dynamics of Structures" - 2nd Edition, McGraw Hill, NewDelhi
5. H.Zeiglar, "Principles of Structural Stability"-BlaisdallPublications

DESIGN CONCEPTS OF SUBSTRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	19CSE254	IA Marks	50
Number of Lecture Hours/Week	04	Exam Marks	50
Total Number of Lecture Hours	52	Exam Hours	03

CREDITS – 03

Course objectives:

The objective of this course is to make students to learn principles of subsoil exploration, To design the sub structures. To evaluate the soil shear strength parameters.

Modules	Teaching Hours	RBT Level
Module -1		
Introduction, Site investigation, In-situ testing of soils, Subsoil exploration, Classification of foundations systems. General requirement of foundations, Selection of foundations, Computations of Loads, Designconcepts.	**12 Hours**	**L_2, L_4, L_5**
Module -2		
Concept of soil shear strength parameters, Settlement analysis of footings, Shallow foundations in clay, Shallow foundation in sand & C-Φ soils, Footings on layered soils and sloping ground, Design for Eccentric or MomentLoads.	**10 Hours**	**L_2, L_4, L_5**
Module -3		
Types of rafts, bearing capacity & settlements of raft foundation, Rigid methods, Flexible methods, soil- structure interaction, different methods ofmodeling the soil. Combined footings (rectangular & trapezoidal), strap footings & wall footings, Raft – super structure interaction effects & general concepts of structural design, Basementslabs	**10 Hours**	**L_2, L_4, L_5**
Module -4		
Deep Foundations: Load Transfer in Deep Foundations, Types of Deep Foundations, Ultimate bearing capacity of different types of piles in different soil conditions, Laterally loaded piles, tension piles & batter piles, Pile groups: Bearing capacity, settlement, uplift capacity, load distribution between piles, Proportioning and design concepts ofpiles.	**10 Hours**	**L_2, L_3, L_4, L_5**

Module -5		
Types of caissons, Analysis of well foundations, Design principles, Well construction and sinking. Foundations for tower structures: Introduction, Forces on tower foundations, Selection of foundation type, Stability and design considerations, Ring foundations – generalconcepts.	**10 Hours**	**L_2, L_3, L_4, L_5**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of subsoilexploration
- Design and develop analyticalskills.
- Identify and evaluate the soil shear strengthparameters.
- Understand the concepts of Settlementanalysis.

IMPORTANT NOTE:

Only design principles of all type footings as per relevant BIS codes are to be covered, design of RC elements need notbe

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Swami Saran – "**Analysis & Design of Substructures**"- Oxford &IBH Pub. Co. Pvt. Ltd.,1998.
2. Nainan P Kurian – "**Design of Foundation Systems**"- Narosa Publishing House,1992.
3. R.B. Peck, W.E. Hanson & T.H. Thornburn– "**FoundationEngineering"-** Wiley Eastern Ltd.,Second Edition,1984.
4. J.E. Bowles – "**Foundation Analysis and Design**"- McGraw-Hill Int. Editions, Fifth Ed.,1998.
5. W.C. Teng – "**Foundation Design"-** Prentice Hall of India Pvt. Ltd., 1983.
6. Bureau of Indian Standards:IS-1498, IS-1892, IS-1903, IS-8403, IS-8009, IS-2950, IS-11089, IS-11033, IS-2911 and allother relevant codes

CORRODION OF STEELINCONCRETE

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	19CSE 255	IA Marks	50
Number of Lecture Hours/Week	03	Exam Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

To impartsufficientknowledgeonmechanismofcorrosionofsteelinconcrete, different types of corrosion, causes for corrosion, corrosion damage in conventionalandprestressedconcretestructures,corrosioncontrolmethods suchasprotectivecoatings,highperformanceconcrete,corrosioninhibitors, stainless steel reinforcement and cathodic protection, condition evaluation ofcorrosionaffectedstructuresandtechniquesforcorrosionmeasurement, rehabilitation methodologies and repair materials for corrosion affected structures based on severity, Indian and American codal requirements for enhancing durability of concrete and performance evaluation of corrosion controlmethods.

Modules	Teaching Hours	RBT Level
Module -1		
INTRODUCTION CorrosionMechanism– Blackrust,pits,straycurrentandbacterialcorrosion. Causes of Corrosion – Carbonation, Chloride attack, Influence of concrete cover.Corrosiondamage–DamageinconventionallyReinforcedConcrete and Prestressedconcrete, Stress Corrosion Cracking, Hydrogen Embrittlement. Cost of Corrosion – A world wide scenario.	**8 Hours**	**L_1, L_2**
Module -2		
CORROSIONCONTROL Energy methods for rectangular and circular plates with clamped edges subjected to symmetric loadings.	**8 Hours**	**L_2, L_3**
Module -3		
CONDITION EVALUATION AND CORROSION RATE MEASUREMENT Control of carbonation, Control of chlorides, High Performance Concrete, Corrosion Inhibitors – Anodic, Cathodic and Mixed Inhibitors. Protective Coatings to Steel Rebars – Fusion Bonded Epoxy Coating, Galvanization, Cement Polymer Composite Coating, Inhibited cement slurry coating and Polymer Cementious coatings, Stainless Steel Reinforcement, Sealersand Membranes, CathodicProtection.	**8 Hours**	**L_2, L_3**
Module -4		

REHABILITATION TECHNIQUESPhysical and Chemical Rehabilitation Techniques - Concrete removal and surface preparation, patches, coatings, sealers, membranes and barriers, Encasement and overlays, Sprayed concrete, corrosion inhibitors. ElectrochemicalRepairTechniques–BasicPrinciple–CathodicProtection, Chloride Removal andRealkalization.	**8 Hours**	**L_2, L_3**
Module -5		
CODAL REQUIREMENTSFORDURABILITY Indian Standard codal requirements for enhancing durability of R.C.C. Structures.IndianandASTMcodalprovisionsforcoatedrebars,Galvanized reinforcement, corrosion inhibitors and Bond strengthtest.	**8 Hours**	**L_2, L_3, L_4**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles of Analysis andDesign
- Design and develop analyticalskills.
- Summarize the performance ofshells
- Understand the concepts of energyprinciple.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. ArnonBentur, Sidney Diamond and Neal S. Berke, "Steel Corrosion in Concrete – Fundamentals and Civil Engineering Practice", E & FN SPON Publications, Madras(1997).
2. John P.Broomfield, "Corrosion of steel in concrete - Understanding, investigation and repair", E & FN SPON Publications, Madras(1997).
3. Mars G. Fontana, "Corrosion Engineering" Mc-Graw Hill Publishers, New Delhi(2001).
4. Philip H. Perkins, "Repair, Protection and Waterproofing of Concrete Structures", Elsevier Applied Science Publishers, London(1988).

STRUCTURAL ANAYSIS AND DESIGN LAB-II

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	19CSEL26	IA Marks	50
Number of Lecture Hours/Week	03	Exam Marks	50
Total Number of Lecture Hours	42	Exam Hours	03
CREDITS – 02			

Course objectives:

The objective of this course is to make students to learn principles of design of experiments, To investigate the performance of structural elements.To evaluate the different testing methods and equipments

Modules	Teaching Hours	RBT Level
1. Testing of beams for deflection, flexureandshear *-12Hrs* 2. Experiments on Concrete, including Mixdesign *-10Hrs* 3. Experiments on vibration of multi storey frame models for Natural frequencyandmodes. *-10Hrs* 4. Use of Non destructive testing (NDT) equipments –Rebound hammer, Ultra sonic pulse velocity meter andProfometer *-10Hrs*	**42 Hours**	**L_1, L_2, L_3, L_4, L_5, L_8**

Course outcomes:

On completion of this course, students are ableto:

- Achieve Knowledge of design and development of programmingskills.
- Understand the principles of structural analysis anddesign
- Design and develop analyticalskills.
- Summarizetheperformanceofstructuresforstaticanddynamicforces.

DESIGN OF CONCRETE BRIDGES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	19CSE 31	IA Marks	50
Number of Lecture Hours/Week	04	Exam Marks	50
Total Number of Lecture Hours	52	Exam Hours	03

CREDITS – 03

Course objectives:

The objective of thiscourse is to make students to learn principles of StructuralDesign,Todesigndifferenttypesofstructuresand to detailthe structures. To evaluate performance of thestructures.

Modules	Teaching Hours	RBT Level
Module -1		
Introduction: Historical Developments, Site Selection for Bridges, Classification of Bridges Forces on Bridges. Bridge substructures: Abutments, piers and wing walls Balanced Cantilever Bridge: Introduction and proportioning of components, Design of simply supported portion and design of cantilever portion, design ofarticulation	**12 Hours**	**L_1, L_2, L_3, L_4**
Module -2		
Box Culvert: Different Loading Cases IRC Class AA Tracked, Wheeled and Class A Loading, working out the worst combination of loading, Moment Distribution, Calculation of BM & SF, Structural Design of Slab Culvert, with ReinforcementDetails.	**10 Hours**	**L_2, L_3, L_4**
Module -3		
T Beam Bridge Slab Design: Proportioning of Components Analysis of interior Slab & Cantilever Slab Using IRC Class AA Tracked, Wheeled Class A Loading, Structural Design of Slab, with Reinforcement Detail. T Beam Bridge Cross Girder Design: Analysis of Cross Girder for Dead Load & Live Load Using IRC Class AA Tracked, Wheeled Class A Loading A Loads, Structural Design of Beam, with ReinforcementDetail.	**10 Hours**	**L_2, L_3, L_4**
Module -4		
T Beam Bridge Main Girder Design: Analysis of Main Girder for Dead Load & Live Load Using IRC Class AA Tracked, Wheeled Class A Loading Using COURBON'S Method, Analysis of Main Girder Using HENDRY-JAEGER and MORICE-LITTLE Methodfor IRC Class AA Tracked vehicle only, BM & SF for	**10 Hours**	**L_2, L_3, L_4**

different loads, Structural Design of Main Girder With Reinforcement Details		
Module -5		
PSC Bridges: Introduction to Pre and Post Tensioning, Proportioning of Components, Analysis and Structural Design of Slab, Analysis of Main Girder using COURBON's Method for IRC Class AA tracked vehicle, Calculation of pre-stressing force, cable profile and calculation of stresses, Design of End block and detailing of maingirder	**10 Hours**	**L_1, L_2, L_3, L_4**

Course outcomes:

On completion of this course, students are ableto:

- Achieve Knowledge of design and development of problem solvingskills.
- Understand the principles ofoptimization.
- Design and develop analyticalskills.
- Summarize the Linear, Non-linear and GeometricProgramming
- Understands the concept of Dynamicprogramming

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. "Essentials of Bridge Engineering"- D Johnson Victor, Oxford & IBH Publishing Co NewDelhi
2. "Design of Bridges"- N Krishna Raju, Oxford & IBH Publishing Co NewDelhi
3. "Principles and Practice of Bridge Engineering"- S P BindraDhanpatRai& Sons NewDelhi
4. IRC 8 – 1988 "Standard Specifications And Code Of Practice For Road Bridges"- Section II Loads and Stresses, The Indian Road Congress NewDelhi
5. IRC 21 – 1988 "Standard Specifications And Code Of Practice For Road Bridges"-Section III Cement Concrete (Plain and reinforced) The Indian Road Congress NewDelhi
6. IS 458 – 2000 "Indian Standard Plain and Reinforced Concrete Code of Practice"- (Fourth Revision) BIS NewDelhi
7. IS 1343 – "Indian Standard Prestressed Concrete Code of Practice"- BIS New Delhi
8. Raina V.K., "Concrete Bridge Practice"- Tata McGrawHill
9. Bakht B &Jaeggar, "Bridge Analysis Simplified"- McGrawHill
10. Ponnuswamy. S, "Bridge Engineering"- Tata McGrawHill.
11. Derrick Beckett, "An Introduction to Structural Design of Concrete Bridges"- Surrey University Press

OPTIMIZATION TECHNIQUES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	19CSE 321	IA Marks	50
Number of Lecture Hours/Week	03	Exam Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

The objective of this course is to make students to learn principles of optimization, To implement the optimization Concepts for the structural engineering problems. To evaluate different methods ofoptimization.

Modules	Teaching Hours	RBT Level
Module -1		
Introduction: Introduction to optimization, engineering applications of optimization, Formulation of structural optimization problems as programming problems. Optimization Techniques: Classical optimization techniques, single variable optimization, multivariable optimization with no constraints, unconstrained minimization techniques and algorithms constrained optimization solutions by penalty function techniques, Lagrange multipliers techniques and feasibilitytechniques.	**8 Hours**	**L_1, L_2, L_4**
Module -2		
Linear Programming: Linear programming, standard form of linear programming, geometry of linear programming problems, solution of a system of linear simultaneous equations, pivotal production of general systems of equations, simplex algorithms, revised simpler methods, duality in linear programming.	**8 Hours**	**L_2, L_4, L_5**
Module -3		
Non-linear programming: Non-linear programming, one dimensional minimization methods, elimination methods, Fibonacci method, golden section method, interpolation methods, quadratic and cubic methods, Unconstrained optimization methods, direct search methods, random search methods, descent methods	**8 Hours**	**L_2, L_3, L_4, L_5**

Module -4		
Constrained optimization techniques such as direct methods, the complex methods, cutting plane method, exterior penalty function methods for structural engineering problems. Formulation and solution of structural optimization problems by differenttechniques	**8 Hours**	**L_2, L_3, L_4, L_5**
Module -5		
Geometric programming: Geometric programming, conversion of NLP as a sequence of LP/ geometric programming. **Dynamic programming:** Dynamic programming conversion of NLP as a sequence of LP/ Dynamic programming	**8 Hours**	**L_4, L_5**

Course outcomes:

On completion of this course, students are ableto:

- AchieveKnowledgeofdesignanddevelopmentofproblemsolvingskills.
- Understand the principles ofoptimization.
- Design and develop analyticalskills.
- Summarize the Linear, Non-linear and GeometricProgramming
- Understands the concept of Dynamicprogramming

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 10marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under amodule.
- The students will have to answer 5 full questions, selecting one full question from eachmodule.

REFERENCE BOOKS:

1. Spunt, “Optimum Structural Design”- PrenticeHall
2. S.S. Rao, “Optimization – Theory and Practice”- Wiley EasternLtd.
3. Uri Krisch, “Optimum Structural Design”- McGrawHill
4. Richard Bronson, “Operation Research”- Schaum’sOutlineSeries
5. Bhavikatti S.S.- “Structural optimization using sequentiallinear programming”- Vikas publishing house

COPOSITE MATERIALS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	19CSE325	IA Marks	50
Number of Lecture Hours/Week	03	Exam Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

This course will enable students to

- Familiarise with different materials of building construction.
- Study various composite materials and their characteristics.
- Analyse the environmental effect on materials and their components

Modules	Teaching Hours	RBT Level
Module -1		
Introduction to Composite materials: Classifications and applications. of fibers, volume fraction and load distribution among constituents, minimum & critical volume fraction, compliance & stiffness matrices, coupling.	**10 Hours**	**L_1, L_2,L3**
Module -2		
Anisotropic elasticity: Unidirectional and anisotropic lamina, thermo-mechanical properties, micro- mechanical analysis, classical composite lamination theory, Cross and angle–play laminates, symmetric, anti-symmetric and general asymmetric laminates, mechanical coupling, laminate stacking,	**10 Hours**	**L_1, L_2,L3**
Module -3		
Analysis of simple laminated structural elements: Ply-stress and strain, lamina failure theories - first fly failure, environmental effects, manufacturing of composites.	**10 Hours**	**L_1, L_2,L3**
Module -4		
Laminates-Laminated Plates, Analysis, Strength and design with composites, Fibre reinforced Pressure	**10 Hours**	**L_1, L_2,L3**
Module -5		

Smart materials: Introduction, Types of smart structures, actuators & sensors, embedded & surface mounted, piezoelectric coefficients, phase transition, piezoelectric constitutive relation.	**10 Hours**	**L_1, L_2,L3**

Course outcomes:

After completing this course, students will be able to:

1. Carry out classification and application of various types of fibres.
2. Explain thermo-mechanical properties of materials.
3. Analyse environmental effects and failure theories of composite materials.
4. Familiarise with smart materials and structures.
5. Carry out the analysis of a beam model with induced strain actuation.

Question paper pattern:

- The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

REFERENCE BOOKS:

1. Robart M Jones, Mechanic of Composite Materials, McGraw Hill Publishing Co, 2015.
2. Bhagwan D Agarawal, and Lawrence J Brutman, Analysis and Performance of Fiber Composites, John Willy and Sons, 2006.
3. MadujitMukhopadyay, Mechanics of composite materials and structures, University Press, 2004.
4. Mercedes C. Reaves and Lucas G. Horta, Piezoelectric actuator modeling using MSC/NASTRAN and MATLAB. NASA/TM-2003-212651, Langley Research Center, Hampton, Virginia, 2003.
5. Inderjit h Chopra, Lecture notes on Smart Structures, Department of Aerospace Engg., University of Maryland.
6. Crawley E F. and deLuis J, Use of piezoelectric actuators elements of intelligent structures, A journal Vol 25, No 10 Oct 1987, Pp 1373-1385.
7. Ceawley E. and Anderson E., Detailed models of piezo-ceramics actuation of beams, Proceedings of the 30th AIAA/ASME/ASCE/ASC – Structural dynamics and materials conference, Washington DC, April 1989.