



## **M.Tech Structural and Construction Engineering**

*Department of Civil Engineering*

*Amrita Vishwa Vidyapeetham, Coimbatore*

**M.Tech- Structural and Construction Engineering  
Curriculum 2023-2025**

**First Semester**

<i>Course Code</i>	<i>Type</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
23MA601	FC	Linear Algebra, Legendre Equations and Numerical Methods	3-0-0	3
23SC601	FC	Advanced Mechanics of Solids	2-1-0	3
23SC602	FC	Advanced Reinforced Concrete Structures	2-1-0	3
23SC603	FC	Advanced Construction Practices	3-0-0	3
23SC604	FC	Construction Project Management	2-1-0	3
23SC681	SC	Experimental Techniques	0-0-3	1
22ADM501		Glimpses of Indian Culture		P/F
22AVP103	HU	Mastery Over Mind	1-0-2	2
23HU601	HU	Career Competency I	1-0-0	P/F
<b>Credits 18</b>				

**Second Semester**

<i>Course Code</i>	<i>Type</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
23SC611	SC	Building Information Modeling	1-0-3	2
23SC612	SC	Advanced Steel Design	2-1-0	3
23SC613	SC	Finite Element Analysis	2-0-3	3
23SC614	SC	Construction Software Laboratory	1-0-3	2
23SC615	FC	Construction Contract Laws & Regulations	2-1-0	3
	E	Programme Elective I	2 1 0	3
	E	Programme Elective II	2 1 0	3
23HU611	HU	Career Competency II	1-0-0	1
<b>Credits 20</b>				

**Third Semester**

<i>Course Code</i>	<i>Type</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
23LIV690*	PE	Programme Elective III/Live in Lab/Open Elective	2 1 0	3
23SC701	SC	Structural Design Studio	1-0-3	2
23SC795	SC	Industry Internship	0-0-3	P/F
23RM701	SC	Research Methodology	0-0-3	1
23SC798		Dissertation I	0-0-30	10
<b>Credits 16</b>				

**Fourth Semester**

<i>Course Code</i>	<b>Type</b>	<b>Course</b>	<b>L T P</b>	<b>Cr</b>
23SC799	P	Dissertation II	0-0-48	16
<b>Credits 16</b>				

**Total Credits 70**

**Summary**

<b>Semester</b>	<b>Construction Management Subjects</b>	<b>Cr</b>	<b>Structural Engineering Subject</b>	<b>Cr</b>
1	2 Theory (Core)	6	2 Theory (Core)	6
2	1 Theory Core Subjects 1 Lab Core Subject 2 Elective Subjects	5+6	2 Theory Core Subjects 2 Elective Subjects	12
3	2 Elective Subjects	6	2 Elective Subjects 1 Lab Subject	6

## List of Courses

### Foundation Core

<i>Course Code</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
23MA601	Linear Algebra, Legendre Equations and Numerical Methods	3-0-0	3
23SC601	Advanced Mechanics of Solids	2-1-0	3
23SC602	Advanced Reinforced Concrete Structures	2-1-0	3
23SC603	Advanced Construction Practices	3-0-0	3
23SC604	Construction Project Management	2-1-0	3
23SC615	Construction Contract Laws & Regulations	2-1-0	3

### Subject Core

<i>Course Code</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
23SC681	Experimental Techniques	0-0-3	1
23SC611	Building Information Modeling	1-0-3	2
23SC612	Advanced Steel Design	2-1-0	3
23SC613	Finite Element Analysis	2-0-3	3
23SC614	Construction Software Laboratory	1-0-3	2
23RM701	Research Methodology	0 0 3	1
23SC795	Industry Internship	0-0-3	P/F
23SC701	Structural Design Studio	1-0-3	2

### Programme Electives

<i>Course Code</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
23SC631	Mechanics of Composite Materials	2-1-0	3
23SC632	Advanced Concrete Technology	2-1-0	3
23SC633	Construction Methods and Equipment	2-1-0	3
23SC634	Structural Dynamics	2-1-0	3
23SC635	Theory of Plates and Shells	2-1-0	3
23SC636	System Integration in Construction	2-1-0	3
23SC637	Quality Control and Safety in Construction	2-1-0	3
23SC638	Pre-stressed Concrete Design	2-1-0	3
23SC639	Seismic Design of Structures	2-1-0	3
23SC640	Forensic Engineering and Rehabilitation of Structures	2-1-0	3
23SC641	Mechanics of Ground Improvement	2-1-0	3
23SC642	Optimization Techniques	2-1-0	3
23SC643	Smart Materials and Structures	2-1-0	3
23SC644	Stability of Structures	2-1-0	3
23SC645	Industrial Structures	2-1-0	3
23SC646	Bridge Engineering	2-1-0	3
23SC647	Prefabrication Engineering	2-1-0	3
23SC648	Design of Offshore Structures	2-1-0	3
23SC649	Pavement Analysis and Design	2-1-0	3
23SC650	Characterization of Materials	2-1-0	3
23SC651	Geotechnical Earthquake Engineering	2-1-0	3
23SC652	Soil Dynamics and Machine Foundations	2-1-0	3
23SC653	Statistical and Probabilistic Modeling In Civil Engineering	2-1-0	3
23SC654	Wind Effects on Structures	2-1-0	3
23SC655	Analysis and Design of Substructures	2-1-0	3
23SC656	Formwork, Scaffolding & Shoring	2-1-0	3
23SC657	Construction Economics & Finance	2-1-0	3
23LIV690*	Live-in-Lab*	2-1-0	3

### Open Electives\*\*

<i>Course Code</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
23SC661	Remote Sensing and GIS	2-1-0	3
23SC662	Sustainable Design & Construction Practices	2-1-0	3
23SC663	Environmental Impact Assessment for Projects	2-1-0	3
23SC731	Geotextiles - Applications in Construction Engineering	2-1-0	3

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

### Evaluation Pattern

Following evaluation pattern will be followed for all **theory courses**

<b>Assessment component</b>	<b>Mark Component</b>
Continuous Assessment (Quiz, Assignment, Seminar, Project etc)	30
Mid Term Exam	30
End semester/Project	40

<i>Semester</i>	<i>Course Code</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
1	23MA601	Linear Algebra, Legendre Equations and Numerical Methods	3-0-0	3
	23SC601	Advanced Mechanics of Solids	3-1-0	4
	23SC602	Advanced Reinforced Concrete Structures	2-1-0	3
	23SC603	Advanced Construction Practices	3-0-0	3
	23SC604	Construction Project Management	2-1-0	3
2	23SC613	Finite Element Analysis	2-0-3	3
	23SC614	Construction Contract Laws & Regulations	2-1-0	3
		Programme Elective I	2-1-0	3
		Programme Elective II	2-1-0	3
	23HU602	Career Competency II	1-0-0	1
3		Programme Elective III/Live in Lab/Open Elective	2-1-0	3
All Electives				

Following evaluation pattern will be followed for all **Lab courses**

<b>Assessment Component</b>	<b>Mark Component</b>
Continuous Assessment	40
Mid Term Exam	20
End semester/Project	40

<i>Semester</i>	<i>Course Code</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
1	23SC681	Experimental Techniques	0-0-3	1
2	23SC611	Building Information Modeling	1-0-3	2
	23SC614	Construction Software Laboratory	1-0-3	2
3	23SC701	Structural Design Studio	1-0-3	2
	23RM701	Research Methodology	0-0-3	1

Following evaluation pattern will be followed for all **P/F courses**

<b>Assessment Component</b>	<b>Mark Component</b>
Continuous Assessment	40
Mid Term Exam	20
End semester/Project	40

<i>Semester</i>	<i>Course Code</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
1	23AVP601	Amrita Values Program		P/F
	23HU601	Career Competency I	1-0-0	P/F
3	23SC795	Industry Internship	0-0-3	P/F

Following evaluation pattern will be followed for **Project**

<b>Assessment Component</b>	<b>Mark Component</b>
Internal Review	60
External Review	40

<i>Semester</i>	<i>Course Code</i>	<i>Course</i>	<i>L T P</i>	<i>Cr</i>
3	23SC798	Dissertation I	0-0-30	10
4	23SC799	Dissertation II	0-0-48	16

## Course Content

23MA601	LINEAR ALGEBRA, LEGENDRE EQUATIONS AND NUMERICAL METHODS	3-0-0-3
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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  $[Q_n(x)]$ , 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.*



<b>CO Code</b>	<b>Course outcome statement</b>
<b>CO1</b>	The concepts of vector Spaces, Understand basis vectors, dimension & span of vector spaces.
<b>CO2</b>	The orthonormal set, simple linear transformation and least square method and apply to some of the structural engineering problems.
<b>CO3</b>	Solutions of differential equations through the special functions. Apply to some engineering problems.
<b>CO4</b>	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.

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

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 and polar coordinates: Stress function, solution by polynomials, problems of axisymmetric stress distribution, pure bending of curved bars- Torsion of straight bars, membrane analogy, narrow rectangular crosssection, torsion of rectangular bars, rolled profile sections, hollow shafts and thin tubes.

Force method and stiffness 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; Linearized buckling analysis.

#### 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. *Richard G Budynas Advanced Strength and Applied Stress Analysis, Mcgraw Hill Series, 1999*
4. *Boresi, A.P , Schmidt, R.J and Sidebottom, O.M. , Advanced Mechanics Of Materials, 5th Ed., John Wiley, 1993.*
5. *William Weaver, Jr. James and M. Gere and Weaver, Matrix Analysis of Framed Structures, Third Edition Springer, 1990.*
6. *Pandit, G.S., and Gupta, S. P. Structural Analysis: A Matrix Approach, Second Edition Tata McGraw - Hill Education, 2008.*
7. *Mcguire and Gallagher, R.H, Matrix Structural Analysis, Second edition, John Wiley, 2001.*
8. *Rajasekaran. S and Sankarasubramanian. G, Computational Structural Mechanics, Prentice Hall of India, New Delhi, 2009.*
9. *Nelson K.J and Mc Cormac J C., Structural Analysis Using Classical and Matrix Methods, Third Edition, Wiley, 2002.*

<b>CO Code</b>	<b>Course outcome statement</b>
<b>CO1</b>	Explain the principles and governing equations in elastic stage under different loading conditions
<b>CO2</b>	Solve 2 D and 3 D elastic boundary value problems in rectangular and polar coordinates
<b>CO3</b>	Analyse the structure using matrix method
<b>CO4</b>	Determine the crippling load by performing linearised buckling analysis

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

Modeling considerations for Linear and Nonlinear Analysis of RC buildings – Analysis of buildings using commercially available software – Stress-strain characteristics of concrete under multi- axial stresses – Design, Nominal, and over-strength stress-strain relationship of Concrete and rebar – Confined concrete – Creep and shrinkage behaviour of Concrete – Effect of cyclic loading on concrete and reinforcing steel.

Review of design of beams, columns and walls – Introduction to interaction of Axial, Flexure and Shear Behaviour of structural elements – Strength hierarchy – Capacity design of elements – Inelastic behaviour of concrete beams and columns, moment – rotation curves – Design of long columns – Design of joints in frames – Curtailment of bars – moment redistribution - Yield line theory and its application for slabs – Basics of Flat slab design and Grid slab design

Strut and Tie Models – Design of corbels, Deep beams and RC squat walls

Control of deflections – Control of cracking – Codal procedures on crack-width and deflection computation. Fire resistance behaviour of RC members

#### 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. B. S. Taranath, *Reinforced Concrete Design of Tall Buildings*, CRC Press

CO Code	Course outcome statement
CO1	Understand properties of concrete and rebar
CO2	Understand the inelastic behaviour of RC elements
CO3	Understand the shear behaviour of RC elements using strut and tie method
CO4	Understand the serviceability requirement for RC elements

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

Construction materials:- Selection criteria. Metals and Special Alloys of Steel – Glass and Glazing - Structural Plastics and Composites - Polymer Membranes, Coatings, Adhesives - Flooring and Facade Materials - High performance concrete, Introduction to 3D concrete printing. Geotextiles- types, properties and construction applications- superstructure, functionality of geotextiles – strengthening material and drainage material. Role of geotextiles in waterproofing of foundation and building roofs - Coir geotextile as interior component-acoustics and thermal insulations - external vertical gardens - Lifecycle cost analysis using coir geotextiles.

Sub-structure construction:- Construction of diaphragm walls, H walls and basement- Shoring for deep cutting - Underpinning; Soil reinforcement – geotextiles- design criteria for geotextiles- Design step for erosion control and Geo-composite drainage. Mechanisms and concept of pavement, design of unpaved road, Giroud and Noiray method, U.S. Forest services, airfield pavement design, reflection cracking, pavement rehabilitation and repair, Nano material. Different types of facing elements, construction procedure, cost, design of Geosynthetics wrap around faced wall,- Trenchless Technology; Box jacking, Pipe Jacking. Tunneling Techniques; TBM - 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 - - aerial transporting, material handling - erecting light weight components on tall structures - In-situ pre-stressing in high rise structures. Composite construction of steel and concrete. Rapid construction techniques.

Special Structures:- 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,*
4. *Prentice Hall, 2013.*
5. *Singh,J., Heavy Construction -Planning, Equipment and Methods,Third Edition, CRC Press, 2009.*
6. *Michael Chew Yit Lin, Construction Technology for Tall Buildings, Singapore University Press, Singapore, 2001.*
7. *Johnson,R.P., Composite Structures of Steel and Concrete, Wiley India Exclusive, 2013.Shukla, S.K. (2002). Geosynthetics and Their Applications. Thomas Telford Publishing, London, UK.*

<b>CO Code</b>	<b>Course outcome statement</b>
<b>CO1</b>	Identify suitability of modern construction materials for application in field situations.
<b>CO2</b>	Suggest the construction procedures for substructures and superstructures
<b>CO3</b>	Apply the suitable construction methods for special and heavy structures.

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

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. Concepts of 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 Neeraj Jha, *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	

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 and durability study in concrete.

Similitude and structural models: dimensional analysis, Buckingham's Pi theorem, scale factors and dynamic similitude;elastic and inelastic models, size effects;Test planning, design and implementation: testing sequence and experimental plan, loading systems, devices, actuators and their control; various types of sensors for displacement, velocity, acceleration, pressure, loads, strains, full-field measurements

#### 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



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			

Modeling considerations for Linear and Nonlinear Analysis of Steel buildings – Analysis of buildings using commercially available software

Properties of steel: mechanical properties, chemical composition, hysteresis, ductility; Hot-Rolled Sections: compactness and non-compactness, slenderness, residual stresses – Introduction to fabrication and erection of structural elements

Design of steel structures: inelastic bending – curvature, plastic moments,

Stability criteria: stability of beams - local buckling of compression flange & web, lateral-torsional buckling, stability of columns - slenderness ratio of columns, local buckling of flanges and web, bracing of column about weak axis, Recap: Method of design - allowable stress design, plastic design, load and resistance factor design;

Strength Criteria: beams – flexure, shear, torsion; columns - moment magnification factor, effective length, P-M interaction, bi-axial bending, joint panel zones;

Drift criteria: P- $\Delta$  effect, deformation-based design;

Connections: types – welded, bolted, location - beam-column, column-foundation, splices.

Types of connections, Behaviour of local elements, Analysis, Design and Detailing. Cold Formed Steel Members: Effective width and Direct Strength Design methods.

Introduction to Prefab Steel Structures – Design considerations – Term project

#### **TEXT BOOKS/ REFERENCES:**

1. *Subramanian .N, Design of Steel Structures, Oxford University Press, New Delhi 2008.*
2. *William T. Segui, Steel Design, Thomson, 2007*
3. *Guo-Qiang Li and Jin-Jun Li Advanced Analysis and Design of Steel Frames, John Wiley & Sons 2007*
4. *Charles G. Salmon, John E. Johnson, Steel Structures Design and Behavior, Prentice Hall 1996*
5. *Abi O. Aghayere, Jason Vigil, Structural Steel Design- A Practice Oriented Approach, Prentice Hall, 2008*
6. *BS Taranath, Structural analysis and design of tall buildings - steel and composite construction, CRC Taylor & Francis, 2012*
7. *Wei-Wen Yu and Roger A .Laboube, Cold-Formed Steel Design, Fourth Edition, Structures, John Wiley & Sons, 2010.*

<b>CO Code</b>	<b>Course outcome statement</b>
<b>CO1</b>	Understand properties of steel and section classification
<b>CO2</b>	Understand the inelastic behaviour of steel members
<b>CO3</b>	Understand buckling behaviour of steel members
<b>CO4</b>	Understand the design of steel buildings considering strength and drift criteria

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

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 – Rayleigh Ritz, 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	-

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.

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

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO1</b>	3	3	2			
<b>CO2</b>	3	3	2			
<b>CO3</b>	3	3	2			

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,*
4. *McGraw Hill, 2013.*
5. *Kwaku, A., Tenah, P.E. Jose M.Guevara, P.E., Fundamentals of Construction Management and Organisation, Prentice Hall, 1985.*
6. *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

Role of different stakeholders in construction sector (i.e., architect, designer, draftsman, construction manager, and site supervisor); Comprehending soil report; Introduction to architectural features of buildings; Estimate of wind force demand; Introduction to Earthquake resistant design and detailing; Estimation of Earthquake force demand; Basic of dynamic behaviour of buildings - Overview to Modelling and Design assumptions using commercially available software; Introduction to Design basis reports; Design, detailing and preparation of drawings. Planning, Analysis and Design of residential, multi- storey buildings, commercial buildings, Industrial structures, and special structures. Overview of foundation design. Design of foundations using commercially available software.

#### 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. 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. B. S. Taranath, *Reinforced Concrete Design of Tall Buildings*, CRC Press
6. U. H. Vary, *Structural Design of Multistoreyed Building*, South Asian Publishers
7. *Relevant IS Codes*.

CO Code	Course outcome statement
CO1	Understand analysis and design of buildings using commercial software
CO2	Design and Detailing the RC multistory building
CO3	Design and Detailing of Industrial structures.

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	

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



**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. Confirmatory Research, 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 Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: 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", 8th Edition, 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*

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

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO1</b>			2			
<b>CO2</b>			2			
<b>CO3</b>			3			
<b>CO4</b>			2	3	2	
<b>CO5</b>				2	3	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 – Whitnissnuismer 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 and Properties*, Carl Hanser Verlag, Munich, 1990.
5. Agarwal B.D. and Broutmen L.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

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, Mixture proportioning. Fresh and hardened concrete properties; quality control. 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, - Vacuum dewatering of concrete-Under water concreting. High performance and High Strength concrete; Self compacting concrete - Light weight concrete, Heavy weight and mass concrete, Fiber reinforced concrete. Sustainability- Recycling of concrete. Nondestructive evaluation of concrete structures; Cement based composites.

#### TEXT BOOKS/ REFERENCES:

1. *Nevile, A.M., Properties of Concrete, Pearson, 2013.*
2. *Mehta P.K. and Monteiro P.J.M, Concrete: Microstructure, Properties and Materials, McGrawHill Education , 2017.*
3. *Gambhir, M.L., Concrete Technology, McGraw Hill Education (India), 2017 .*
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	

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 and G.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 and paving 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

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 - Single degree of freedom system - Response to impulsive loads - Duhamels Integrals- Time domain analysis using numerical integration scheme - Response to general dynamic loading –Multi degree of freedom system - analysis of multi- degree of freedom system - mode superposition analysis – Mode combination rule – Application of dynamics to machine foundation and seismic analysis of buildings – Seismic design of non-structural elements

**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 the application of principles of dynamics – Seismic design and machine foundation

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	-

**Prerequisite: 23SC601- Advanced Mechanics of Solids**

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
3. - Hill Education, 2010.
4. Chandrashekhara .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	-

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 environmental quality-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. Peter R Smith and Warren G Jullian, *Building Services*, Applied Science Publishers Ltd, 1976.
4. A.J. Elder and Martiz Vinden Barg, *Handbook of Buildings and Enclosure*, McGraw Hill Book Co, 1983
5. Derek Clements-Croome, *Intelligent Buildings: Design, Management and Operation*, 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



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

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. Lin T .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		

Engineering Seismology, Ground Motion parameters, Behaviour of Building during past earthquakes - Evolution of seismic design philosophy - Recap of concepts related to dynamics of buildings - Capacity design - Estimate of seismic demand: Equivalent static analysis and dynamic analysis method – Elastic design spectra and Inelastic design spectra - Design and detailing of structural elements to resist seismic action; Response modification factor, Cyclic behaviour of RC, steel elements – Seismic demand for non-structural elements- Introduction to displacement based design of buildings, performance based design of buildings, and resilience based design of buildings - Retrofitting and Strengthening of Structures – Concept of Base Isolation Design – Types of Base Isolators – Hands-on: nonlinear static and dynamic analysis of buildings using commercially available software. Introduction to Seismic design of Industrial structures, storage tank, and soil retaining structures.

**TEXT BOOKS/ REFERENCES:**

1. Anil K Chopra, *Dynamics of Structures - Theory and Applications to Earthquake Engineering*, Prentice Hall, New Delhi, 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	Understand the behaviour of building during earthquakes
CO2	Understand the methods to estimate seismic demand on buildings
CO3	Understand the design of structural elements to resist seismic action
CO4	Understand and evaluate the nonlinear behaviour of building using commercially available software

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

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.T Ratay, *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

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, Spens 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

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. *Prentice Hall, 2012.*
3. *Rao S. S, Engineering Optimization Theory and Practice, Third Edition, New Age International, 2010.*
4. *Saravanan. R, Manufacturing Optimization Through Intelligent Techniques, Taylor and Fransis, 2006.*
5. *Ravindran, Phillips and Solberg, Operations Research Principles and Practice, Wiley India, 2007.*
6. *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

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			

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



Planning and Functional Requirements: Classification of Industries and Industrial Structures – understanding the workflow of the industry - 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

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

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

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. Swamidias, Essentials of Offshore Structures, CRC Press, 2013.B.C*
2. *.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

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, Reclaimed Asphalt Pavement

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 EWL factors - 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 Jointed 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

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 and mineralogical 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

**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.*

<b>CO Code</b>	<b>Course outcome statement</b>
<b>CO1</b>	Develop basic competence in assessing seismic hazard and in characterizing earthquake actions
<b>CO2</b>	Understand basic aspects of soil under dynamic loading and role of soil deposits.
<b>CO3</b>	Perform ground response analysis using conventional approaches
<b>CO4</b>	Evaluate the liquefaction potential using a range of simplified methodologies and understand the principles of mitigation measures
<b>CO5</b>	Understand the behavior of soil slopes under seismic loading

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



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 Jersey, 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	-

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 Stochastic Processes*, 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	

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. Analysis 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

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

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

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

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. Elements of formwork costing- Material Cost-Labour/Manpower/Worker cost - Overhead cost -Formwork cost Reduction. 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. *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.*

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

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

#### TEXT BOOKS/ REFERENCES:

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



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.

CO 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

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.

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

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

This can be an extension to work on the topic identified in previous semester “Dissertation I” 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 on the work done 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

23SC661

REMOTE SENSING AND GIS

2 1 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.

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

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

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 Sustainable Design*, Routledge, 2014.
3. *Sandy Halliday, Sustainable Construction*, Routledge, 2018.
4. *Dejan Mumovic 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

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 contemporary 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.*
6. *Barrow, C. J., Environmental and Social Impact Assessment – An Introduction, Edward Arnold, 1997.*
7. *Evan. K. Paleologos and Ian Lerche, Environmental Risk Analysis, McGraw Hill Inc, 2001.*
8. *Peter Morris (ed.) and Riki Therivel (ed.), Methods of Environmental Impact Assessment, Routledge, 2001.*
9. *UNEP, Environmental Impact Assessment Training Resource Manual, 2002.*
10. *Website of the Ministry of Environment and Forests, Govt. of India and the USEPA.*
11. *World Bank –Source book on EIA*

<b>CO Code</b>	<b>Course outcome statement</b>
<b>CO1</b>	Identify and analyze the need and legal requirements of EIA for projects
<b>CO2</b>	Identify the factors and perform Impact assessment methods for various Projects
<b>CO3</b>	Analyze the various components and prepare the EIA document for infrastructure projects.

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



**Course Objective**

- Introduction to the geotextiles
- Exploring various types of geotextiles
- Application of geotextiles in structural and construction engineering.

**Syllabus****Unit 1**

Introduction to geotextiles -Types- Properties:- mechanical, functional and durability tests of geotextiles- Advantages and disadvantages of geotextiles -Application of geotextiles in structural members for strength enhancement- Role of geotextiles in waterproofing of foundation and building roofs - Coir geotextile as an interior component- acoustics and thermal insulations - external vertical gardens.

**Unit 2**

Types of geotextiles used in pavement construction - Use of geotextiles in flexible concrete pavement as reinforcement and separation layer - Use of geotextiles in drainage applications of pavements – Role of geotextile in embankment construction – Geocells and its applications in pavements- Strength enhancement of pervious concrete using geotextiles – Flexible pavement design using Coir and jute geotextiles as per IRC – Case studies on real-time application of geotextiles embedded pavements

**Unit 3**

Technical textiles – functions: separation, filtration, drainage, fluid barrier, reinforcement - hydraulic and environmental properties. Applications in flood management – river training works – design of embankments - erosion and sediment control works. Applications in dams – seepage prevention in embankment dams, earthen dams and gravity dams – drainage of infiltrated water. Canal lining – seepage mechanism in canals – detection, measurement and analysis of seepage – remedial measures. Reservoirs and ponds – seepage measurement and control – cutoff trenches – reduction – usage of geosynthetics – applications in environmental pollution control – landfills – case studies.

**TEXT BOOKS/ REFERENCES:**

*SenthilKumar, “Textiles in Civil Engineering Applications”, Createspace Independent Publishing Platform, 2014.*

*Shukla S.K, “Handbook on Geosynthetics and their applications”, Thomas Telford, 2002*

*Tapabrata Sanyal, “Jute Geotextiles and their Applications in Civil Engineering”, Springer Singapore, 2016*

*Shukla, S.K. (2002). Geosynthetics and Their Applications. Thomas Telford Publishing, London, UK.*

CO Code	Course outcome statement
CO1	Understand the types of geotextiles and its application in structural engineering
CO2	Application of the geotextiles in the field of pavement engineering
CO3	Understand the application of the geotextiles in water resource engineering

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

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