M.TECH- STRUCTURAL AND CONSTRUCTION ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

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

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

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

CURRICULUM

First Semester

Course Code	Type	Course	L T P	Cr
16MA618	FC	Linear Algebra, Legendre Equations and Numerical Methods	3- 0- 0	3
16SC601	FC	Advanced Structural Mechanics	4- 0- 0	4
16SC611	SC	Theory of Elasticity and Plasticity	3- 0- 0	3
16SC612	SC	Advanced Structural Design	3- 1- 0	4
16SC613	SC	Construction Project Management	3- 0- 0	3
16SC615	SC	Experimental Techniques	1- 0 - 1	2
16HU601	HU	Cultural Education*		P/F
				Credits 19

*Non Credit Course

Second Semester

Course Code	Type	Course	L T P	Cr
16SC602	FC	Finite Element Analysis	3- 0- 0	3
16SC603	FC	Advanced Construction Practices	3- 0- 0	3
16SC614	SC	Advanced Foundation Systems	3- 0- 0	3
	E	Elective I	3- 0- 0	3
16SC616	SC	Structural Design Studio	0- 1- 2	3
16SC617	SC	Construction Software Laboratory	0- 0 - 1	1
16EN600	HU	Technical Writing*		P/F
				Credits 16

*Non Credit Course

Third Semester

Course Code	Type	Course	L T P	Cr
	E	Elective II	3- 0- 0	3
	E	Elective III	3- 0- 0	3
16SC618	SC	Live-in-Lab / Industrial Seminar	0 -0-1	1
16SC798	P	Dissertation		8
			Credits 15	

Fourth Semester

Course Code	Type	Course	L T P	Cr
16SC799	P	Dissertation		14
				Credits 14

Total Credits 64

List of Courses

Foundation Core

Course Code	Course	L T P	Cr
16MA618	Linear Algebra, Legendre Equations and Numerical Methods	3- 0 - 0	3
16SC601	Advanced Structural Mechanics	4- 0 - 0	4
16SC602	Finite Element Analysis	3- 0 - 0	3
16SC603	Advanced Construction Practices	3 -0- 0	3

Subject Core

Course Code	Course	L T P	Cr
16SC611	Theory of Elasticity and Plasticity	3- 0- 0	3
16SC612	Advanced Structural Design	3- 1- 0	4
16SC613	Construction Project Management	3- 0- 0	3
16SC614	Advanced Foundation Systems	3- 0- 0	3
16SC615	Experimental Techniques	1- 0- 1	2
16SC616	Structural Design Studio	0- 1- 2	3
16SC617	Construction Software Laboratory	0- 0- 1	1
16SC618	Live – in – Lab / Industrial Seminar	0- 0- 1	1

Electives

Course Code	Course	L T P	Cr
16SC701	Mechanics of Composite Materials	3- 0- 0	3
16SC702	Advanced Concrete Technology	3- 0- 0	3
16SC703	Construction Methods and Equipment	3- 0- 0	3
16SC704	Structural Dynamics	3- 0- 0	3
16SC705	Theory of Plates and Shells	3- 0- 0	3
16SC706	System Integration in Construction	3- 0- 0	3
16SC707	Quality Control and Safety in Construction	3- 0- 0	3
16SC708	Pre-stressed Concrete Design	3- 0- 0	3
16SC709	Analysis and Design for Wind and Earthquake Forces	3- 0- 0	3
16SC710	Forensic Engineering and Rehabilitation of Structures	3- 0- 0	3
16SC711	Geotechnics for Infrastructure	3- 0- 0	3
16SC712	Optimization Techniques	3- 0- 0	3
16SC713	Smart Materials and Structures	3- 0- 0	3
16SC714	Stability of Structures	3- 0- 0	3
16SC715	Industrial Structures	3- 0- 0	3
16SC716	Bridge Engineering	3- 0- 0	3
16SC717	Prefabrication Engineering	3- 0- 0	3
16SC718	Design of Offshore Structures	3- 0- 0	3
16SC719	Pavement Analysis and Design	3- 0- 0	3
16SC720	Sustainable Design & Construction Practices	3- 0- 0	3
16SC721	Characterization Of Materials	3- 0- 0	3
16SC722	Geotechnical Earthquake Engineering	3- 0- 0	3
16SC723	Soil Dynamics and Machine Foundations	3- 0- 0	3

Project Work

Course Code	Course	L T P	Cr
16SC798	Dissertation		8
16SC799	Dissertation		14

16MA618 LINEAR ALGEBRA, LEGENDRE EQUATIONS AND NUMERICAL METHODS 3-0-0-3

Linear algebra:Review of matrices and linear systems of equations, Vector spaces and subspaces, linear independence, basis and dimensions, linear transformations, orthogonality, Orthogonal basis, Gram Schmidt Process, least-square applications, Differential equation with series solutions**:** Legendre's equation, Legendre's polynomial $P_n(x)$, Legendre's function of the second kind [Qn(x)], General solution of Legendre's equation, Rodrigue's formula, Legendre polynomials, A generating function of Legendre's polynomial, Orthogonality of Legendre polynomials, Recurrence formulae for $P_n(x)$ Green's function – Green's Identities – Generalized functions.Numericalmethods: Solution of systems of equations – iterative methods, method of determining Eigen values and Eigen vectors by Power method. Numerical solution of partial differential equations – Elliptic, parabolic and hyperbolic equations.

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.

16SC601 ADVANCED STRUCTURAL MECHANICS 4-0-0-4

Review of the concepts: Basic concepts of structural analysis; Basis for principle of virtual work; Principle of virtual forces - standard and matrix formulation; Force method for analysing skeletal structures; Principle of virtual displacements - standard and matrix formulation; Displacement method for analysing skeletal structures; Extension of displacement method to the generalised 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; Gauss quadrature numerical integration scheme; Flexibility approach for determining element stiffness; Stiffness approach for determining element stiffness; Special consideration of shear effects in stiffness approach; Consideration of torsional effects for thin-walled member; Special considerations for finite joints (both rigid and flexible); Consideration of local load (incl. temperature) effects; Formulation of geometric stiffness due to axial force; Linearised buckling analysis. - Structural dynamics- SDOF- introduction to MDOF- behavior of structures subjected to wind and earthquake loads.

TEXT BOOKS/ REFERENCES:

1. William Weaver,Jr. James and M. Gere and Weaver, "*Matrix Analysis of FramedStructures"*, Third Edition Springer, 1990.

2. Pandit, G.S.andGupta, S. P. "*Structural Analysis : A Matrix Approach"*,Second Edition Tata McGraw - Hill Education, 2008.
3. Mcguire and Gallagher,R.H, "*Matrix Structural Analysis"*, John Wiley, 2001.
4. Rajasekaran. S and Sankarasubramanian.G,"*Computational Structural Mechanics"*,Prentice Hall of India, NewDelhi, 2009.
5. NelsonK.J and Mc Cormac J C.,"*StructuralAnalysis Using Classical and MatrixMethods"*, Third Edition, Wiley, 2002.

16SC611 THEORY OF ELASTICITY AND PLASTICITY 3-0-0-3

Introduction to Cartesian Tensors: Transformation laws of cartesian tensors, special tensors and tensor operations, the *e*-δ identity, symmetry and skew-symmetry, contraction, derivatives and the comma notation, Gauss' theorem, the base vectors and some special vector operations, eigenvalue problem of a symmetric second order tensor, equations of elasticity using index notation. - Introduction to the mathematical theory of elasticity**:** Two-dimensional idealisations, plane stress and plane strain problems, equations of equilibrium, strain-displacement relations, constitutive relations, compatibility conditions, displacement and traction boundary conditions. Two-dimensional problems in rectangular coordinates: Stress function, solution by polynomials, Saint Vénant's principle, bending of a cantilever. Two-dimensional problems in polar coordinates: General equations, problems of axisymmetric stress distribution, pure bending of curved bars, effect of circular hole, concentrated force on a straight boundary. -Stress and strain problems in three dimensions: Principal stresses, principal strains, three-dimensional problems. Energy Theorems and Variational Principles of Elasticity, uniqueness of elasticity solution. - Torsion of straight bars, membrane analogy, narrow rectangular cross-section, torsion of rectangular bars, rolled profile sections, hollow shafts and thin tubes. Introduction to plasticity: One-dimensional elastic-plastic relations, isotropic and kinematic hardening, yield function, flow rule, hardening rule, incremental stress-strain relationship, governing equations of elastoplasticity.

TEXT BOOKS/ REFERENCES:

1. Timoshenko,S.P and Goodier,J.N., "*Theory of Elasticity*", Mc.Graw Hill, Singapore, 1982.
2. Srinath, L.S, "*Advanced Mechanics of Solids*", Second Edition, Tata McGraw Hill, India, 2003.
3. Ameen,M., "*Computational Elasticity—Theory of Elasticity, Finite and BoundaryElement Methods*", Narosa Publishing House, 2004.
4. Chakrabarty, J,*"Theory of Plasticity"*, Elsevier, London, 2006.
5. Chen, W.F and Han, D.J., *"Plasticity for Structural Engineers"*, Springer Verlag, 1998.

16SC612 ADVANCED STRUCTURAL DESIGN 3 -1-0-4

Stress-strain characteristics of concrete under multi- axial stresses- confined concrete- Effect of cyclic loading on concrete and reinforcing steel. Ultimate Deformation and ductility of members with flexure- strength and deformation of members with tension - Control of deflections- Control of cracking – Codal procedures on crack-width computation. Strut and

Tie Models- Design methodology- Applications - RCC beam – column joints- shear strength - design of exterior and interior joints- wide beam joints. Strength and ductility of concrete frames- analysis and design of shear walls- design of special RCC members – corbel, deep beam, ribbed slab.- Stress strain behaviour and strength of steel under static and cyclic loading; Buckling and post buckling behaviour of plates; Linear elastic, plastic, linear buckling and nonlinear and advanced analysis methods. Limit States Design: Uncertainties in load and resistance; Limit States and Load and Resistance Factor Design methods. Behaviour and design of members under combined forces. Fasteners: Methods of installation and behavior. Screws and rivets in cold formed steel construction. Types of connections, Behaviour of local elements, Analysis, Design and Detailing. Cold Formed Steel Members: Effective width and Direct Strength Design methods

TEXT BOOKS/ REFERENCES:

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

16SC613 CONSTRUCTION PROJECT MANAGEMENT 3-0-0-3

Introduction to project management processes - Initiating, Planning, Executing, Controlling, and Closing processes; Project Integration Management; Project Scope Management; 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, program evaluation and review technique, production curves, Linear scheduling method; line-of-balance method. Duration compression, Resource constrained scheduling. Use of Advanced Scheduling Techniques; Scheduling with Uncertain Durations-Calculations for Monte Carlo Schedule Simulations - Schedule control. Techniques for project monitoring and control, Earned value analysis, Schedule and Cost Performance Index, Cumulative S curves. Project Resource Management - Resource aggregation, Resource leveling – method of moments, double moments, Resource allocation; Time-cost Tradeoff; Project Quality management; Material Management; Contract administration, and Contract close-out.

TEXT BOOKS/ REFERENCES:

1. Chitkara, K. K."*Construction Project Management Planning, Scheduling and Controlling"*, Tata McGraw Hill Publishing Co., New Delhi, 2010.
2. Kumar NeerajJha, "*Construction Project Management"*, Pearson Education, 2011.

3. G.D. Oberlender "*Project Management for Engineering and Construction*", McGraw-Hill, 2000.
4. Saleh Mubarak, "*Construction Project Scheduling and Control*", Wiley Inda Pvt. Ltd., 2013.
5. S. M. Levy, "*Project Management in Construction",* McGraw Hill, New York, 2007.

16SC615 EXPERIMENTAL TECHNIQUES 1-0-1-2

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

TEXT BOOKS / REFERENCES:

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

16SC602 FINITE ELEMENT ANALYSIS 3-0-0-3

Basic Equations of Solid Mechanics - Review of equilibrium conditions, Strain displacement relations, Stress Strain relations, Principle of Virtual work & Stationery potential energy and variational formulation. Approximate methods - RayleighRitz, Weighted residual (Galerkin) and finite difference methods - 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 and 3D truss and beam elements and applications. Analysis of plane stress/strain and axisymmetric solids triangular, quadrilateral and isoparametric elements, incompatible models. Three dimensional stress analysis-Isoparametric eight and twenty noded elements. Analysis of plate bending Basic equations of thin plate theory. Reissner-Mindlin theory - Plate elements and applications. Analysis of shells - degenerated shell elements. -Finite element programming and 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, 2007 .
2. Rao S S, "*The Finite Element Method in Engineering",* Elsevier, 2012.
3. Zienkiewicz,O. C., and Taylor,R .L., "*The Finite Element Method,* Vol.1 –*The Basic Formulation and Linear Problems",* Butterworth and Heiamann,2005.
4. M.Asghar Bhatti., "*Fundamental Finite Element Analysis and Applications",* Wiley India Pvt.Ltd., 2013.

5. M.Asghar Bhatti., "*Advanced Topics in Finite Element Analysis"*,Wiley India Pvt.Ltd.- 2014.

16SC603 ADVANCED CONSTRUCTION PRACTICES 3-0-0-3

Construction materials:- High performance concrete, Structural Plastics and Composites- Polymer Membranes – Coatings, Adhesives, Non-weathering materials - Flooring and Facade Materials - Metals and Special Alloys of Steel. - Sub-structure construction:- Construction of diaphragm walls, H walls and basement- Shoring for deep cutting-Underpinning;Trenchless Technology; Box jacking, Pipe Jacking.Tunneling Techniques- Piling Techniques-Driving Well And Caisson-Sinking Cofferdam-Cable Anchoring and Grouting.-Super Structure Construction:- Techniques of construction for continuous concreting operation in Tall buildings of various shapes and varying sections- erection techniques of tall structures - rapid construction techniques, composite construction of steel and concrete. Large span structures - Launching techniques for heavy decks- in-situ pre-stressing in high rise structures, aerial transporting, handling, erecting light weight components on tall structures.-Special Structures:- Construction Sequences in cooling towers, Silos, Chimney, Sky scrapers, bow string bridges, cable stayed bridges-Launching and pushing of box decks- support structure for heavy Equipment, conveyor and machinery in heavy industries-erection of articulated structures.

TEXT BOOKS/ REFERENCES:

1. Mamlouk, M.S. and Zaniewski, J.P.,"*Materials for Civil and Construction Engineers",* Prentice Hall, 2010.
2. Harris,F.,"*ModernConstruction and Ground Engineering Equipment and Methods",* Prentice Hall, 2013.
3. Singh,J., "*Heavy Construction -Planning, Equipment and Methods"*,ThirdEdition, CRC Press, 2009.
4. Michael ChewYit Lin, "*Construction Technology for Tall Buildings"*, Singapore University Press, Singapore, 2001.
5. Johnson,R.P., "*Composite Structures of Steel and Concrete",* Wiley India Exclusive, 2013.

16SC614 ADVANCED FOUNDATION SYSTEMS 3-0-0-3

Foundation classification; Choice of foundations; Bearing capacity and settlement analysis of shallow foundations like footings and rafts, Deep foundations like piles, piers and Caissons; Foundations on expansive soils, laterites, fills and rock.Introduction to Limit StateDesign of reinforced concrete in foundations; Soil pressure for structuraldesign; Conventional structural design of continuous footings, individualfootings, combined footings and rafts of various types subjected tovertical and lateral loads and moments; Design of circular rafts; Soilstructure interaction and 'flexible' approach to the design of foundations. Analysis and design of pile foundations, piers, well foundations. Special foundations - ring foundations, offshore foundations.

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.

16SC616 STRUCTURAL DESIGN STUDIO 0-1-2-3

Planning, Analysis and Design of Industrial structures, Multi storeyedbuildings, Post-tensioned slabs in buildings,RCC walled multi-storied buildings (applicable to residential buildings).Bridges, Towers, Storage structures, Material handling equipment and special structures. Geotechnical aspects in foundation design. Special emphasis on Earthquake resistant design. Design,detailing and preparation of drawings.

TEXT BOOKS/ REFERENCES:

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

16SC617 CONSTRUCTION SOFTWARE LABORATORY 0-0-1-1

Project management software - Project estimation, project planning,project scheduling, network analysis, project time reduction and optimization, resourceleveling, project time, cost and finance management, earned value analysis. Visualization software –Exposure to BIM modelling.

16EN600 TECHNICAL WRITING P/F

Technical terms- Definitions- extended definitions- grammar checks- error detection- punctuation- spelling and number rules - tone and style- pre-writing techniques - Online and offline library resources- citing references – plagiarism - Graphical representation - documentation styles- instruction manuals- information brochures- research papers, proposals – reports (dissertation, project reports etc.) - Oral presentations.

TEXTBOOKS/REFERENCES

1. Hirish, Herbert L. "*Essential Communication Strategies for Scientists, Engineers and Technology Professionals"*. Second Edition. New York: IEEE Press, 2002.

2. Anderson, Paul V. "*Technical Communication: A Reader-Centred Approach"*. VI Edition. Cengage Learning India Pvt. Ltd., New Delhi, Reprint, 2010.
3. Strunk, William Jr. and White, E.B. "*The Elements of Style New York"*. Alliyanand Bacon, 1999.

16SC618 LIVE-IN-LAB / INDUSTRIALSEMINAR 0-0-1-1

Live In Lab

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.

INDUSTRIAL SEMINAR

The objective of the training is to expose the students to industry environment and practices.

The students can identify the problem with the support of experts from industry at the end of first year (summer vacation) and start working on it.

Apart from this, experts from the Civil Engineering industry are invited to deliver lectures on field related issues and share their professional experience including aspects of Professional ethics. Each student is required to prepare a detailed report and present the same for evaluation.

16SC 798 DISSERTATION 8

16SC 799 DISSERTATION 14

16SC701 MECHANICS OF COMPOSITE MATERIALS 3-0-0-3

Composite materials and its characteristics – Analysis of an orthotropic lamina- Analysis of laminated composites- Fracture mechanics- Determination of strain energy release rate- Manufacturing Processes- Testing of Composites – Stress analysis – interlaminar stresses and free edge effects- Failure Criteria – Whitnessnuismer failure criteria- Vibration and stability analysis – Introduction to Design of Composite Structures – Introduction to structural Design and Analysis of mechanically fastened joints – Optimization Concepts – Fatigue in Composites – Effects of holes in Laminates – Transverse shear effects- Post curing shapes of

Unsymmetric Laminates – Environmental Effects on Composite Materials – Study of Hygrothermic effects on laminates- Quality control and Characterization of Composite- Non Destructive testing on Composites- Recycling of Composites – Primary and Secondary Recycling of Composites.

TEXTBOOKS/REFERENCES:

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

16SC702 ADVANCED CONCRETE TECHNOLOGY 3-0-0-3

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

TEXT BOOKS/ REFERENCES:

1. Nevile, A.M., "*Properties of Concrete"*, Pearson, 2013.
2. Mehta P.K. andMonteiro P.J.M, "*Concrete: Microstructure, Properties andMaterials",*Third Edition, McGraw-Hill , 2006.
3. A RSanthakumar, "*Concrete Technology"* Oxford University Press, 2006
4. Zongjin Li, "*Advanced Concrete Technology"*, John Wiley and Sons, Inc., Hoboken, New Jersey, 2011.

16SC703 CONSTRUCTION METHODS AND EQUIPMENT 3-0-0-3

Planning Process for Equipment and Methods; Cost of Owning and Operating Construction Equipment - Ownership cost, Depreciation, Operating cost, and Ownership and operating costs calculation methods; 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; Earthmoving, Excavating, and Lifting Equipment Selection - Bulldozers, Front-end Loaders, Scrapers, Trucks, Excavators, Backhoes, Front shovels, Cranes, and Forklifts; Piles and Pile-Driving Equipment; Production of Crushed-stone Aggregate; Concreting Equipment; Asphalt Mix Production and Placement - Asphalt Plants, and Paving Equipment; Estimating and Optimizing Construction Equipment System Productivity - Scheduling Equipment-Intensive Horizontal Construction Projects - Scheduling Lifting Equipment for Vertical Construction; Equipment Financing Decision - Financing methods, Rental and lease contract considerations.

TEXT BOOKS/ REFERENCES:

1. R.L.Peurifoy, C.J. Schexnayder and A.Shapira, "*Construction Planning, Equipment, and Methods"*, Tata McGraw - Hill Education, 2010.
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.Singh, "*Heavy Construction - Planning, Equipment and Methods"*, Third Edition, CRC Press, 2009.

16SC704 STRUCTURAL DYNAMICS 3-0-0-3

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

TEXT BOOKS/ REFERENCES:

1. Paz.M, "*Structural Dynamics - Theory and Computation"*, Springer, 2007.
2. Anil K Chopra*, "Dynamics of Structures - Theory and Applications to EarthquakeEngineering"*, Prentice Hall, NewDelhi, 2004.

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, 2007

16SC705 THEORY OF PLATES AND SHELLS 3-0-0-3

Introduction – Formulation of governing equations and associated boundary conditions by equilibrium and energy methods, Rectangular plates- Solution of equation by double and

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

TEXT BOOKS/ REFERENCES:

1. Vardhan T.K. and Bhaskar. K, "*Analysis of Plates: Theory and Problems"*,Narosa Book Distributors Pvt Ltd, 1999.
2. Timoshenko. S, and Woinowsky - Kreiger, "*Theory of Plates and Shells"*, Tata McGraw - Hill Education, 2010.
3. Chandrashekharan.K, "*Theory of Plates"*, Universities Press (India) Ltd., 2001.

16SC706 SYSTEM INTEGRATION IN CONSTRUCTION 3-0-0-3

Structural system, Systems for enclosing buildings, Functional aesthetic system,Materials selection and Specification. Environmental-Qualities of enclosure necessary to maintaina specified level of interior environmental quality-Weather Resistance-Thermal infiltration-Acoustic control-Transmission reduction-Air quality-Illumination-Relevant Systems integrationwith structural systems -Elevators, Escalators, Conveyors, Security Systems inHigh Rise Building Complexes, Public Buildings, Parking Lots And Complex Structures likeHospitals, 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 todeleterious forces-Planning systems for least maintenance-Feasibility for replacement of damagedcomponents -equal life elemental design-Maintenance free exposed and finished surfaces.- Intelligent Buildings & Building Management System (BMS)-Concept-Purpose-ControlTechnologies- 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 VChadderton, "*Building Services Engineering"*, Routledge, 2012.
3. PeterR Smith and Warren G Jullian,"*BuildingServices"*, Applied Science Publishers Ltd, 1976.
4. A.J.Elder and MartizVindenBarg, "*Handbook of Buildings and Enclosure"* , Mc Graw-Hill Book Co, 1983.
5. Derek Clements-Croome, "*Intelligent Buildings: Design, Management andOperation"*, Thomas Telford, 2004.

16SC707 QUALITY CONTROL AND SAFETY IN CONSTRUCTION 3-0-0-3

Introduction to quality; Importance of quality; Quality transition - quality control andinspection, quality assurance, total quality management; Evolution of quality management;Planning and control of quality during design of structures; Tools and techniques for qualitymanagement; 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 safetyand health manual.

TEXT BOOKS/ REFERENCES:

1. Dale B. G,"*Managing Quality"*, Fourth Edition, Blackwell Publishing, Oxford, 2003.
2. Reese. C.D and Eidson J.V, *"Handbook of OSHA Construction Safety and Health"*, Second Edition, CRC Press, Boca Raton, 2006.
3. Jimmie W. Hinze*"Construction Safety",* Prentice Hall of India, 1997.
4. Harris .F, McCaffer .R and Edum-Fotwe .F, "*Modern Construction Management"*, Sixth Edition, Blackwell Publishing, Oxford, 2006.
5. Holt S. J, "*Principles of Construction Safety"*, Blackwell Publishing, Oxford, 2008.

16SC708 PRE-STRESSED CONCRETE DESIGN 3-0-0-3

Introduction to prestressed concrete: types of prestressing, systems anddevices, materials, losses in prestress. Analysis of PSC flexuralmembers: basic concepts, stresses at transfer and service loads, ultimatestrength in flexure, code provisions. - Statically determinatePSC beams: design for ultimate and serviceability limit states for flexure,and flexure combined with axial compression or tension; analysisanddesign for shear and torsion, code provisions. Transmission of prestressinpretensioned members; Anchorage zone stresses for post tensionedmembers.Statically indeterminate structures Analysisand design continuousbeams and frames, choice of cable profile, lineartransformation and concordancy.-Composite construction with precastPSC beams and cast insituRC slab Analysisand design, creep andshrinkage effects. Partial prestressingprinciples,analysis and design concepts, crack-widthcalculations. Analysis and design of prestressedconcrete pipes, tanks and spatial structures slabs,grids, folded platesand shells.

TEXT BOOKS/ REFERENCES:

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

16SC709 ANALYSIS AND DESIGN FOR WINDAND EARTHQUAKE FORCES 3-0-0-3

Engineering Seismology, Ground Motion parameters, Design philosophy, Code provisions, Inelastic Design Response Spectra (IDRS), Response reduction factors, Pushover analysis, Inelastic cyclic behaviour of steel and reinforced concrete structures, ductility and energy dissipation capacity, Principles of Capacity Design, Detailing of RC members and joints, Design and detailing of Steel structures including braced and moment resistant frames, Damage evaluation and retrofit techniques; Application of relevant IS codes to practical design. - Wind gust loading: Basic concepts, spectral description structural response of the line like structure, Aerodynamics damping Aerodynamics instability: Vortex shedding, Along wind and ovalling excitation - design impact and counter measures, Aeroelastic excitation: galloping - flutter. Design Wind speeds and risk coefficients, Design wind pressure and pressure coefficients, Vortex shedding, gust factors, wind tunnel testing.

TEXT BOOKS/ REFERENCES:

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

16SC710 FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES 3-0-0-3

Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability – case studies – learning from failures – causes of distress in structural members – design and material deficiencies – over loading - Diagnosis and Assessment of Distress: Visual inspection – non destructive tests – ultrasonic pulse velocity method – rebound hammer technique– pullout tests– Windsor probe test – crack detection techniques – case studies – single and multistorey buildings – Fibreoptic method for

prediction of structural weakness -Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment – pollution and carbonation problems – durability of RCC structures – damage due to earthquakes and strengthening of buildings – provisions of BIS 1893 and 4326. Methods of repair in concrete, steel and timber structural components.- Modern Techniques of Retrofitting: Structural first aid after a disaster – guniting, jacketing – use of chemicals in repair – application of polymers – ferrocement and fiber concretes as rehabilitation materials – strengthening by pre-stressing – case studies.- Maintenance - inspection and planning, budgeting and management.

TEXT BOOKS/ REFERENCES:

1. Dovkaminetzky,"*Design and Construction Failures"*,Galgotia Publication, New Delhi, 2009.
2. Macdonald S, "*Concrete – Building Pathology"*, John Wiley and Sons, 2002.
3. Robert.TRatay, "*Forensic Structural Engineering Handbook"*, Mc GrawHill, 2009.
4. James Douglas and Bill Ransom, "*Understanding Building Failures"*, Taylor and Francis Group, 2007.
5. Peter H Emmons, "*Concrete Repair and Maintenance"*,Galgotia Publications, 2010.

16SC711 GEOTECHNICS FOR INFRASTRUCTURE 3 -0-0-3

Site investigation for infrastructure projects; Principles of exploration; Modern methods of boring and sampling; Sampling records, Soil profiles, various types of field tests; Excavation scheme. - Engineering properties of soft, weak and compressible deposits; Methods of soil improvement lime stabilization and injection; thermal, electrical and chemical methods; - Dynamic consolidation; Vibroflotation - Types of foundations for industrial structures; Design of deep foundations for heavy structures, railway and highway bridges; Foundations for transmission line towers, storage tanks, silos, chimneys etc., Sheet piles and cofferdams; Design of dewatering systems. Preloading and vertical drains, Introduction to Geotextiles and Geomembranes,Grouting (along with injection).Recent trends in infrastructure projects like soil nailing, reinforced earth, gabion walls .

TEXT BOOKS/ REFERENCES:

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

16SC712 OPTIMIZATION TECHNIQUES 3-0-0-3

Introduction to Optimization: Engineering application of Optimization – Statement of an optimization problem- Optimal Problem formulation – Classification of optimization problems. Definition of Global and Local minima. Unconstrained Optimization: Optimality Conditions- Algorithms for univariate optimization- Algorithms for multivariate optimization- Convergence of algorithms – Engineering applications of unconstrained algorithms. Lagrange multiplier Theory & Duality: Lagrange Multipliers- Kuhn- Tucker Optimality Conditions and sufficiency for convex problems- Lagrangian duality- Saddle point conditions. Constrained Optimization: Optimality conditions- Feasible direction methods- Frank- Wolfe algorithm- Gradient Projection – Active set methods- Penalty function methods- Constrained steepest descent method. Modern methods of optimization: Genetic Algorithms- Simulated Annealing – Tabu search – Ant Colony optimization – Particle Swarm Optimization – Neural- Network based Optimization – Fuzzy optimization techniques. Introduction to Multi – Objective optimization – Classical methods- Pareto Optimality – Use of evolutionary algorithms for solving Multi Objective optimization problems. - Lab Practice:Use of programming languages and Matlab to solve optimization problems.

TEXTBOOKS/REFERENCES:

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

16SC713 SMART MATERIALS AND STRUCTURES 3-0-0-3

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

TEXT BOOKS/ REFERENCES:

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

16SC714 STABILITY OF STRUCTURES 3-0-0-3

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

16SC715 INDUSTRIAL STRUCTURES 3-0-0-3

Planning and Functional Requirements: Classification of Industries and Industrial Structures – planning for layout requirements regarding lighting, ventilation and fire safety - protection against noise and vibration – guidelines from factories act – material handling systems - structural loads - Single Storey Industrial Structures: Types of roofing – roofing sheets – purlins – light gauge sections – built-up sections – roof trusses – pre-engineered structures. Foundations for industrial structures - Material Handling Systems: Cranes – Types design of EOT over head travelling cranes, zib cranes and Goliath cranes. Design of Gantry girders for over head cranes. Conveyor systems – Supports for conveyor systems. - Industrial Storage Structures: Silos, Bins and Bunkers – Design of supporting system for storage hoppers and bunkers - Environmental Control Structures for Industries : Various components – Concept of Electro Static Precipitators functioning and components – Wet and dry Scrubbers – Chimneys – Self supporting, Guyed and Braced chimneys.

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"*, Third 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.

16SC716 BRIDGE ENGINEERING 3-0-0-3

Introduction Classificationand components of bridges, historicalperspective, layout and planning, investigations for Bridges, choice oftype of the bridges, conceptual bridge design, bridge aesthetics. Bridgeappurtenances. Loads on bridges loadingstandards for highway andrailway bridges (IRC, IRS) - Analysis and design of RC and PSC bridgedecks: slab culvert bridges, slabandbeambridges, load distribution inslabs and beams, bowstringgirder bridges, behaviour of skew bridgedecks. Behaviour, analysis and design of RC and PSC boxgirderbridgedecks.Behaviour, analysis and design of steel bridge decks: girderbridges, truss bridges, arch bridges, composite construction. Design ofbearings, substructure and foundations piersand abutments of differenttypes, shallow and deep foundationsdesignand constructional aspects.-Modern methods of construction of concrete, steel and compositebridges, 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 Practic*", 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)

16SC717 PREFABRICATION ENGINEERING 3-0-0-3

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

TEXT BOOKS/ REFERENCES:

1. SharonChung-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.

16SC718 DESIGN OF OFFSHORE STRUCTURES 3-0-0-3

Small Amplitude Wave Theory - Wave trains and Wave energy - Wave reflection, Wave refraction and Wave diffraction - Breaking of waves - Finite Amplitude Waves –Higher Order Wave Theories - Wave Forces –Wave force on a Circular Cylinder, Froude Krylov theory - Diffraction theory - Types of offshore structures and conceptual development - Materials and their behaviorunder static and dynamic loads - Statutory regulations - Allowable stresses - Various designmethods and Code Provisions - Design specification of API, DNV, Lloyd's and other classification societies - Operational loads - Environmental loads due to wind, wave, currentand buoyancy - Morison's Equation - Maximum wave force on offshore structure - Concept of Random waves - Principles of Static and dynamic analyses of fixed platforms - Use of approximate methods – Analytical models for jacket structures-Introduction to tubular joints - Possible modes of failure - Eccentric connections and offset connections - Cylindrical and rectangular structural members – In plane and multi plane connections - Parameters of inplane tubular joints - Kuang's formulae - Elastic stress distribution - Punching shear Stress - Overlapping braces - Stress concentration - Chord collapse and ring stiffener spacing - Stiffened tubes - External hydrostatic pressure - Fatigue of tubular joints - Fatigue behaviour - S-N curves - Palmgren-Miner cumulative damage rule - Design of tubular joints as per API Code. Corrosion - Corrosion mechanism - Offshore structure corrosion zones – Biological corrosion - Preventive measures - Online corrosion monitoring - Corrosion fatigue.

TEXT BOOKS/ REFERENCES:

1. D. V. Reddy and A. S. J. Swamidas, "*Essentials of Offshore Structures"*, CRC Press, 2013.
2. B.C Gerwick, Jr. "*Construction of Marine and Offshore Structures"*, CRC Press, Florida, 2007.21
3. Dawson, T. H., "*Offshore Structural Engineering"*, Prentice Hall, 1983.
4. API RP 2 A., "*Planning, Designing and Constructing Fixed Offshore Platforms"*, API., 2000.
5. McClelland, B and Reifel, M. D., "*Planning & Design of fixed Offshore Platforms"*, Kluwer Academic Publishers, 1986.

16SC719 PAVEMENT ANALYSIS AND DESIGN 3-0-0-3

Introduction - Comparison between Flexible & Rigid Pavements -Highway and Airport pavements – Types and Component layers of Pavements – their functions - A brief study on aggregates, bitumen and modified bitumen like cutback, emulsion, polymer modified bitumen - Factors affecting Design and Performance of Pavements - Various Methods of Assessment of Subgrade Soil Strength for Pavement Design - Causes and Effects of variation in Moisture Content and Temperature. Bituminous mix design methods, specifications and

testing.Analysis& Design of Flexible Pavement: Stresses and Deflections in Homogeneous Masses - Burmister's 2-layer, 3- layer Theories - Wheel Load Stresses - ESWL of Multiple Wheels – Repeated Loads and EWLfactors - Sustained Loads and Pavement behaviour under Traffic Loads - Empirical, Semi-empirical and Theoretical Approaches - Development, Principle, Design steps, Advantages and Applications of different Pavement Design Methods Analysis & Design of Rigid pavements: Types of Stresses and Causes, Factors influencing the Stresses; General conditions in Rigid Pavement Analysis, ESWL, Wheel Load Stresses, Warping Stresses, Friction Stresses, Combined Stresses - Types of Joints in Cement Concrete Pavements and their Functions, Joint Spacing, Design of Slab Thickness, Design of Joint Details for Longitudinal Joints, Contraction Joints and Expansion Joints, IRC Method of Design.- Pavement Structure & Its Evaluation: Factors affecting Structural Condition of Flexible and Rigid Pavements; Evaluation by Non-Destructive Tests. Pavement Overlays & Design.

TEXT BOOKS/ REFERENCES:

1. Huang Yang H.,"*Pavement Analysis and Design"*, Pearson Education India, 2008
2. Yoder and Witczak, "*Principles of Pavement Design"*, Wiley India Pvt Ltd, 2011
3. Nai C. Yang, "*Design of Functional Pavements"*, McGraw Hill ,1972
4. Hass and Hudson, "*Pavement Management System"*, McGraw Hill Book Co. ,1978

16SC720 SUSTAINABLE DESIGN AND CONSTRUCTION PRACTICES 3-0-0-3

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

TEXT BOOKS/ REFERENCES:

1. Kibert, C.J., "*Sustainable Construction: Green Building Design and Delivery"*, John Wiley and Sons, 2013.
2. Steven V. Szokolay., "*Introduction to Architectural Science - The Basis of SustainableDesign"*, Elsevier, 2007.
3. Sandy Halliday, "*Sustainable Construction"*, Routledge, Taylor & Francis Group, 2013.
4. DejanMumovic and Mat Santamouris (Ed), "*A Handbook of Sustainable Building Design and Engineering"*, Earthscan Publishing, 2009.
5. Osman Attmann, *"Green Architecture: Advanced Technologies and Materials"*, Mc-Graw Hill, 2010.

16SC721 CHARACTERISATION OF MATERIALS 3-0-0-3

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

Characterisation of rheological behavior:Rheological parameters; Classifications of fluids, time independent and time-dependent fluids, elastic viscous fluids. Constitutive equation of rheology, shear and extensional viscosities, dependence of viscosity on temperature, pressure, molecular weight, strain rate and time. Flow curve.Viscoelasticity - effect of rate of strain, temperature and time on mechanical behavior; Creep, creep compliance, stress relaxation;Dynamic mechanical properties. Flow analysis using rheological models. Measurement of rheological properties. Application of rheology in cement-based materials.

TEXT BOOKS/ REFERENCES:

1. Robert W. Kelsal, Ian W. Hamley, Mark Geoghegan, "*Nanoscale-Science and Technology"*, John Wiley and 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 YaMalkin, 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.

16SC722 GEOTECHNICAL EARTHQUAKE ENGINEERING 3 -0-0-3

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

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

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

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

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

TEXT BOOKS/ REFERENCES:

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

SC723 SOIL DYNAMICS AND MACHINE FOUNDATIONS 3 -0-0-3

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

Wave propagation: Types of waves, Waves in unbound 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, Retaining wall problems under Dynamic loads. Dynamic slope stability Analysis. Liquefaction: Basic concept, Evaluation and effects, Vibratory motion of foundation, Vibration screening, Design of machine foundations.

TEXT BOOKS/ REFERENCES:

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