M.TECH- STRUCTURAL AND CONSTRUCTION ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING

The growth in infrastructure requirements has posed a definite and critical need of qualified Structural as well as Construction Engineers. The aim of this program is to impart advanced fundamental concepts related to mechanics and dynamics of the structures. These coupled with courses related to recent developments in construction materials and technologies will impart cutting edge design methodologies and implementation strategies to students in both Sub and Superstructures of various infrastructure facilities. The course will also focus on laboratory work, industry oriented project exposure and dissertation based on research for all round development of Design & Construction Engineer.

The program's goal is to provide students with advanced technical knowledge of evolving structural systems integrated with a solid grounding of design approaches. This program is designed for students and industry professionals seeking to advance their careers, and for academics preparing for the challenges of research and teaching. The courses are designed to establish a fine balance between academic fundamentals and industry realities and requirements.

This program will be able to find many employers from Government, private corporations, public sector undertakings, and teaching and/or research institutions in the country as well as abroad. The uniqueness of this course is the blend of exposure to strong theoretical foundation, practical design & construction approaches through adequate computational, analytical and execution skill development.

Programme Educational Objectives (PEOs)

PEO1: Create man power in Structural and Construction Engineering with competence in planning, design and execution of diverse projects as well as for academia.

PEO2: Develop an attitude of lifelong learning through research and multidisciplinary studies with consideration to global requirements and issues concerning society and environment.

PEO3: Demonstrate the ability to function as ethical and responsible professionals with leadership and management skills.

Program Outcomes (POs):

After completion of the program, graduates will have the

PO1: Ability to demonstrate a degree of mastery in order to identify, formulate and solve problems in the domains of Structural and Construction Engineering

PO2: An ability to use the techniques, skills and modern engineering tools to analyze critically, carry out safe and economical design.

PO3: An ability to independently carry out research /investigation and development work to solve practical problems.

PO4: Ability to write and present a substantial technical report/document.

PO5: Ability for professional practice; to engage in lifelong learning to gain knowledge of contemporary issues and adapt oneself to the changing needs of the society.

PO6: Competence to function as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.

CURRICULUM

First Semester

Course Code	Type	Course	L T P	Cr
21MA606	FC	Linear Algebra, Legendre Equations and Numerical Methods	3- 0- 0	3
21SC601	FC	Advanced Structural Mechanics	2- 1- 0	3
21SC602	SC	Theory of Elasticity and Plasticity	2- 1- 0	3
21SC603	FC	Advanced Construction Practices	3- 0- 0	3
21SC604	SC	Construction Project Management	2- 1- 0	3
21SC605	SC	Structural Design Studio	1-0-3	2
21SC681	SC	Experimental Techniques	0- 0-3	1
21HU601	HU	Amrita Values Program*		P/F
21HU602	HU	Career Competency I*		P/F
				Credits 18

*Non Credit Course

Second Semester

Course Code	Type	Course	L T P	Cr
21SC611	FC	Finite Element Analysis	2- 1- 0	3
21SC612	FC	Construction Contract Laws & Regulations	3- 0- 0	3
	E	Programme Elective I	3- 0- 0	3
	E	Programme Elective II	3- 0- 0	3
21SC613	SC	Advanced Structural Design	2- 1- 0	3
21SC614	SC	Construction Software Laboratory	1-0-3	2
21HU603	HU	Career Competency II	1-0-0	1
21RM612	SC	Research Methodology	2- 0- 0	2
				Credits 20

Third Semester

Course Code	Type	Course	L T P	Cr
	E	Programme Elective III/Live in Lab	3- 0- 0	3
	E	Open Elective/ Programme Elective IV	3- 0- 0	3
21SC797	SC	Industry Training /Internship (Vacation)	0 -0-3	P/F
21SC798	P	Dissertation I		10
				Credits 16

Fourth Semester

Course Code	Type	Course	L T P	Cr
21SC798	P	Dissertation II		16
				Credits 16

Total Credits 70

List of Courses

Foundation Core

Course Code	Course	L T P	Cr
21MA606	Linear Algebra, Legendre Equations and Numerical Method	3- 0 - 0	3
21SC601	Advanced Structural Mechanics	2- 1- 0	3
21SC611	Finite Element Analysis	2- 1- 0	3
21SC603	Advanced Construction Practices	3 -0- 0	3
21SC612	Construction Contract Laws & Regulations	3- 0- 0	3

Subject Core

Course Code	Course	L T P	Cr
21SC602	Theory of Elasticity and Plasticity	2- 1- 0	3
21SC613	Advanced Structural Design	3- 1- 0	4
21SC604	Construction Project Management	2- 1- 0	3
21SC681	Experimental Techniques	0- 0- 3	1
21SC605	Structural Design Studio	1- 0- 3	2
21SC614	Construction Software Laboratory	1- 0- 3	2
21RM612	Research Methodology	2-0-0	2
21SC797	Industry Training /Internship (Vacation)	0 -0-3	P/F

Programme Electives

Course Code	Course	L T P	Cr
21SC631	Mechanics of Composite Materials	3- 0- 0	3
21SC632	Advanced Concrete Technology	3- 0- 0	3
21SC633	Construction Methods and Equipment	3- 0- 0	3
21SC634	Structural Dynamics	3- 0- 0	3
21SC635	Theory of Plates and Shells	3- 0- 0	3
21SC636	System Integration in Construction	3- 0- 0	3
21SC637	Quality Control and Safety in Construction	3- 0- 0	3
21SC638	Pre-stressed Concrete Design	3- 0- 0	3
21SC639	Analysis and Design for Earthquake Forces	3- 0- 0	3
21SC640	Forensic Engineering and Rehabilitation of Structures	3- 0- 0	3
21SC641	Geotechnics for Infrastructure	3- 0- 0	3

21SC642	Optimization Techniques	3- 0- 0	3
21SC643	Smart Materials and Structures	3- 0- 0	3
21SC644	Stability of Structures	3- 0- 0	3
21SC645	Industrial Structures	3- 0- 0	3
21SC646	Bridge Engineering	3- 0- 0	3
21SC647	Prefabrication Engineering	3- 0- 0	3
21SC648	Design of Offshore Structures	3- 0- 0	3
21SC649	Pavement Analysis and Design	3- 0- 0	3
21SC650	Characterization of Materials	3- 0- 0	3
21SC651	Geotechnical Earthquake Engineering	3- 0- 0	3
21SC652	Soil Dynamics and Machine Foundations	3- 0- 0	3
21SC653	Statistical and Probabilistic Modeling In Civil Engineering	3-0-0	3
21SC654	Wind Effects on Structures	3-0-0	3
21SC655	Analysis and Design of Substructures	3-0-0	3
21SC656	Formwork, Scaffolding & Shoring	3-0-0	3
21SC657	Construction Economics & Finance	3-0-0	3
21SC658	Building Information Modeling	3-0-0	3
21LIV606	Live-in-Lab	3-0-0	3

Open Electives**

Course Code	**Course**	**L T P**	**Cr**
21SC701	Remote Sensing and GIS	3- 0- 0	3
21SC702	Sustainable Design & Construction Practices	3- 0- 0	3
21SC703	Environmental Impact Assessment for Projects	3- 0- 0	3

**Students can opt for open electives offered by other departments with the consent of Department

Project Work

Course Code	**Course**	**L T P**	**Cr**

21MA606 LINEAR ALGEBRA, LEGENDRE EQUATIONS AND NUMERICAL METHODS 3-0-0-3

Linear Algebra: Linear systems of equations and solutions by iterative methods. Method of determining Eigen values and Eigen vectors by Power method. Vector spaces and subspaces, linear independence, basis and dimensions, linear transformations, orthogonality, Orthogonal basis, Gram Schmidt Process, least-square applications.

Differential equation with series solutions: Legendre's equation, Legendre's polynomial $P_n(x)$, Legendre's function of the second kind [Qn(x)], General solution of Legendre's equation, Rodrigue's formula, Legendre polynomials, A generating function of Legendre's polynomial, Orthogonality of Legendre polynomials, Recurrence formulae for $P_n(x)$ Green's function – Green's Identities – Generalized functions.

Numerical methods: Numerical solution of partial differential equations – Elliptic, parabolic and hyperbolic equations.

Skills Acquired: Vector Spaces, Linear Independence, Orthogonality, Least square technique, Legendre's polynomial and generating functions. Solutions of System of equations-iterative method, iterative solutions of partial differential equations.

Employability: Employability in all the fields of science and engineering in both national and international industries / institutions.

TEXT BOOKS / REFERENCES:

1. Howard Anton and Chris Rorrs, *Elementary Linear Algebra*,Ninth Edition, John Wiley and Sons, 2000.
2. Gilbert Strang, *Linear Algebra and Its Applications*, Fourth Edition, Cengage, 2006.
3. G. Sansone, *Orthogonal Functions*,Dover Phoenix Edition, 2004.
4. J .N.Sharma and R. K. Gupta, *Special Functions*, Krishna Prakashan, 2006.
5. Curtis. F. Gerald and Patrick O Wheatley, *Applied Numerical Analysis*, Fifth Edition, Addison Wesley, 2002.

CO Code	Course outcome statement
CO1	The concepts of vector Spaces, Understand basis vectors, dimension & span of vector spaces.
CO2	The orthonormal set, simple linear transformation and least square method and apply to some of the structural engineering problems.
CO3	Solutions of differential equations through the special functions. Apply to some engineering problems.
CO4	Iterative methods to solve the system of equations, to obtain the largest eigen values and to solve some PDE equations like, 1-D heat and wave equations.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2				
CO2	2	3				
CO3	3	2				
CO4	2	3				

21SC601 ADVANCED STRUCTURAL MECHANICS 2-1-0-3

Review of the concepts: Basic concepts of structural analysis; Basis for principle of virtual work; Principle of virtual forces - standard and matrix formulation; Force method for analyzing skeletal structures; Principle of virtual displacements - standard and matrix formulation; Displacement method for analyzing skeletal structures; Extension of displacement method to the generalized stiffness method; Basic concepts associated with computer implementation of stiffness method. - One-dimensional beam element : Basis for cross-sectional level formulation of flexibility and stiffness; Flexibility approach for determining element stiffness; Stiffness approach for determining element stiffness; Special consideration of shear effects in stiffness approach; Consideration of torsional effects for thin-walled member; Special considerations for finite joints (both rigid and flexible); Consideration of local load (incl. temperature) effects; Formulation of geometric stiffness due to axial force; Linearised buckling analysis.

TEXT BOOKS/ REFERENCES:

1. William Weaver,Jr. James and M. Gere and Weaver, *Matrix Analysis of FramedStructures*, Third Edition Springer, 1990**.**
2. Pandit**,** G.S.,and Gupta**,** S. P. *Structural Analysis: A Matrix Approach,*Second Edition Tata McGraw - Hill Education, 2008.
3. Mcguire and Gallagher,R.H, Matrix Structural Analysis,Second edition, John Wiley, 2001.
4. Rajasekaran. S and Sankarasubramanian.G,*Computational Structural Mechanics,* Prentice Hall of India, NewDelhi, 2009.
5. NelsonK.J and Mc Cormac J C., *Structural Analysis Using Classical and MatrixMethods*, Third Edition, Wiley, 2002.

CO Code	Course outcome statement
CO1	Analyse the structure using principle of virtual work
CO2	Analyse the structure using matrix method
CO3	Determine the crippling load by performing linearised buckling Analysis

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2		2	1
CO2	3	3	3		3	1
CO3	3	3	2		2	1

21SC602 THEORY OF ELASTICITY AND PLASTICITY 2-1-0-3

Introduction to the mathematical theory of elasticity**:** Representation of 3 D state of stress at a point - Equations of equilibrium - 3 D state of strain- strain-displacement relations, constitutive relations, compatibility conditions, displacement and traction boundary conditions- Principal stresses, principal strains, three dimensional problems. Two - dimensional idealisations, plane stress and plane strain problems, 2 D problems in rectangular coordinates: Stress function, solution by polynomials, Saint Vénant's principle, bending of a cantilever. Two-dimensional problems in polar coordinates: General equations, problems of axisymmetric stress distribution, pure bending of curved bars, effect of circular hole, concentrated force on a straight boundary. Energy Theorems and Variational Principles of Elasticity, uniqueness of elasticity solution. - Torsion of straight bars, membrane analogy, narrow rectangular crosssection, torsion of rectangular bars, rolled profile sections, hollow shafts and thin tubes. Introduction to plasticity: One-dimensional elastic-plastic relations, isotropic and kinematic hardening, yield function, flow rule, hardening rule, incremental stress-strain relationship, governing equations of elastoplasticity.

TEXT BOOKS/ REFERENCES:

1. Timoshenko,S.P and Goodier,J.N.,*Theory of Elasticity,* McGraw Hill International, 2010.
2. Srinath, L.S,*Advanced Mechanics of Solids,* Second Edition, Tata McGraw Hill, India, 2008.

3. Ameen,M., *Computational Elasticity—Theory of Elasticity, Finite and BoundaryElement Methods*, Narosa Publishing House, 2004.
4. Richard G Budynas*Advanced Strength and Applied Stress Analysis*, Mcgraw Hill Series, 1999
5. Boresi, A.P , Schmidt, R.J and Sidebottom, O.M. , Advanced Mechanics Of Materials, 5th Ed., John Wiley, 1993.
6. Chakrabarty, J,*Theory of Plasticity*, Elsevier, London, 2006.
7. Chen, W.F and Han, D.J., *Plasticity for Structural Engineers*, Springer Verlag, 1998.

CO Code	Course outcome statement
CO1	Explain the principles and governing equations in elastic stage under different loading
CO2	Idealise plane stress and plane strain problems
CO3	Solve 2 D and 3 D elastic boundary value problems in rectangular and and polar coordinates
CO4	Explain plasticity effects during loading

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	2	1
CO2	2	1	0	0	0	0
CO3	3	2	2	1	2	2
CO4	1	0	1	0	0	0

21SC604 CONSTRUCTION PROJECT MANAGEMENT 2-1-0-3

Project management processes - Stakeholders, Construction organisation. Contracts - bidding process-contract document. Project Time Management - Activity definition - work breakdown structure, Activity sequencing – scheduling logic, precedence diagramming method, arrow diagramming method, Activity duration estimation, Schedule development and analysis - critical path method, production curves, Linear scheduling method; line-of balance method. Resource constrained scheduling. Scheduling with Uncertain Durations-PERT- Monte Carlo Schedule Simulations. Techniques for project monitoring and control, Earned value analysis. Project Resource Management - Resource aggregation, Resource leveling – minimum moment algorithm, Resource allocation; Time-cost Tradeoff.
Introduction to Digitalization in Construction. Economics - time value of money, evaluating alternatives.

TEXT BOOKS/ REFERENCES:

1. Chitkara, K. K. *Construction Project Management,* McGraw Hill Publishing Co., New Delhi, 2019
2. Kumar NeerajJha, *Construction Project Management*, Pearson Education, 2015
3. G.D. Oberlender*Project Management for Engineering and Construction*, McGrawHill, 2014.
4. Saleh Mubarak, *Construction Project Scheduling and Control*, Wiley, 2015.
5. S. M. Levy, *Project Management in Construction*, McGraw Hill, New York, 2018.

CO Code	Course outcome statement
CO1	Prepare a project scope and identify the various project delivery processes
CO2	Develop a schedule with physical, resource, time constraints
CO3	Monitor & control the time and cost of project execution

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3			1	1
CO2	3	3			1	
CO3	3	3			1	

21SC603 ADVANCED CONSTRUCTION PRACTICES 3-0-0-3

Construction materials:- Introduction to material structure and properties. Metals and Special Alloys of Steel – Glass and Glazing - Structural Plastics and Composites - Polymer Membranes, Coatings, Adhesives - Flooring and Facade Materials - High performance concrete.

Sub-structure construction:- Construction of diaphragm walls, H walls and basement- Shoring for deep cutting - Underpinning; Trenchless Technology; Box jacking, Pipe Jacking. Tunneling Techniques- Piling Techniques-Driving Well and Caisson-Sinking Cofferdam - Cable Anchoring and Grouting.

Super Structure Construction:- Techniques of construction for continuous concreting operation in Tall buildings of various shapes and varying sections - cooling towers, silos, chimney - erection techniques of tall structures - erection of articulated structures - aerial transporting, handling, erecting light weight components on tall structures - Large span structures - In-situ pre-stressing in high rise structures. Composite construction of steel and concrete. Rapid construction techniques.

Special Structures:- Construction sequences in sky scrapers, bow string bridges, cable stayed bridges - Launching techniques for heavy decks and box decks - support structure for heavy equipment and machinery in industries.

TEXT BOOKS/ REFERENCES:

1. Peter Domone and John Illston, Construction Materials- Their Nature and Behaviour, CRC Press,2010.
2. William P. Spence, Eva Kultermann., *Construction Materials, Methods and Techniques,* Cengage Learning, 2016.
3. Harris,F.,*Modern Construction and Ground Engineering Equipment and Methods,* Prentice Hall, 2013.
4. Singh,J., *Heavy Construction -Planning, Equipment and Methods,*Third Edition, CRC Press, 2009.
5. Michael Chew Yit Lin, *Construction Technology for Tall Buildings,* Singapore University Press, Singapore, 2001.
6. Johnson,R.P., *Composite Structures of Steel and Concrete,* Wiley India Exclusive, 2013.

CO Code	**Course Outcome Statement**
CO1	Identify suitability of modern construction materials for application in field situations.
CO2	Suggest the construction procedures for substructures and superstructures
CO3	Apply the suitable construction methods for special and heavy structures.

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	3	3	3	2
CO2	-	-	3	3	3	2
CO3	-	-	3	3	3	2

21SC605 STRUCTURAL DESIGN STUDIO 1-0-3-2

Planning, Analysis and Design of residential, Multi storeyed buildings, commercial buildings and Industrial structures, Material handling equipment and special structures. Geotechnical aspects in foundation design. Special emphasis on Earthquake resistant design. Design, detailing and preparation of drawings.

TEXT BOOKS/ REFERENCES:

1. Arthur.HNilson, David Darwin and Charles W Dolan, *Design of Concrete Structures,*Tata McGraw Hill, 2004.
2. Park .R and Paulay. T, *Reinforced Concrete Structure,* MISL-WILEY - Series Edition, 2009.
3. Subramanian.N, *Design of Steel Structures,* Oxford University Press, NewDelhi, 2008.
4. Swami Saran, *Analysis and Design of Substructures*, Oxford and IBH Publishing, New Delhi, 2008.
5. Relevant IS Codes.

CO Code	Course outcome statement
CO1	Design and Detailing the industrial structures with emphasis on connections, base plate and splices
CO2	Design and Detailing of storage structures.
CO3	Design and Detailing of Earthquake resistant multi storey building in compliances with IS1893 and IS13920.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	3	2	1	
CO2	1	3	1	2	1	
CO3	1	3	3	2	1	

21SC681 EXPERIMENTAL TECHNIQUES 0-0-3-1

Concrete mix proportioning, Study of High performance concrete -Introduction to Non Destructive Test methods.- Principles of operations of hydraulic loading systems, strain gauges, strain and force measuring devices, etc.-Utilization of Mechanical, electrical resistance and other types of strain gauges to study the behavior of structural members.-Use of static and dynamic data recording and processing systems. Demonstration on wind tunnel testing.

TEXT BOOKS / REFERENCES:

1. Dalley J W and Riley W F, *Experimental Stress Analysis*, Mc Graw Hill Book Company, 1991.
2. Srinath . L.S, *Experimental Stress Analysis*, Tata McGraw Hill Company, 1984.
3. IS: 10262, *Concrete Mix Proportioning: Guidelines,* BIS, New Delhi, 2019.
4. Shetty.M.S, *Concrete Technology*,S.Chand Publishers, 2009.

CO Code	Course outcome statement
CO1	Analyze the characteristics of mix constituents and design a concrete mix for field applications.
CO2	Implement various special concrete and various NDT methods based on the field conditions.
CO3	Analyze the stress -strain behaviour of steel and concrete elements using electrical/mechanical sensors and using data acquisition system.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	3	3	1
CO2	1	2	3	3	3	1
CO3	1	2	3	3	3	1

21SC611 FINITE ELEMENT ANALYSIS 2-1-0-3

Basic Equations of Solid Mechanics - Review of equilibrium conditions, Strain displacement relations, Stress Strain relations, Principle of Virtual work & Stationery potential energy and variational formulation. Approximate methods - RayleighRitz, Weighted residual (Galerkin) and finite difference methods (examples on plates) - Finite Element Method: Displacement model - Shape functions - Lagrange and serendipity elements, Element properties - Isoparametric elements - numerical integration, technique, Assemblage of elements and solution techniques for static analysis - Analysis of framed Structures - 2D truss and beam elements and applications. Analysis of plane stress/strain and axisymmetric solids - triangular and quadrilateral elements - incompatible mode elements. Three dimensional stress analysis - Isoparametric eight and twenty noded elements. Finite element programming/FEA Software.

TEXT BOOKS/ REFERENCES:

1. Cook,R.D., Malkus, D.S., Plesha, M.E., and Witt,R.J., *Concepts and Applications of Finite Element Analysis*, Wiley, 2001 .
2. Rao S S, *The Finite Element Method in Engineering*, Elsevier, 2014.
3. Zienkiewicz,O. C., and Taylor,R .L., *The Finite Element Method for Solid and Structural Mechanics*, Butterworth and Heiamann,2005.
4. M.Asghar Bhatti., *Fundamental Finite Element Analysis and Applications*, Wiley India Pvt.Ltd., 2017.
5. M.Asghar Bhatti., *Advanced Topics in Finite Element Analysis*,Wiley India Pvt.Ltd.-2013.

CO Code	Course Outcome Statement
CO1	Understand fundamental theory of the Finite Element method
CO2	Formulate and assess the element type, properties and its assembly
CO3	Analyse 2 D and 3 D structural problems using finite elements both manually and with software

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	3	1
CO2	2	2	2	-	1	-
CO3	2	2	1	-	1	-

21SC612 CONSTRUCTION CONTRACT LAWS AND REGULATIONS
3-0-0-3

Construction Contracts - Indian Contracts Act – Elements of Contracts – Types of Contracts – Features – Suitability – Tenders - Prequalification – Bid Formation – Accepting – Bid evaluation from Technical, Contractual and Commercial Points of View – Contract Formation and Interpretation – FIDIC, CPWD &NitiAayog Standard contract conditions. Design of Contract Documents – International Contract Document – Standard Contract Document – Law of Torts – World Bank Procedures and Guidelines – Potential Contractual Problems Transparency in Tenders Act.

Dispute resolution systems - Engineer In Charge decision-Change orders, Dispute Resolution studies, Documentation. Arbitration - Comparison of Actions and Laws – Agreements – Subject Matter – Violations – Appointment of Arbitrators – Conditions of Arbitration – Powers and Duties of Arbitrator – Rules of Evidence – Enforcement of Award – Costs. Legal Requirements - Insurance and Bonding – Laws Governing Sale, Purchase and Use of Urban and Rural Land – Land Revenue Codes – Tax Laws – Income Tax, Sales Tax, Excise and Custom Duties and

their Influence on Construction Costs – Legal Requirements for Planning – Property Law – Agency Law – Local Government Laws for Approval – Statutory Regulations.
Labour Regulation - Social Security – Welfare Legislation – Laws relating to Wages, Bonus and Industrial Disputes, Labour Administration – Insurance and Safety Regulations – Workmen's Compensation Act – Factory Acts – Labour Laws.

TEXT BOOKS/ REFERENCES:

1. Gajaria G.T., *Laws Relating to Building and Engineering Contracts in India*, Lexis Nexis, Butterworth, 2000.
2. Jimmie Hinze, *Construction Contracts*, McGraw Hill, 2013.
3. Joseph T. Bockrath, *Contracts and the Legal Environment for Engineers and Architects*, McGraw Hill, 2013.
4. Kwaku, A., Tenah, P.E. Jose M.Guevara, P.E., *Fundamentals of Construction Management and Organisation*, Prentice Hall, 1985.
5. Patil. B.S, *Civil Engineering Contracts and Estimates*, Orient Blackswan Private Ltd, 2015.

CO Code	Course outcome statement
CO1	Evaluate various types of construction contracts and their legal aspects
CO2	Identify proper dispute resolution systems.
CO3	Oversee labour and safety regulations in construction projects.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2		1	2	3
CO2	3	2		1	2	3
CO3	3	2		1	2	3

21SC613 ADVANCED STRUCTURAL DESIGN 2 -1-0-3

Stress-strain characteristics of concrete under multi- axial stresses- confined concrete- Effect of cyclic loading on concrete and reinforcing steel. Control of deflections- Control of cracking – Codal procedures on crack-width and deflection computation. Strut and Tie Models- corbels and deep beams. Design of corbels, Deep beams and RC walls. Inelastic behviour of concrete beams, moment – rotation curves, Strength and ductility concept- Design of joints in frames. Design of retaining wall and column jacketing. Fasteners: Methods of installation and behavior. Screws and rivets in cold formed steel construction. Types of connections, Behaviour of local elements, Analysis, Design and Detailing. Cold Formed Steel Members: Effective width and Direct Strength Design methods.

TEXT BOOKS/ REFERENCES:

1. Arthur. H. Nilson, David Darwin and Charles W Dolan, *Design of Concrete Structures*, Tata McGraw Hill, 2004.
2. Park.R and Paulay, T, Reinforced *Concrete Structure*, MISL-WILEY - Series Edition, 2009.
3. Varghese P .C, *Advanced Reinforced Concrete Design*, Prentice Hall of India, 2007.
4. Subramanian .N, *Design of Steel Structures*, Oxford University Press, New Delhi 2008.
5. Wei-Wen Yu and Roger A .Laboube, *Cold-Formed Steel Design*, Fourth Edition, Structures, John Wiley & Sons, 2010.

CO Code	Course outcome statement
CO1	Understand the detailed characteristics of concrete stress- strain curves and deflection concepts
CO2	Design the advanced RC structures
CO3	Design and detail of steel members , fasteners and connections
CO4	Understand the behaviour and application of Cold formed Steel structures.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	3	2	1	
CO2	1	3	2	1	1	
CO3	1	3	2	1	1	
CO4	2	1	2	2		1

21SC614 CONSTRUCTION SOFTWARE LABORATORY 1-0-3-2

Project management software - Project estimation, project planning, project scheduling, network analysis, project time reduction and optimization, resource leveling, project time, cost and finance management, earned value analysis.

CO Code	Course outcome statement
CO1	Prepare construction project schedules and allocate resources.
CO2	Monitor performance of the projects and update the schedules.
CO3	Perform budgeting, earned value analysis, and prepare reports

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	-		
CO2	3	3	2	-		-
CO3	3	3	2	-		-

21RM612 RESEARCH METHODOLOGY 2-0-0-2

Unit I:

Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research,Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach,Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. ConfirmatoryResearch, Experimental vs Theoretical Research, Importance of reasoning in research.

Unit II:

Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review,Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval,Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:

Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement SystemsAnalysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, FieldExperiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical DataAnalysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:

Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract,introduction, methodology, results and discussion, conclusion sections of a manuscript. References,Citation and listing system of documents

Unit V:

Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific

Misconduct.Plagiarism, Unscientific practices in thesis work, Ethics in science

TEXT BOOKS/ REFERENCES:

1. Bordens, K. S. and Abbott, B. B., "Research *Design and Methods – A Process Approach*", 8thEdition, McGraw-Hill, 2011
2. C. R. Kothari, "*Research Methodology – Methods and Techniques*", 2nd Edition, New Age International Publishers
3. Davis, M., Davis K., and Dunagan M., "*Scientific Papers and Presentations*", 3rd Edition,Elsevier Inc.
4. Michael P. Marder," *Research Methods for Science",* Cambridge University Press, 2011
5. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "*Intellectual Property in New Technological Age".* Aspen Law & Business; 6th Edition July 2012

CO Code	Course outcome statement
CO1	To understand the Meaning, motivation, objectives and type of research.
CO2	To understand and apply review of literature, identification of variables and construction of hypotheses for formulating a research problem to decide what to research.
CO3	To understand how to conduct a research study through learning system analysis, design of experiment and data collection, for writing a research proposal.
CO4	To understand and apply the writing skills for formulating a manuscript.
CO5	To understand the Intellectual property rights, Ethics of Research and Plagiarism

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	0	0	2	0	0	0
CO2	0	0	2	0	0	0
CO3	0	0	3	0	0	0
CO4	0	0	2	3	2	0
CO5	0	0	0	2	3	3

21SC797 INDUSTRY TRAINING/ INTERNSHIP (Vacation) 0-0-3-P/F

Students have to undergo minimum of one-month practical training/internship in Structural and Construction related organizations of their choice with the approval of the department. At the end of the training student will submit a report as per the prescribed format to the department.

CO Code	Course outcome statement
CO1	Understand industry environment, practices and related problems
CO2	Prepare technical documents and give presentations related to the training completed.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	0	3	3
CO2	3	3	3	2	3	3

PROGRAMME ELECTIVES

21SC631 MECHANICS OF COMPOSITE MATERIALS 3-0-0-3

Composite materials and its characteristics – Analysis of an orthotropic lamina- Analysis of laminated composites- Fracture mechanics- Determination of strain energy release rate- Manufacturing Processes- Testing of Composites – Stress analysis – interlaminar stresses and free edge effects- Failure Criteria – Whitnessnuismer failure criteria- Vibration and stability analysis – Introduction to Design of Composite Structures – Introduction to structural Design and Analysis of mechanically fastened joints – Optimization Concepts – Fatigue in Composites – Effects of holes in Laminates – Transverse shear effects- Post curing shapes of Unsymmetric Laminates – Environmental Effects on Composite Materials – Study of Hygrothermic effects on laminates- Quality control and Characterization of Composite- Non Destructive testing on Composites- Recycling of Composites – Primary and Secondary Recycling of Composites.

TEXTBOOKS/REFERENCES:

1. Mallick P.K., *Fiber Reinforced Composites: Materials, Manufacturing and Design,* CRC Press, 2007.
2. Robert M. Jones, *Mechanics of Composite Materials,* Second Edition, Taylor and Francis, 1998.
3. Halpin J.C., *Primer on Composite Materials Analysis,* CRC Press, 1992.
4. Mallick P.K and Newman S. (Ed.), *Composite Materials Technology – Processes andProperties,* Carl HanserVerlag, Munich, 1990.
5. Agarwal B.D. and BroutmenL.J.,*Analysis and Performance of Fiber Composites,* John Wiley and Sons, 1990.

CO Code	Course outcome statement
CO1	Explain the mechanical behavior of layered composites compared to isotropic materials.
CO2	Apply constitutive equations of composite materials and understand mechanical behavior at micro, macro and meso level.
CO3	Understand mechanical behavior of composites due to variation in temperature and moisture.
CO4	Understand the nondestructive testing and recycling of composites

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	0	1	1
CO2	2	3	2	1	1	1
CO3	2	3	1	0	1	2
CO4	3	3	1	0	2	3

21SC632 ADVANCED CONCRETE TECHNOLOGY 3-0-0-3

Concrete as a composite material; Materials science aspects of the properties and behavior of Cement Concrete: physical and chemical aspects of cement hydration, type and morphology of hydrates; Chemical and Mineral admixtures for concrete. Rheological behaviour of fresh Concrete - Fresh and hardened concrete properties; elastic behavior, shrinkage, creep, behavior under various stress states. Durability - Permeability, chemical attack, acid attack, corrosion in concrete. -Modern trends in concrete manufacture and placement techniques, Methods of transportation, placing and curing-extreme weather concreting, Special concreting methods - Vacuum dewatering of concrete-Under water concreting. High performance and High Strength concrete; Self compacting concrete - Light weight concrete, Heavy weight and mass concrete, Heat resisting concrete, Fiber reinforced concrete.Sustainability- Recycling of concrete. Nondestructive evaluation of concrete structures; Cement based composites; Fracture mechanics of concrete.

TEXT BOOKS/ REFERENCES:

1. Nevile, A.M., *Properties of Concrete,* Pearson, 2013.
2. Mehta P.K. and Monteiro P.J.M, *Concrete: Microstructure, Properties andMaterials,*McGrawHillEducation , 2017.

3. Gambhir, M.L., Concrete Technology, McGraw Hill Education (India), 2013.
4. Zongjin Li, *Advanced Concrete Technology*, Wiley
5. Shetty, M.S. and Jain, A.K., Concrete Technology, S.Chand Publishing, 2018.

CO Code	Course outcome statement
CO1	Explain the materials science aspects of the properties concrete.
CO2	Proportion concrete mixtures to meet performance requirements.
CO3	Evaluate durability related issues and suggest preventive measures.
CO4	Apply the modern trends in concrete production and placement.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1		1	
CO2	3	3	1	1	1	
CO3	3	3	1	1	1	
CO4	3	3	1	1	1	

21SC633 CONSTRUCTION METHODS AND EQUIPMENT 3-0-0-3

Planning Process for Equipment and Methods; Cost of Owning and Operating Construction Equipment - Ownership cost, Depreciation, Operating cost, and Ownership and operating costs calculation methods; Financing methods, Rental and lease contract considerations. Equipment Life and Replacement Procedures - Physical, profit and economic life, Replacement analysis; Engineering Fundamentals of Moving Earth - Rolling resistance, Effect of grade on tractive effort, Effect of altitude on performance of IC engines; Selection of Earthmoving equipment, Excavating equipment, Hauling equipment, Lifting equipment, Paving equipment, Pile driving equipment, Concreting equipment. Selection of forming systems. Estimating and Optimizing Construction Equipment System Productivity - Scheduling Equipment intensive construction projects.

TEXT BOOKS/ REFERENCES:

1. R.L.Peurifoy, C.J. Schexnayder, R.L.Schmitt. and A.Shapira, *Construction Planning, Equipment, and Methods*, McGraw Hill Education, 2018.
2. F. Harris, *Modern Construction and Ground Engineering Equipment and Methods*, Second Edition, Longman, London, 1994.
3. D.G. Gransberg, C.M. Popescu and R.C. Ryan, *Construction Equipment Management for Engineers, Estimators, and Owners*, CRC Press, 2006.

4. D.A.Day and N.B.H. Benjamin, *Construction Equipment Guide,* Second Edition, Wiley, New Jersey, 1991.

5. J.E.Schaufelberger andG.C.Migliaccio, *Construction Equipment Management,* Routledge, 2019.

CO Code	Course outcome statement
CO1	Analyse equipment cost and replacement alternatives.
CO2	Select appropriate equipment for earthmoving, excavating, lifting, concreting in construction projects.
CO3	Optimise construction equipment system productivity.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1		2	1
CO2	3	3	1		2	
CO3	3	3	1		2	1

21SC634 STRUCTURAL DYNAMICS 3-0-0-3

Overview - Basic features of dynamic loading and response - models for dynamic analysis - lumped mass, generalized displacements and finite element models - Formulation of equation of motion - Degrees of freedom - mass moment of inertia - Generalized single degree of freedom systems - Free vibration of single degree of freedom system - Negative damping - Single degree of freedom system - Response to impulsive loads - Approximate analysis - Response to general dynamic loading - Numerical analysis in the frequency domain, fast Fourier transform analysis - Multi degree of freedom system - analysis of multi- degree of freedom system - mode superposition analysis - Distributed Parameter System-Practical Vibration Analysis. Design examples: - Turbo generator machine foundations , Analysis of buildings for E.Q force using IS 1893.

TEXT BOOKS/ REFERENCES:

1. Paz Mario, *Structural Dynamics - Theory and Computation,* Springer, 2007.
2. Anil K Chopra, *Dynamics of Structures - Theory and Applications to Earthquake Engineering,*Pearson Education India, 2007.
3. Clough,R.W, and Penzien J., *Dynamics of Structures* , McGraw-Hill, Inc, 1993.
4. Agarwal .P and Shrikande. M, *Earthquake Resistant Design of Structures,* Prentice Hall of India, 2006.

CO Code	Course Outcome Statement
CO1	Explain the basic concepts of structural dynamics
CO2	Develop equations of motion of single and multi-degree of freedom systems
CO3	Perform dynamic analysis of single and multi-degree of freedom systems subjected to different type of loads
CO4	Understand dynamic analysis of continuous systems

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	3	-
CO2	3	2	3	-	2	-
CO3	2	2	2	-	1	-
CO4	2	2	1	-	1	-

21SC635 THEORY OF PLATES AND SHELLS 3-0-0-3

Prerequisite: : A course on Theory of Elasticity.

Introduction – Formulation of governing equations and associated boundary conditions by equilibrium and energy methods, Rectangular plates- Solution of equation by double and single series, Circular plates – Symmetric and unsymmetric loading cases, Continuous Plates, Plates with various plan forms, plates with variable flexural rigidity, plates on elastic foundation . Numerical and Approximate Methods- finite difference method- finite element method, energy methods and other variational methods. Introduction, Theory of Surfaces- first and second fundamental forms- principal curvatures, Formulation of governing equations in general orthogonal curvilinear coordinates based on classical assumptions- Various shell theories, Membrane theory- governing equations- shells of revolution- application to specific geometric shapes- ax symmetric and non –axisymmetric loading cases. General theory of shells- governing equations and associated boundary conditions for specific geometry of shells (cylindrical, conical and spherical shells)- classical solutions – finite difference and finite element methods applied to shell problems.

TEXT BOOKS/ REFERENCES:

1. Vardhan T.K. and Bhaskar. K, *Analysis of Plates: Theory and Problems,*Narosa Book Distributors Pvt Ltd, 1999.

2. Timoshenko. S, and Woinowsky - Kreiger, *Theory of Plates and Shells*, Tata McGraw - Hill Education, 2010.
3. Chandrashekharan .K, *Theory of Plates,* Universities Press (India) Ltd., 2001.

CO Code	Course Outcome Statement
CO1	Understand the behavior of plate and shells
CO2	Use analytical methods for the solution of thin plates and shells.
CO3	Apply the numerical techniques for solving complex problems in shells and plates.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	1	2	-
CO2	3	2	3	-	1	-
CO3	2	2	2	-	1	-

21SC636 SYSTEM INTEGRATION IN CONSTRUCTION 3-0-0-3

Structural system, Systems for enclosing buildings, Functional aesthetic system, Materials selection and Specification. Environmental-Qualities of enclosure necessary to maintain a specified level of interior enviromentalquality-Weather Resistance-Thermal infiltration-Acoustic control-Transmission reduction-Air quality-Illumination-Relevant Systems integration with structural systems -Elevators, Escalators, Conveyors, Security Systems in High Rise Building Complexes, Public Buildings, Parking Lots And Complex Structures like Hospitals, Public Transport Terminals. Design parameters for Determining the Loads & Requirement, Operation and Maintenance of these Services.- Component Longevity in terms of operation performance and resistance to deleterious forces-Planning systems for least maintenance-Feasibility for replacement of damaged components -equal life elemental design-Maintenance free exposed and finished surfaces.- Intelligent Buildings & Building Management System (BMS)-Concept-Purpose-Control Technologies- Automation of Services and Equipment – BMS - Commercial, Industrial, Institutional and Domestic Buildings-Energy Management Systems and Building controls.

TEXT BOOKS/ REFERENCES:

1. Fred Hall and Roger Greeno, *Building Services Handbook,* Routledge, 2013.
2. David V Chadderton, *Building Services Engineering,* Routledge, 2012.
3. PeterR Smith and Warren G Jullian, *BuildingServices,* Applied Science Publishers Ltd, 1976.
4. A.J.Elder and MartizVindenBarg, *Handbook of Buildings and Enclosure* , Mc GrawHill Book Co, 1983.

5. Derek Clements-Croome, *Intelligent Buildings: Design, Management andOperation*, Thomas Telford, 2004.

CO Code	Course Outcome Statement
CO1	Select structural systems and materials for meeting functional criteria
CO2	Integrate Services, Safety and Maintenance requirements in construction.
CO3	Identify appropriate Building Management System (BMS)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	-	2	1
CO2	2	2	1	-	3	2
CO3	2	2	1	-	3	2

21SC637 QUALITY CONTROL AND SAFETY IN CONSTRUCTION 3-0-0-3

Introduction to quality; Importance of quality; Quality transition - quality control and inspection, quality assurance, total quality management; Evolution of quality management; Planning and control of quality during design of structures; Tools and techniques for quality management; Inspection of materials and machinery; Quality assurance in construction; Formwork planning and design for quality. Systems quality management; Quality standards/codes in design and construction; (ISO:9000); Total quality management (TQM) - principles, tools and techniques. - Introduction to safety; Safety and health programs in construction industry; Planning for safety provisions; Analysis of construction hazards and accidents; Construction hazards and safety guidelines; Prevention techniques for construction accidents; Safety requirements for scaffolding; Site management with regard to safety recommendations; Training for safety awareness and implementation; Construction safety and health manual.

TEXT BOOKS/ REFERENCES:

1. Dale B. G, *Managing Quality,*Sixth Edition, John Wiley & sons, Inc., 2016.
2. Reese. C.D and Eidson J.V, *Handbook of OSHA Construction Safety and Health*, Second Edition, CRC Press, Boca Raton, 2006.
3. Reese, Charles D..*Occupational Safety and Health: Fundamental Principles and Philosophies*. United States, CRC Press, 2017.
4. Jimmie W. Hinze "*Construction Safety*", Prentice Hall of India, 1997.
5. Harris .F, McCaffer .R and Edum-Fotwe .F, *Modern Construction Management*, Sixth Edition, Blackwell Publishing, Oxford, 2006.

6. Holt S. J, *Principles of Construction Safety*, Blackwell Publishing, Oxford, 2008.

CO Code	Course Outcome Statement
CO1	Recognise and examine the quality control management concepts
CO2	Apply quality control concepts for improving the quality of construction.
CO3	Maintain the records of quality assurance processes and audits.
CO4	Examine construction safety management.
CO5	Apply safety management in construction operations

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	0	3	3
CO2	2	1	2	0	3	3
CO3	3	1	1	3	3	3
CO4	1	1	1	0	3	3
CO5	3	2	3	2	3	3

21SC638 PRE-STRESSED CONCRETE DESIGN 3-0-0-3

Introduction to prestressed concrete: types of prestressing, systems and devices, materials, losses in prestress. Analysis of PSC flexural members: basic concepts, stresses at transfer and service loads, ultimate strength in flexure, code provisions. - Statically determinate PSC beams: design for ultimate and serviceability limit states for flexure, and flexure combined with axial compression or tension; analysis and design for shear and torsion, code provisions. Transmission of prestress in pretensioned members; Anchorage zone stresses for post tensioned members. Composite construction with precast PSC beams and cast insitu RC slab Analysis and design, creep and shrinkage effects. Partial prestressing principles, analysis and design concepts, crack- width calculations. Analysis and design of prestressed concrete pipes, tanks and spatial structures slabs, grids, folded plates and shells.

TEXT BOOKS/ REFERENCES:

1. LinT .Y and Burns N.H, *Design of Prestressed Concrete Structures,* John Wiley and Sons, 1982.
2. RajaGopalan .N, *Prestressed Concrete,*Narosa Publishing House, New Delhi, 2002.
3. Arthur. H. Nilson, *Design of Prestressed Concrete,* Wiley India Pvt Ltd, 2011
4. Guyon .Y, *Limit State Design of Prestressed Concrete Vols I and II,* Applied Science Publishers, London, 1974.
5. Sinha N.C and Roy S. K, *Fundamentals of Prestressed Concrete,* S Chand and Co., New Delhi, 1985.

CO Code	Course Outcome Statement
CO1	Explain the general mechanical behavior of prestressed concrete.
CO2	Analyse and design prestressed concrete members under various loading conditions.
CO3	Analyse and design for deflection and crack control of prestressed concrete members.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	1		
CO2	2	3	2	1		
CO3	2	3	2	1		

21SC639 ANALYSIS AND DESIGN FOR EARTHQUAKE FORCES 3-0-0-3

Engineering Seismology, Ground Motion parameters, Design philosophy, Code provisions(IS1893 & 13920), Building equivalent static analysis, design of water tanks, shear wall, special RC frame, Calculation of EQ load – 3D modelling of building systems and analysis (theory only), Design and detailing of frames, shear wall and frame. Cyclic loading behaviour of RC, steel and pre-stressed concrete elements - modern concepts – base isolation – Adoptive systems – case studies. Introduction to Inelastic Design Response Spectra (IDRS), Response reduction factors, Pushover analysis, Inelastic cyclic behaviour of steel and reinforced concrete structures, ductility and energy dissipation capacity, Principles of Capacity Design. Aseismic design of steel buildings. Introduction to Wind load as per IS873 and its application on truss.

TEXT BOOKS/ REFERENCES:

1. Anil K Chopra, *Dynamics of Structures - Theory and Applications to EarthquakeEngineering*, Prentice Hall, NewDelhi, 2004.
2. Agarwal. P and Shrikande .M, *Earthquake Resistant Design of Structures,* Prentice Hall of India, 2007
3. Taranath,B. S, *Wind and Earthquake Resistant Buildings – Structural Analysis &Design,* Marcel Decker, New York, 2005.
4. Lawson T. V, *Wind Effects on Building: Design Applications,*Spon Press, 1990.
5. Taranath B.S, *Structural Analysis and Design of Tall Building,* CRC Press, 2011.

CO Code	Course Outcome Statement
CO1	Explain the importance of seismic design and the underlying principles of seismic analysis.
CO2	Critically evaluate application of earthquake engineering concepts in the field.
CO3	Understand the various codal provisions regarding seismic design.
CO4	Design buildings according to earthquake design philosophy

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	0	1	1
CO2	2	2	1	0	0	1
CO3	3	2	2	0	1	2
CO4	3	3	2	1	1	2

21SC640 FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES 3-0-0-3

Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability – case studies – learning from failures – causes of distress in structural members – design and material deficiencies – over loading - Diagnosis and Assessment of Distress: Visual inspection – non destructive tests – ultrasonic pulse velocity method – rebound hammer technique – pullout tests– Windsor probe test – crack detection techniques – case studies – single and multistorey buildings – Fibreoptic method for prediction of structural weakness -Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment – pollution and carbonation problems – durability of RCC structures – damage due to earthquakes and strengthening of buildings – provisions of BIS 1893 and 4326. Methods of repair in concrete, steel and timber structural components.- Modern Techniques of Retrofitting: Structural first aid after a disaster – guniting, jacketing – use of

chemicals in repair – application of polymers – ferrocement and fiber concretes as rehabilitation materials – strengthening by pre-stressing – case studies.- Maintenance - inspection and planning, budgeting and management.

TEXT BOOKS/ REFERENCES:

1. Robert.TRatay, *Forensic Structural Engineering Handbook,* Mc Graw Hill, 2009.
2. James Douglas and Bill Ransom, *Understanding Building Failures*,Routledge, 2013.
3. Peter H Emmons, *Concrete Repair and Maintenance,*Galgotia Publications, 2010.
4. Dovkaminetzky, Design and Construction Failures, Galgotia Publication, New Delhi, 2001.
5. Macdonald S, Concrete – Building Pathology, Wiley, 2002.

CO Code	Course outcome statement
CO1	Diagnose the distress through understanding of the causes and factors.
CO2	Assess structural distress through systematic inspection.
CO3	Suggest repairs and rehabilitation measures of the structure

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	0	1		2	
CO2	3	2	1		1	
CO3	3	2	1	1	1	1

21SC641 GEOTECHNICS FOR INFRASTRUCTURE 3 -0-0-3

Site investigation for infrastructure projects; Principles of exploration; Modern methods of boring and sampling; Sampling records, Soil profiles, various types of field tests; Excavation scheme. - Engineering properties of soft, weak and compressible deposits; Methods of soil improvement using mechanical, chemical; Thermal, electrical methods; - Dynamic consolidation; Vibroflotation - Types of foundations for industrial structures; Sheet piles and cofferdams; Design of dewatering systems. Preloading and vertical drains, Introduction to Geotextiles and Geomembranes, Grouting and Injection. Recent trends in infrastructure projects like soil nailing, reinforced earth, gabion walls.

TEXT BOOKS/ REFERENCES:

1. Purushotham Raj, *Ground Improvement Techniques*,Laxmi Publications, 2005.
2. Lymon C Reese, William M Isenhower and Shin-Tower Wang, *Analysis and Design of Shallow and Deep Foundations*, John Wiley and Sons, 2005.
3. Swami Saran, *Analysis and Design of Substructures*, Oxford and IBH Publishing, New Delhi, 2008.
4. Ninan P Kurian, *Design of Foundation Systems*,Narosa Publishing House, New Delhi, 2005.
5. Moseley, *Text Book on Ground Improvement*,Spons Architecture Price Book, 2004.
6. Jones J.E.P, *Earth Reinforcement and Soil Structure*, Butterworths, 1995.

CO Code	Course outcome statement
CO1	Understand the significance of site investigation and various sampling techniques
CO2	Explain a range of ground improvement techniques with respect to field conditions
CO3	Suggest alternative solutions to difficult earth construction problems and evaluate their effectiveness
CO4	Understand different types of geo-synthetics and applications in field conditions.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	2
CO2	3	3	2	2	3	2
CO3	3	3	2	3	3	2
CO4	3	3	2	2	3	2

21SC642 OPTIMIZATION TECHNIQUES 3-0-0-3

Introduction to Optimization: Engineering application of Optimization – Statement of an optimization problem- Optimal Problem formulation – Classification of optimization problems. Definition of Global and Local minima. Unconstrained Optimization: Optimality Conditions- Algorithms for univariate optimization- Algorithms for multivariate optimization- Convergence of algorithms – Engineering applications of unconstrained algorithms. Lagrange multiplier Theory & Duality: Lagrange Multipliers- Kuhn- Tucker Optimality Conditions and sufficiency for convex problems- Lagrangian duality- Saddle point conditions. Constrained Optimization: Optimality conditions- Feasible direction methods- Frank- Wolfe algorithm- Gradient Projection – Active set methods- Penalty function methods- Constrained steepest

descent method. Modern methods of optimization: Genetic Algorithms- Simulated Annealing – Tabu search – Ant Colony optimization – Particle Swarm Optimization – Neural- Network based Optimization – Fuzzy optimization techniques. Introduction to Multi – Objective optimization – Classical methods- Pareto Optimality – Use of evolutionary algorithms for solving Multi Objective optimization problems. - Lab Practice: Use of programming languages and Matlab to solve optimization problems.

TEXTBOOKS/REFERENCES:

1. Kalyanmoy Deb, *Optimization for Engineering Design Algorithms and Examples,* Prentice Hall, 2012.
2. Rao S. S,*Engineering Optimization Theory and Practice*, Third Edition, New Age International, 2010.
3. Saravanan. R,*Manufacturing Optimization Through Intelligent Techniques*, Taylor and Fransis,2006.
4. Ravindran, Phillips and Solberg, *Operations Research Principles and Practice,* Wiley India, 2007.
5. Hadley. G, *Non Linear and Dynamic Programming,* Addison Wesley, 1964.

CO Code	Course Outcome Statement
CO1	Describe a problem clearly, identify its components and analyze the individual functions
CO2	Translate the given set of conditions to that of an optimization problem and develop an algorithm.
CO3	Understand various modern techniques of optimisations using soft computing techniques
CO4	Analyse the optimization problem using programming languages and Matlab

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	2
CO2	3	2	2		2	1
CO3	2	2	1	2	2	2
CO4	1	1	1		3	2

21SC643 SMART MATERIALS AND STRUCTURES 3-0-0-3

Introduction to passive and active systems – need for active systems – smart systems – definitions and implications - active control and adaptive control systems – examples. Components of smart systems– system features and interpretation of sensor data – pro active and reactive systems – demo example in component level – system level complexity. Materials used in smart systems – characteristics of sensors – different types smart materials – characteristics and behaviour of smart materials – modelling smart materials – examples. Control Systems – features – active systems – adaptive systems – electronic, thermal and hydraulic type actuators – characteristics of control systems – application examples. Integration of sensors and control systems – modelling features – sensor-response integration – processing for proactive and reactive components – FE models – examples.

TEXT BOOKS/ REFERENCES:

1. Srinivasan, A.V. and Michael McFarland, D., *Smart Structures: Analysis and Design*, Cambridge University Press, 2009.
2. Yoseph Bar Cohen, *Smart Structures and Materials 2003*, The International Society for Optical Engineering, Spie, 2003.
3. Michelle Addington and Daniel L. Schodek, *Smart Materials and Technologies: For the Architecture and Design Professions*,Routledge 2004.
4. Culshaw,B., *Smart Structures and Materials*, Artec House Publishers, 1996

CO Code	Course Outcome Statement
CO1	Understand the concepts of functional material, smart material and smart system
CO2	Select smart materials for specific structural applications

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	1			
CO2	2	2	1			

21SC644 STABILITY OF STRUCTURES 3-0-0-3

Buckling of columns – introduction – concepts of stability – methods of Neutral Equilibrium – Euler column – Eigen value problem – Axially loaded column – Eccentrically loaded column, Energy principle – Raleigh Ritz method – Galerkin method – Numerical methods (New mark's Finite Difference and matrix methods) Beams and Beam columns – introduction – lateral buckling of beams – beam column with concentrated and distributed loads – effect of axial load on bending stiffness, Buckling of frames – introduction – modes of buckling – critical load using various methods. Neutral equilibrium – slope deflection equations, matrix method.

Buckling of plates – Differential equation of plate buckling – critical load on plates for various boundary conditions – Energy method – Finite difference method.

TEXT BOOKS/ REFERENCES:

1. Timoshenko and Gere. *Theory of elastic stability*, Tata McGraw Hill, 2010.
2. Alexander Chajes, *Principles of Structural Stability Theory*, Prentice Hall, New Jersey, 1980
3. Iyenger, N.G.R., *Structural Stability of columns and plates*, Affiliated East west press Pvt Ltd., 1990.
4. Bleich F., *Buckling Strength of metal structures*, McGraw Hill, 1991.

CO Code	Course outcome statement
CO1	Understand the difference between stability and instability
CO2	Evaluate the stability of column, beam column and frames.
CO3	Assess the influence of plate buckling feature in the design

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1		3	1
CO2	3	3	3	2	3	2
CO3	3	3	3	2	3	2

21SC645 INDUSTRIAL STRUCTURES 3-0-0-3

Planning and Functional Requirements: Classification of Industries and Industrial Structures – planning for layout requirements regarding lighting, ventilation and fire safety – protection against noise and vibration – guidelines from factories act – material handling systems – erection sequence and guidelines for supporting structure. Introduction to Steel structures and connection details. Design of Gantry girders, Plate girders, Cooling towers, Bunkers and Silos. Light gauge steel structures – Direct strength method, Behaviour of Compression Elements - Effective width for load and deflection determination – Behaviour of Unstiffened and Stiffened Elements – Design of webs of beams – Flexural members – Lateral buckling of beams – Shear Lag – Flange Curling – Design of Compression Members – Wall Studs.

TEXT BOOKS/ REFERENCES:

1. Alexander Newman, *Metal Building Systems – Design and Specifications*, second Edition, Tata McGraw - Hill Education, 2003.
2. Gaylord E.H, Gaylord N.C and Stallmeyer J. E, *Design of Steel Structures*, 3rd edition, Tata McGraw - Hill Education, 2010.
3. S.N.Manohar, *Tall Chimneys - Design and Construction*, Tata McGraw Hill, 1985.
4. Subramanian N, *Design of Steel Structures*, Oxford University Press, NewDelhi 2008.

CO Code	Course outcome statement
CO1	Understand and appreciate basic concepts in planning and functional requirements.
CO2	Analyze and design of plate girders, gantry girder, cooling tower bunker and silos
CO3	Understand the behavior of cold form steel and design the structural component by direct strength method.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	2	3	3
CO2	3	3	2	2	2	3
CO3	3	3	2	2	2	3

21SC646 BRIDGE ENGINEERING 3-0-0-3

Introduction Classification and components of bridges, historical perspective, layout and planning, investigations for Bridges, choice of type of the bridges, conceptual bridge design, bridge aesthetics. Bridge appurtenances. Loads on bridges, loading standards for highway (IRC) - Analysis and design of RC and PSC bridge decks: slab culvert bridges, slab and beam bridges, load distribution in slabs and beams, bowstring girder bridges, behaviour of skew bridge decks. Behaviour, analysis and design of composite construction. Design of bearings, substructure and foundations piers and abutments of different types, shallow and deep foundations design and constructional aspects.Modern methods of construction of concrete, steel and composite bridges, their impact on analysis and design.

TEXT BOOKS/ REFERENCES:

1. E.J. O'Brien and D.L. Keogh, *Bridge deck analysis*, Spons Architecture,1999.
2. D.Johnson Victor, *Essentials of bridge engineering*, Oxford University Press, 2008.
3. Raina,V.K.*Concrete Bridge Practice*, Shroff Pub & Dist. Pvt. Ltd (2007)
4. N.Krishna Raju, *Design of bridges*, Oxford University Press, 2008.
5. Ponnuswamy,S., *Bridge Engineering*, Tata McGraw - Hill Education (2007)

CO Code	Course outcome statement
CO1	Comprehend and appreciate the basic concepts in layout, planning and proportioning of bridges
CO2	Understand the load distribution and IRC standards
CO3	Analyse and design of super structure and substructure
CO4	Design of bearing, dirt wall and crash barrier

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	1	2	2	3
CO2	2	2	1		3	2
CO3	3	3	2	2	3	2
CO4	3	3	2	2	3	2

21SC647 PREFABRICATION ENGINEERING 3-0-0-3

Types of prefabrication, prefabrication systems and structural schemes- Disuniting of structures- Structural behaviour of precast structures. Handling and erection stresses- Application of prestressing of roof members; floor systems two way load bearing slabs, Wall panels, hipped plate and shell structures.-Dimensioning and detailing of joints for different structural connections; construction and expansion joints. Production, Transportation & erection- Shuttering and mould design Dimensional tolerances- Erection of R.C. Structures, Total prefabricated buildings.-Designing and detailing prefabricated units for 1) industrial structures 2) Multistorey buildings and 3) Water tanks, silos bunkers etc., 4) Application of prestressed concrete in prefabrication.

TEXT BOOKS/ REFERENCES:

1. Sharon Chung-Klatte, Ulrich Knaack, ReinhardHasselbach, *Prefabricated Systems: Principles of Construction*, Birkhauser, 2013.
2. Hass, A.M., *Precast Concrete Design and Applications*, CRC Press, 1983.
3. Promyslolw, V., *Design and Erection of Reinforced Concrete Structures*, MIR Publishers,Moscow 1980.
4. B.Lewicki, *Building with Large Prefabricates*, Elsevier Publishing Company, 1966.
5. LassloMokk, *Prefabricated Concrete for Industrial and Public Sectors*, AkademiaiKiado, Budapest, 1964.

CO Code	Course Outcome Statement
CO1	Formulate structural schemes and choose prefabrication systems
CO2	Analyse handling and erection stresses.
CO3	Design and detail prefabricated units for applications

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	2	1
CO2	3	3	3	2	-	-
CO3	3	3	3	2	-	1

21SC648 DESIGN OF OFFSHORE STRUCTURES 3-0-0-3

Introduction to Wave Mechanics – Wave generation by Wind - Small Amplitude Wave Theory ; Formulation and solution, Wave Celerity, Length and Period, Classification of waves based on relative depth, Orbital motions and Pressure - Standing waves - Wave trains and Wave energy - Wave reflection, Wave refraction and Wave diffraction - Breaking of waves. Types of wave theories and its applications Types of offshore structures and conceptual development - Analytical models for jacket structures - Materials and their behaviour under static and dynamic loads - Statutory regulations - Allowable stresses - Various design methods and Code Provisions - Design specification of API, DNV, Lloyd's and other classification societies - Construction of jacket and gravity platforms. Operational loads - Environmental loads due to wind, wave, current and buoyancy - Morison's Equation - Maximum wave force on offshore structure - Concept of Return waves - Principles of Static and dynamic analyses of fixed platforms - Use of approximate methods - Design of structural elements. Introduction to tubular joints - Possible modes of failure - Design aspects as per API Code for tubular joints - Fatigue of tubular joints - Fatigue behaviour - S-N curves - Palmgren-Miner cumulative damage rule - Corrosion - Corrosion mechanism - Types of corrosion - Offshore structure corrosion zones – Biological corrosion - Preventive measures of Corrosion - Principles of cathode protection systems - Sacrificial anode method and impressed current method – Online corrosion monitoring - Corrosion fatigue. Case studies on fixed platform construction and its erection

TEXT BOOKS/ REFERENCES:

1. D. V. Reddy and A. S. J. Swamidas, *Essentials of Offshore Structures*, CRC Press, 2013.

2. B.C Gerwick, Jr. *Construction of Marine and Offshore Structures*, CRC Press, Florida, 2007.21
3. Dawson, T. H., *Offshore Structural Engineering*, Prentice Hall, 1983.
4. API RP 2 A., *Planning, Designing and Constructing Fixed Offshore Platforms*, API., 2000.
5. McClelland, B and Reifel, M. D., *Planning & Design of fixed offshore Platforms*, Kluwer Academic Publishers, 1986.

CO Code	Course Outcome Statement
CO1	Understand the different offshore structures and differences from onshore structures
CO2	Find and understand important recommendations regarding environmental conditions and load estimation.
CO3	Describe the layout of marine structures from a functional and safety requirements point of view

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	1		1	2
CO2	2	2	1		1	2
CO3	2	2	3	2	2	2

21SC649 PAVEMENT ANALYSIS AND DESIGN 3-0-0-3

Introduction - Comparison between Flexible & Rigid Pavements -Highway and Airport pavements – Types and Component layers of Pavements – their functions - A brief study on aggregates, bitumen and modified bitumen like cutback, emulsion, polymer modified bitumen - Factors affecting Design and Performance of Pavements - Various Methods of Assessment of Subgrade Soil Strength for Pavement Design - Causes and Effects of variation in Moisture Content and Temperature. Bituminous mix design methods, specifications and testing.Analysis& Design of Flexible Pavement: Stresses and Deflections in Homogeneous Masses - Burmister's 2-layer, 3- layer Theories - Wheel Load Stresses - ESWL of Multiple Wheels – Repeated Loads and EWLfactors - Sustained Loads and Pavement behaviour under Traffic Loads - Empirical, Semi-empirical and Theoretical Approaches - Development, Principle, Design steps, Advantages and Applications of different Pavement Design Methods Analysis & Design of Rigid pavements: Types of Stresses and Causes, Factors influencing the Stresses; General conditions in Rigid Pavement Analysis, ESWL, Wheel Load Stresses, Warping Stresses, Friction Stresses, Combined Stresses - Types of Joints in Cement Concrete Pavements and their Functions, Joint Spacing, Design of Slab Thickness, Design of Joint Details for Longitudinal Joints, Contraction Joints and Expansion Joints, IRC Method of

Design.- Pavement Structure & Its Evaluation: Factors affecting Structural Condition of Flexible and Rigid Pavements; Evaluation by Non-Destructive Tests. Pavement Overlays & Design.

TEXT BOOKS/ REFERENCES:

1. Huang Yang H.,*Pavement Analysis and Design*, Pearson Education India, 2008
2. Yoder and Witczak, *Principles of Pavement Design*, Wiley India Pvt Ltd, 2011
3. Nai C. Yang, *Design of Functional Pavements*, McGraw Hill ,1972
4. Hass and Hudson, *Pavement Management System*, McGraw Hill Book Co. ,1978.
5. IRC 37- 2018, "Guidelines for the Design of Flexible Pavements".
6. IRC 58-2015, "Guidelines for the Design of Plain Joined Rigid Pavements for Highways".

CO Code	Course Outcome Statement
CO1	Understand different materials and factors affecting rigid and flexible pavement design
CO2	Comprehend mix design of flexible pavements and its theoretical underpinnings
CO3	Evaluate the various procedures for the design and analysis of flexible and rigid pavements

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1		2	2
CO2	3	3	1	1	2	2
CO3	3	2	1	1	2	2

21SC650 CHARACTERISATION OF MATERIALS 3-0-0-3

Characterization Techniques: Structure of solids: crystal systems and space groups, Bravais lattices, direct and reciprocal lattice, Bragg law, powder diffraction and phase identification, single crystal diffraction, structure factor, X-ray crystal structure determination. Fundamental principles and application to Material characterization: Macroscopic and microscopic techniques– visual examination-optical and electron microscopy (SEM,TEM); chemical andmineralogical analysis techniques – X-ray and neutron diffraction; spectroscopic techniques- image analysis, and nondestructive techniques. Methods for Structure Determination-X-ray diffraction; Analytical techniques for the determination of Structure of construction materials- FTIR, AFM and thermal analyses (sample preparation), energy dispersive analysis (EDAX) -

Characterisation of rheological behavior: Rheological parameters; Classifications of fluids, time independent and time-dependent fluids, elastic viscous fluids. Constitutive equation of rheology, shear and extensional viscosities, dependence of viscosity on temperature, pressure,

molecular weight, strain rate and time. Flow curve. Viscoelasticity - effect of rate of strain, temperature and time on mechanical behavior; Creep, creep compliance, stress relaxation; Dynamic mechanical properties. Flow analysis using rheological models. Measurement of rheological properties. Application of rheology in cement-based materials.

TEXT BOOKS/ REFERENCES:

1. Robert W. Kelsal, Ian W. Hamley, Mark Geoghegan, *Nanoscale-Science and Technology*, John Wiley & Sons Ltd, 2005.
2. Callister WD, *Materials Science and Engineering: An introduction*, Seventh Edition, John Wiley and Sons, 2007.
3. Pillai S.O., *Solid state physics*,New Age International (P) Limited, 2005.
4. Alexander Ya Malkin, Avraam I Isayev, *Rheology: Concepts, Methods & Applications*, ChemTec Publishing, 2006.
5. Nicolas Roussel, *Understanding the Rheology of Concrete*, Woodhead Publishing in Materials Series, Woodhead Pub, 2012.

CO Code	Course Outcome Statement
CO1	Understand and describe the fundamental principles behind the methods of characterization
CO2	Judge suitable method of characterization for a particular material problem
CO3	Understand the theory and methods of modern rheology
CO4	Apply the concepts of rheology in cement-based materials

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1		2	2
CO2	3	3	1	1	2	2
CO3	3	2	1	1	2	2
CO4	3	2	1	1	2	2

21SC651 GEOTECHNICAL EARTHQUAKE ENGINEERING 3-0-0-3

Seismology and Earthquakes: Internal Structure of the Earth, Continental Drift and Plate Tectonics, Faults, Elastic rebound theory, Different sources of Seismic Activity, Geometric Notation, Location of Earthquakes, Size of Earthquakes.

Dynamic Properties of Soils: Measurement of Dynamic Properties of soils, Field Tests, Low strain, Seismic Reflection, Seismic Refraction, Horizontal layering, Steady State Vibration, Spectral analysis of surface wave, Seismic cross hole, Down Hole, Up hole, tests, Laboratory tests, Resonance Column Test, Bender Element, Cyclic Tri-axial test.

Seismic Hazard Analysis: Identification and Evaluation of Earthquake Sources, Geologic Evidence, Tectonic Evidence, Historical Seismicity, Instrumental Seismicity, Deterministic Seismic Hazard Analysis, Probabilistic Seismic Hazard Analysis.

Ground Response Analysis: Ground Response Analysis, One Dimensional Linear, Evaluation of Transfer Function, Uniform undamped soil on rigid rock, Uniform damped soil on Rigid Rock, Uniform damped soil on elastic rock, layered damped soil on elastic rock, Equivalent linear Approximation, Deconvolution.

Site characterization and Design: Different methods and experiments. Local site effects: ground motion amplifications, Development of response /design spectrum, Liquefaction hazard assessments, Landslide hazard assessment, Seismic slope stability analysis, Seismic Analysis and Design of Various Geotechnical Structures.

TEXT BOOKS/ REFERENCES:

1.Steven L. Kramer, *Geotechnical Earthquake Engineering* Prentice Hall, 2003
2.Towhata, Ikuo, *Geotechnical Earthquake Engineering*, Springer, 2008.
3. Day, R.W., *Geotechnical Earthquake Engineering Handbook*, McGraw-Hill, 2002
4. Bolt B., *The Nature of Earthquake Ground Motion*, Springer, 1988
5. Amr S. Elnashai and Luigi Di Sarno*Fundamentals of Earthquake Engineering: From Source to Fragility*, Wiley Press, 2015
6. Hashash et al. (2001), *Seismic Design and Analysis of Underground Structures*, Tunnelling and Underground Space Technology 16 ,2001, 247 -293 (ITA/AITES Accredited Material)
7. Roberto Villaverde, *Fundamental Concepts of Earthquake Engineering*, CRC Press Taylor & Francis Group, 2009.

CO Code	Course Outcome Statement
CO1	Develop basic competence in assessing seismic hazard and in characterizing earthquake actions
CO2	Understand basic aspects of soil under dynamic loading and role of soil deposits.

CO3	Perform ground response analysis using conventional approaches
CO4	Evaluate the liquefaction potential using a range of simplified methodologies and understand the principles of mitigation measures
CO5	Understand the behavior of soil slopes under seismic loading

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	-	3	2
CO2	3	2	2	-	2	2
CO3	3	2	2	-	2	1
CO4	3	2	2	-	2	2
CO5	2	3	2	-	2	2

21SC652 SOIL DYNAMICS AND MACHINE FOUNDATIONS 3-0-0-3

Introduction: Nature and types of dynamic loading, Importance of soil dynamics. Fundamentals of vibration: Vibration of elementary systems, Dynamics of elastic systems, Degrees of freedom, Free and forced vibration.

Wave propagation: Types of waves, Waves in unbounded media, Waves in semi-infinite media, Waves in layered media. Dynamic soil properties: Laboratory tests, Field tests, Correlation of different parameters.

Dynamic bearing capacity of foundations: Theories and methods, Design aspects. Dynamic earth pressure: Active and Passive Pressures, Design considerations in retaining walls. Dynamic slope stability Analysis. Liquefaction: Basic concept, Evaluation and effects, Vibratory motion of foundation, Vibration screening, Design of machine foundations.

TEXT BOOKS/ REFERENCES:

1. Braja M. Das, G.V. Ramana, *Principles of soil dynamics*, Cengage Learning, 2010
2. S. L. Kramer,*Geotechnical Earthquake Engineering*, Prentice Hall, New Jersy, 2003.
3. E.E. Rihcart et al., *Vibrations of Soils and Foundations*, Prentice Hall Inc., 1970.
4. Swami Saran, *Soil Dynamics and Machine Foundations*, Galgotia Publications Pvt Ltd, 1999.

CO Code	Course Outcome Statement
CO1	Explain the behavior and response of soil subjected to various types of dynamic or time-dependent loadings

CO2	Understand the fundamental principles of wave propagation and apply them in engineering.
CO3	Determine dynamic properties of soils using laboratory and non-destructive field tests
CO4	Demonstrate the ability to design machine foundations subjected to different kinds of vibrations

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	3	-
CO2	3	2	3	-	2	1
CO3	2	2	1	-	2	-
CO4	3	2	1	-	2	-

21SC653 STATISTICAL AND PROBABILISTIC MODELING IN CIVIL ENGINEERING 3-0-0-3

The Role of Statistics and Probability in Civil Engineering, Elements of Probability theory: random variables, random events, Bayes theorem, Common Probabilistic models: models for Simple discrete random trails, Random occurrences and Limiting cases; Modeling of Observed data and Estimation of model parameters -Maximum likely hood, K-means; Probabilistic Models for Civil Engineering problems

Numerical Modeling and Descriptive statistics, Hypothesis testing for civil engineering studies -Significance level, Tests Concerning the Mean of a Normal Population, Variance of a Normal Population, Equality of means of Two Normal Populations, Case of Unknown and Unequal Variances, Hypothesis Tests, The Paired t-Test, Normal Population, Null and Alternate Hypothesis,Interval Estimation and Selection of Training data.

Sample size estimation and Field data training for civil engineering studies, Sampling distribution and Point estimation of parameter,Regression models -simple linear and multiple linear models, Parameter Estimation, Least Squares Estimators of the Regression Parameters, Statistical Inferences, Distribution of the Estimators, Coefficient of Determination, NSE and MSE,Real time Case studies and Applications.

TEXT BOOKS/REFERENCES:

1. Ang A. H-S. and W. H. Tang, *Probability Concepts in Engineering Planning and Design*, John Wiley & Sons, Inc., USA, 2010.
2. Papoulis, A, and S. U. Pillai, *Probability, Random Variables and StochasticProcesses*, McGraw-Hill, New York, USA, 2002.

3. Richard A. Jonson and C. B. Gupta,*Miller and Freund's Probability and Statistics for Engineers*,Pearson Education, Inc., USA, 2005.
4. Sheldon Ross, *Introduction to Probability and Statistics for Engineers and Scientists,* Elsevier, USA, 2004.
5. Halder A and Mahadevan S. Probability, Reliability, and Statistical Methods in Engineering Design, Wiley, 1999.

CO Code	Course outcome statement
CO1	Understand the roles of probability and statistics in Civil Engineering
CO2	Understand the frequency paradigm in probability theory, and analyse parameter properties and its estimation procedures.
CO3	Apply the descriptive comparison and regression modeling of sample data in Civil Engineering

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	1		1	
CO2	1	3	1		1	
CO3	1	3	1		1	

21SC654 WIND EFFECTS ON STRUCTURES 3-0-0-3

Introduction, Types of wind – Characteristics of wind – Wind velocity, Method of measurement, variation of speed with height, shape factor, aspect ratio, drag effects - Dynamic nature of wind – Pressure and suctions - Spectral studies, Gust factor. Wind Tunnel Studies, Types of tunnels, - Prediction of acceleration – Load combination factors – Wind tunnel data analysis – Calculation of Period and damping value for wind design. Design Wind speeds and risk coefficients, Design wind pressure and pressure coefficients. Classification of structures – Rigid and Flexible – Effect of wind on structures - Static and dynamic effects on Tall buildings – Chimneys. Design of Structures for wind loading – as per IS codal provisions Industrial Sheds: Types of roofing – roofing sheets – purlins – light gauge sections – built-up sections – roof trusses – pre-engineered building. Analyis and design of steel monopoles, transmission line towers, self-supporting, Guyed and Braced chimneys.

TEXT BOOKS/ REFERENCES:

1. Cook.N.J., *The Designer's Guide to Wind Loading of Building Structures*, Butterworths, 1989.

2. Kolousek.V, Pirner.M, Fischer.O and Naprstek.J, *Wind Effects on Civil Engineering Structures*, Elsevier Publications, 1984
3. Lawson T.V., *Wind Effects on Building Vol. I and II*, Applied Science Publishers, London, 1980.
4. Peter Sachs, *Wind Forces in Engineering*, Pergamon Press, New York, 1978.
5. Lynn S. Beedle, *Plastic Design of Steel Frames*, John Wiley and Sons, 1990.
6. Narayanan.R.et.al., *Teaching Resource on Structural steel Design, INSDAG*, Ministry of Steel Publishing, 2000.
7. Subramanian.N, *Design of Steel Structures*,second edition, Oxford University Press, 2018.
8. Manohar S.N, *Tall Chimneys - Design and Construction*, Tata McGraw Hill, 1985
9. Santhakumar A.R. and Murthy S.S., *Transmission Line Structures*, Tata McGraw Hill,1992.
10. Wie Wen Yu, *Design of Cold Formed Steel Structures*, McGraw Hill Book Company, 1996
11. Taranath B.S., *Structural Analysis and Design of Tall Buildings*, McGraw Hill, 1988.

CO Code	Course outcome statement
CO1	Perceive the effects of wind on the design of structures.
CO2	Understand the fundamental concepts of design of structures subjected to wind loads.
CO3	Understand the building code requirements for structural systems subjected to wind loading.
CO4	Design chimneys, roof truss, pre-engineered building and its components, transmission towers

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	3	-	-
CO2	3	3	1	1	-	-
CO3	3	3	3	1	1	1
CO4	3	3	3	1	2	1

21SC655 ANALYSIS AND DESIGN OF SUB-STRUCTURES 3-0-0-3

Foundation classification; Choice of foundations; Bearing capacity and settlement analysis of shallow foundations like footings and rafts, Deep foundations like piles, piers and Caissons; Foundations on problematic soils. Introduction to Limit State Design method; Structural design of continuous footings, individual footings, Combined footings and rafts of various types subjected to vertical and lateral loads, and moments; Design of circular rafts; Introduction to soil structure interaction. Analysis and design of deep foundations: pile foundations, piers, well foundations. Introduction to special foundations - ring foundations, offshore foundations. Foundations for transmission line towers, storage tanks, silos, chimneys etc.

TEXT BOOKS/ REFERENCES:

1. Das B.M., *Principles of Foundation Engineering*, Seventh Edition, CL Engineering, 2013.
2. Ninan P Kurian, *Design of Foundation Systems*, Narosa Publishing House, New Delhi, 2005.
3. Swami Saran, *Analysis and Design of Substructures*, Oxford and IBH Publishing, New Delhi, 2008.
4. Varghese P.C, *Design of Reinforced Concrete Foundations*, PHI Learning, 2009.
5. Ghosh Karuna Moy, *Foundation Design in Practice*, PHI Learning, 2009.

CO Code	Course outcome statement
CO1	Determine the bearing capacity of soil based on various soil conditions
CO2	Perform geotechnical design of shallow and deep foundations using limit state design
CO3	Suggest different types of foundations based on the type of the structure
CO4	Understand limitations and uncertainties in geotechnical design

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	2
CO2	3	3	3	2	2	2
CO3	3	3	3	3	2	2
CO4	3	2	2	2	2	2

21SC656 FORMWORK, SCAFFOLDING & SHORING 3-0-0-3

Materials, Accessories and Proprietary Products - Lumber - Types - Finish - Sheathing ratio - Working stresses -Repetitive member stress - Plywood -Types and grades -Textured surfaces and strength - Reconstituted wood -Steel -Aluminium -Form lining materials

Planning- Overall Planning -Detailed planning - Standard units - Corner units - Schedule - Planning at Tender stage - Development of basic system - Planning for maximum reuse – Planning examples - Site layout plan-Crane arrangements -Recheck plan details - Planning for safety- Transporting plant -Wales and ties - Vertical transportable form work.Design

considerations- Live loads and Wind pressure -Concrete pressure on form work- concrete density -Height of discharge -Temperature -Rate of Placing -Consistency of concrete - Vibration - Hydrostatic pressure and pressure distribution -Examples -Adjustment for nonstandard conditions- Basic simplification - Beam forms -Slab forms- Column forms -Wall forms -Allowable stresses - Check for deflection, bending and lateral stability - Codal provisions Examples on form designs. Building and Erecting the Framework- Location of job mill -Storage -Equipment-Form for Wall footings -Column footings -Slab on grade and paving work -Highway and Airport paving - External vibration - Prefabricated panel systems - Giant forms -Curved wall forms –Erection Practices - Column heads-Beam or girder forms - Suspended forms- Concrete Joint construction- Flying system forms.
Formwork Failures - Causes of Failures - Case studies- Finish of exposed concrete –Design deficiencies - Safety factors -Stripping sequence – Reshore installation -Advantages of reshoring.Special Formwork - Shell forms -Design considerations -Loads -Building forms –
Strength requirements -Tunnel forming components - Curb and gutter forms - Invert forms Arch forms - Concrete placement methods - Slip forms-Principles -Types -Advantages Functions of various components-Planning -Safety in slip forms -Special structures built with slip form technique – Shuttering for Precast members and continuous casting forms.Scaffolding – Different types -Putlog and Independent scaffold -Single pole scaffolds - Fixing ties- Spacing of ties,- bracing, safety netting -General safety requirements-.Working & Erection at Site : Mock up and hands on assembly for various vertical & Horizontal formwork , assembly , checking & dismantling- key considerations. (Site visits preferred)

TEXT BOOKS/ REFERENCES:

1. Kumar NeerajJha, Formwork for concrete structures, McGraw Hill Education, 2017.
2. Austin, C.K., *Formwork for Concrete,* Cleaver -Hume Press Ltd., London, 1996.
3. Hurd, M.K., *Formwork for Concrete*, Special Publication No.4, American Concrete Institute, Detroit, 2005
4. *Concrete Formwork Systems* – Awad. Hanna- University of Wisconsin –Copy right Marcel Dekkel Inc.
5. Formwork – *A guide to Good Practice* –Concrete Society –U.K 2nd Edition 1995 6. Robert L. Peurifoy and Garold D. Oberlender, *Formwork For Concrete Structures*, McGraw -Hill , 2010.

7. Tudor Dinescu and Constantin Radulescu, *Slipform Techniques,* Abacus Press, Turn Bridge Wells, Kent, 1984.

CO Code	Course Outcome Statement
CO1	Select proper formwork, accessories and material.
CO2	Design the form work for beams, slabs, columns, walls and foundations.
CO3	Evaluate the formwork failures.
CO4	Suggest scaffolding types to meet safety requirements

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	-	-	1	1
CO2	2	2	1	-	3	2
CO3	2	3	1	-	3	3
CO4	3	3	1	-	3	3

21SC657 Construction Economics & Finance 3-0-0-3

Engineering economics: Basic principles – Time value of money, Quantifying alternatives for decision making, Cash flow diagrams, Equivalence - Single payment in the future (P/F, F/P), Present payment compared to uniform series payments (P/ A, A/P), Future payment compared to uniform series payments (F/A, A/F), Arithmetic gradient, Geometric gradient.

Comparison of alternatives: Present, future and annual worth method of comparing alternatives, Rate of return, Incremental rate of return, Break-even comparisons, Capitalized cost analysis, Benefit-cost analysis. Depreciation, Inflation and Taxes. Equipment economics: Equipment costs, Ownership and operating costs, Buy/ Rent/Lease options, Replacement analysis.

Cost estimating: Types of Estimates, Approximate estimates – Unit estimate, Factor estimate, Cost indexes, Parametric estimate, Life cycle cost. Financial management: Construction accounting, Chart of Accounts, Financial statements – Profit and loss, Balance sheets, Financial ratios, Working capital management.

1. Gould, F. E., “Managing the Construction Process”, 4th ed., Pearson Education, 2012.
2. Harris, F., McCaffer, R. and Edum-Fotwe, F., “Modern Construction Management”, 6th ed., Wiley India, New Delhi, 2006.
3. Jha, K. N., “Construction Project Management, Theory and Practice”, Pearson, New Delhi, 2011.
4. Peurifoy, R. L. and Oberlender, G. D., “Estimating Construction Costs”, 5th ed., Tata McGraw-Hill, New Delhi, 2004.

CO Code	Course Outcome Statement
CO1	Recognise and examine the construction economics concepts
CO2	Analyse and evaluate the alternatives
CO3	Recognise and examine the construction finance concepts
CO4	Manage construction finances using fundamental financial tools.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	0	1	2
CO2	1	2	2	2	2	3
CO3	1	1	1	0	1	2
CO4	1	2	2	2	2	3

21SC658 BUILDING INFORMATION MODELLING 3-0-0 -3

Introduction to/Review of Buildings & Systems- Building components and systems Integrating BIM in Construction Contracts- Contract Systems, Work Organisation and Process Details. BIM-for modelling (Autodesk Revit) Model Support in Coordination, Creating Levels and Grids, Walls Modelling, Object Modification, Doors and Windows, Floors and Roofs, Curtain, Stairs and Ramps, Dimensions and Constraints, Annotation and Documentation. - Importing and modifying families of objects and elements, Clash Detection, Model Support in Coordination. BIM for Energy Analysis- Use of BIM for the Tasks of Energy Demand Calculation and Building Simulation. BIM for Construction Safety and Health- Integrating BIM in the Safety Planning Process, Safety and BIM-Based Quantity Take-Off. BIM in Industrial Prefabrication for Construction - BIM in Industrial Prefabrication for Construction- Production Models for Digital Production Methods. BIM for 3D Printing in Construction.

TEXT BOOKS / REFERENCES:

1. Karen Kensek and Douglas Noble, *Building Information Modelling: BIM in Current and Future Practice* Wiley; 1st edition (15 August 2014)
2. Andre Borrmann, Markus Konig, Christian Koch, JakobBeetz, *Building Information Modelling*, Springer 2015
3. Rafael Sacks, Chuck Eastman, Ghang Lee, Paul Teicholz , *BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers*, Wiley; 3rd edition (2 October 2018)

CO Code	Course outcome statement
CO1	Create BIM model which helps in the coordination of construction process
CO2	Develop energy models for energy demand calculation using simulation
CO3	Prepare schedule and quantity take off with the help of BIM

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2			

CO2	3	3	2			
CO3	3	2	3			

21LIV606 LIVE-IN- LAB 3-0-0-3

The interested students will get an opportunity to work in any of the villages and solve the technical problems in areas related to the course by applying the engineering knowledge they have acquired through their study. The students can visit the village and identify the problem at the end of first year (summer vacation), start working on it and complete in the third semester.

Code	Course Outcome Statement
CO1	Understand the problems faced by rural communities in India: Service to society
CO2	Study, observe, and interact with rural populations while living in rural communities and gain a better understanding of challenges in various areas
CO3	Undertake experiential learning opportunities, by taking theory into practice
CO4	Generate innovative solutions, thereby facilitating critical and collaborative problem solving abilities

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	2	3
CO2	3	2	3	1	3	3
CO3	3	2	3	-	2	3
CO4	3	3	3	1	2	3

21SC798 DISSERTATION I 0-0-0-10

Dissertation will have two internal review presentations and an end semester presentation. The first presentation will include identification of the problem based on the literature review on the topic referring to latest literature available. Second review presentation should be done on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data and determining solutions. The end semester presentation must bring out individuals contribution and should have a strong conclusion .The review committee can make the decision on continuation of the project in the next semester.

CO Code	Course outcome statement
CO1	Identify structural , construction and construction management problems reviewing available literature.
CO2	Identify appropriate techniques to analyze complex systems.
CO3	Apply engineering and management principles through efficient handling of project.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	2	3	1
CO2	3	3	3	1	3	2
CO3	1	1	3	3	2	2

21SC799 DISSERTATION II 0-0-0-16

This can be an extension to work on the topic identified in previous semester "Dissertation" or can be a new one based on the recommendations of review committee. Continuous assessment should be done on the work done by adopting the methodology decided involving numerical analysis/ conduct experiments, collection and analysis of data, etc. After approval by the internal review committee the student has to submit the detail report and external examiner is called for the viva-voce. The student has to submit a technical paper based on the dissertation in any of the peer reviewed Scopus indexed journal.

CO Code	Course outcome statement
CO1	Solve complex structural, construction and management related problems by applying appropriate techniques and tools.
CO2	Exhibit good research orientation, communication and writing skill to the engineering community and society.
CO3	Demonstrate professional ethics and work culture

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2		1	1
CO2	2	2	3	3	2	1
CO3	1	1	3	2	1	3

OPEN ELECTIVES

21SC702 SUSTAINABLE DESIGN & CONSTRUCTION PRACTICES 3-0-0-3

Sustainability in the built environment: sustainable development relative to ecological, economic and social conditions – efforts in sustainable development and construction – international organisations involved. Ethics and sustainability: environmental and resource concerns – resource consumption by construction industry-Green building movement. Ecological design – concept – major contributions. Building assessment and eco labels – standards (LEED, GRIHA) – assessment structure and process. Green building design process – documentation requirements. -Sustainable site and landscape – storm water management, heat island mitigation- assessment of sustainable sites. Building energy issues - building energy design strategy- building envelope – internal load reduction – energy optimisation - renewable energy systems. Reducing carbon footprint. Built environment hydrologic cycle – water resources issues – strategies for conservation and recycling – waste water and storm water handling strategies. Materials resources - Life cycle assessment – embodied energy – Green building materials and products – assessing for environmental impacts – design for deconstruction. Indoor environmental quality – issues and causes, components of integrated design – emissions from building materials. Construction operations – site planning, indoor air quality during construction – materials management – Construction and Demolition – waste management – building commissioning – LEED credits for different aspects. -Green building economics – quantifying benefits. Recent advances in sustainable construction.

TEXT BOOKS/ REFERENCES:

1. Kibert, C.J., *Sustainable Construction: Green Building Design and Delivery*, Wiley, 2016.
2. Steven V. Szokolay., *Introduction to Architectural Science - The Basis of SustainableDesign*, Routledge, 2014.
3. Sandy Halliday, *Sustainable Construction*, Routledge, 2018.
4. DejanMumovic and Mat Santamouris (Ed), *A Handbook of Sustainable Building Design and Engineering*, Earthscan Publishing, 2009.
5. Osman Attmann, *Green Architecture: Advanced Technologies and Materials*, McGraw Hill, 2010.

CO Code	Course outcome statement
CO1	Assess resource consumption by the construction industry.
CO2	Evaluate Life cycle energy of materials and products.
CO3	Conceptualise eco-friendly constructions.
CO4	Quantify benefits of green buildings.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1		2	2
CO2	3	3	1	1	2	2
CO3	3	2	1		2	2
CO4	3	2	1		2	2

21SC703 ENVIRONMENTAL IMPACT ASSESSMENT FOR PROJECTS **3 0 0 3**

Concept of environment - Sustainable development - role of environmental impact assessment. EIA – definitions, terminology and overview. Evolution of EIA and its legal requirements for projects in India. EIA process for infrastructure projects- screening – scoping - setting – analysis – mitigation. Cross sectoral issues and terms of reference in EIA – Public Participation in EIA-EIA Consultant Accreditation.

EIA methodology for projects - Matrices – Networks – Checklists –Cost benefit analysis – Analysis of alternatives – Software packages for EIA – Expert systems in EIA. Prediction tools for EIA – Mathematical modeling for impact prediction – Assessment of impacts of projects on – air – water – soil – noise – biological — Cumulative Impact Assessment - Socioeconomic impact analysis, Evaluation of alternatives

Preparing the EIA report for infrastructure projects. Environmental impact statement (EIS), Environmental monitoring, Environmental audit (EA) - Case studies of infrastructure projects. Environmental Management Plan - preparation, implementation and review – Mitigation and Rehabilitation Plans – Policy and guidelines for planning and monitoring programmes – case studies of various projects

TEXT BOOKS/ REFERENCES:

1. Larry W Canter, *Environmental Impact Assessment*, McGraw Hill, Inc, 1995.
2. Raman N.S, *Environmental Impact Assessment*, Dreamtech Press – Wiley, 2019

3.Lawrence, D.P, *Impact assessment – Practical solutions to recurrent problems and contempory challenges*, John Wiley and Sons , 2nd edition 2013
4. John Glasson, *Introduction to Environmental Impact Assessment*, Routledge,5th edition, 2019
5.Betty Bowers Marriot, *Environmental Impact Assessment: A Practical Guide*, McGraw Hill, Inc, 1997.
5. Barrow, C. J., *Environmental and Social Impact Assessment – An Introduction*, Edward Arnold, 1997.
6. Evan. K. Paleologos and Ian Lerche, *Environmental Risk Analysis*, McGraw Hill Inc, 2001.
7.Peter Morris (ed.) and RikiTherivel (ed.), *Methods of Environmental Impact Assessment*, Routledge, 2001.
8. UNEP, *Environmental Impact Assessment Training* Resource Manual, 2002.
9. Website of the *Ministry of Environment and Forests*, Govt. of India and the USEPA.
10. World Bank –Source book on EIA

CO Code	Course Outcome statement
CO1	Identify and analyze the need and legal requirements of EIA for projects
CO2	Identify the factors and perform Impact assessment methods for various projects
CO3	Analyze the various components and prepare the EIA document for infrastructure projects

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3			1	1
CO2	3	3			1	
CO3	3	3		3	1	

21SC701 REMOTE SENSING AND GIS 3
0 0 3

Concepts and principles of remote sensing, Mechanism of Remote sensing, Definition components of remote sensing - energy sensor, interacting body, Active and Passive remote sensing, EMR interaction with earth surface material – Radiance, Irradiance, Incident, Reflected, Absorbed and Transmitted energy, Interaction with the atmosphere, Reflectance – specular and diffused reflection surfaces, Spectral signature – spectral signature curves – Interaction with targets: EMR interaction with water, soil and earth surface and its applications. Satellite characteristics – Orbits, Swath, Nadir, Pixel size, Sensor resolutions – Spatial, Spectral, Radiometric and Temporal, Indian Satellites and other purpose driven satellites, Data products, introduction to panchromatic, multispectral and hyperspectral data, Basics of Optical and Infra-red Remote sensing, Thermal remote sensing, Microwave remote sensing.

Photogrammetry – Aerial and Terrestrial, Photo interpretation, Sensors – Colour scanners, thematic mapper. Digital image processing system, Pre-processing of raw data, Image enhancement, Transformation, Supervised and Un-supervised Classification, Integration, Analysis and Interpretation.

Geographic information system, Components of GIS, Data, Spatial and non-spatial maps, Types of maps – projection – Types of projection, Data input – Digitiser, Scanner, Editing, Data acquisition – Raster and Vector data structures – comparison of raster and vector data structure, Analysis using raster and vector data – retrieval, reclassification, overlaying, buffering, Open source software, GIS and remote sensing applications in Civil Engineering.

TEXT BOOKS/ REFERENCES:

1. Lillesand, Kiefer and Chipman, "Remote Sensing and Image Interpretation", Wiley student edition, 2015.
2. A.M.Chandra and S.K. Gosh, "Remote Sensing and GIS", Atlantic, 2008
3. James B. Campbell & Randolph H. Wynne., *Introduction to Remote Sensing*, The Guilford Press, 2011.
4. Sabins, F., *Remote Sensing Principles and Interpretation*, W. H. Freeman and Company, New York, Third edition, 2007.
5. LRA Narayana, "*Remote Sensing and its applications*", Universities Press, 1999
6. M G Srinivas (Edited by), "*Remote sensing applications*",Narosa Publishing House, 2001.
7. Burrough P A., "*Principles of GIS for land resource assessment*", Clarendon Press, 1994.

CO Code	Course Outcome Statement
CO1	Understand and analyze the principles and components of remote sensing and EMR
CO2	Schematize the process of data acquisition of satellite images and their characteristics
CO3	Understand the principles of digital image processing and its applications
CO4	To understand the concepts and fundamentals of GIS and employ them in different civil engineering applications.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	1	-	2	-
CO2	2	1	1	-	2	2
CO3	2	1	1	-	3	2

CO4	3	1	1	-	2	2