Proposed
Curriculum of
M. Tech. Structural Engineering Program

Department of Civil Engineering
Harcourt Butler Technical University
Kanpur-02
(10th BOS 14.11.2025)

Department of Civil Engineering

Proposed Course Structure of M.Tech. Structural Engineering (Applicable from Academic Session 2025-26)

Table 1: Course structure and Proposed Course Codes

S.N.	Course Name	Course code	Periods/Structure			Total Credits
1st Semester			**L**	**T**	**P**	
1	Advanced Structural Analysis	NSE 501	2	1	2	4
2	Advanced Concrete Design	NSE 503	3	1	0	4
3	Numerical Methods for Structural Engineering	NMA 551	3	1	0	4
4	Program Elective-I (See Table-2)	NSE 509/511/ 513/515/517	3	1	0	4
					Total Credits (1st Semester)	16
2nd Semester			**L**	**T**	**P**	
1	Finite Element Analysis	NSE 502	3	1	0	4
2	Structural Dynamics	NSE 504	3	1	0	4
3	Design of Tall Buildings	NSE 506	3	1	0	4
4	Program Elective-II (See Table-2)	NSE 512/514/ 516/518/520	3	1	0	4
					Total Credits (2nd Semester)	16
3rd Semester			**L**	**T**	**P**	
1	Program Elective- III (See Table-2)	NSE 601/603/ 605/607/609	3	1	0	4
2	Open Elective (OEC)	OSE 601/603/605	3	0	0	3
3	Seminar	NSE 671	0	0	3	1
4	Dissertation -I	NSE 697	0	0	16	8
					Total Credits (3rd Semester)	16
4th Semester			**L**	**T**	**P**	
	Dissertation -II	NSE 698	0	0	32	16
					Total Credits (4th Semester)	16
					Total Credits of the M.Tech. Programme	64

Table 2: List of Program Elective Course (PEC)

PEC I		
S.no		**Name of the Courses**
1	NSE 509	Repair and Maintenance of Concrete Structures
2	NSE 511	Site Investigation and Foundation Design
3	NSE 513	Design of Concrete Bridges
4	NSE 515	Design of Hydraulic Structures
5	NSE 517	Theory of plates and shells
PEC II		
1	NSE 512	Special Concretes: Development and Applications
2	NSE 514	Earthquake Resistant Design of Structures
3	NSE 516	Advanced Steel Design
4	NSE 518	Maintenance and Rehabilitation of Structures
5	NSE 520	Analysis of Deep Foundation
PEC III		
1	NSE 601	Soil Structure Interaction
2	NSE 603	Stability of Structures
3	NSE 605	Structural Health Monitoring
4	NSE 607	Vibration Control
5	NSE 609	Planning and management of buildings

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Table 1: Course structure and Proposed Course Codes

S.N.	Course Name	Course code	Structure				Sessional Marks				ESE	Total Marks
1st Semester			**L**	**T**	**P**	**C**	MSE	TA	Lab	Total	Total	
1	Advanced Structural Analysis	NSE 501	2	1	2	4	15	20	15	50	50	100
2	Advanced Concrete Design	NSE 503	3	1	0	4	30	20	-	50	50	100
3	Numerical Methods for Structural Engineering	NMA 551	3	1	0	4	30	20	-	50	50	100
4	Program Elective-I (See Table-2)	NSE 509/511/513/515/517	3	1	0	4	30	20	-	50	50	100
Total Credits (1st Semester)						16						
2nd Semester			**L**	**T**	**P**	**C**						
1	Finite Element Analysis	NSE 502	3	1	0	4	30	20	-	50	50	100
2	Structural Dynamics	NSE 504	3	1	0	4	30	20	-	50	50	100
3	Design of Tall Buildings	NSE 506	3	1	0	4	30	20	-	50	50	100
4	Program Elective-II (See Table-2)	NSE 512/514/516/518/520	3	1	0	4	30	20	-	50	50	100
Total Credits (2nd Semester)						16						
3rd Semester			**L**	**T**	**P**	**C**						
1	Program Elective- III (See Table-2)	NSE 601/603/605/607/609	3	1	0	4	30	20	-	50	50	100

2	Open Elective (OEC)	OSE 601/603/605	3	0	0	3	30	20	-	50	50	100
3	Seminar	NSE 671	0	0	3	1	-	-	-	50	50	100
4	Dissertation -I	NSE 697	0	0	16	8	-	-	-	100	100	200
Total Credits (3rd Semester)						16						
4th Semester			**L**	**T**	**P**	**C**						
	Dissertation -II	NSE 698	0	0	32	16	-	-	-	100	100	200
Total Credits (4th Semester)						16						
Total Credits of the M.Tech. Programme						64						

Table 2: List of Program Elective Courses (PEC)

PEC I		
S.no	**Course Code**	**Name of the Courses**
1	NSE 509	Repair and Maintenance of Concrete Structures
2	NSE 511	Site Investigation and Foundation Design
3	NSE 513	Design of Concrete Bridges
4	NSE 515	Design of Hydraulic Structures
5	NSE 517	Theory of Plates and Shells
PEC II		
1	NSE 512	Special Concretes: Development and Applications.
2	NSE 514	Earthquake Resistant Design of Structures
3	NSE 516	Advanced Steel Design
4	NSE 518	Maintenance and Rehabilitation of Structures
5	NSE 520	Analysis of Deep Foundation
PEC III		
1	NSE 601	Soil Structure Interaction
2	NSE 603	Stability of Structures
3	NSE 605	Structural Health Monitoring
4	NSE 607	Vibration Control
5	NSE 609	Planning and Management of Buildings

Table 3: List of Open Elective Courses

OSE		
S.no	**Course Code**	**Name of the Courses**
1	OSE 601	Principles and Applications of Building Science
2	OSE 603	Optimization Techniques for ~~Civil~~ Engineers
3	OSE 605	Infrastructure Asset Management

FIRST SEMESTER COURSES

NSE 501 ADVANCED STRUCTURAL ANALYSIS

Unit 1

Review of basic concepts in structural engineering: Equilibrium, Stress-strain relationships, Types of structures, Stability, Static indeterminacy, Kinematic indeterminacy, Calculation of member forces and deflections of truss, Beams and frames under static loads, Influence line diagrams, Calculations and visualisation using MS Excel

Unit 2

Introduction to matrix methods of analysis, Stiffness method, Flexibility method, Formulation of element and structure matrices, Coordinate transformation.

Analysis of truss using matrix methods, Hand calculations and analyses using MATLAB/ Python and STAAD Pro.

Unit 3

Analysis of beams and frames using matrix methods, Hand calculations and analyses using MATLAB/Python and STAAD Pro

Unit 4

Introduction to nonlinear analysis of structures, Types of nonlinearities- material, geometric and boundary conditions, Iterative methods, Path-following methods, Beam example.

Unit 5

Introduction to stability and buckling, Euler's buckling theory for columns, Buckling of pin-ended, fixed, and guided column, Inelastic buckling and column strength curves, Matrix approach to stability analysis, Critical load calculation for frames

Lab Exercises

1. Introduction to computational tools – MS Excel/ MATLAB/ Python
2. Analysis of beams and visualization of displacements – using first principles and MS Excel
3. Analysis of plane truss using direct stiffness method using MS Excel/MATLAB/Python and validation using hand calculations
4. Analysis of continuous beam using stiffness and flexibility matrix methods using MS Excel/MATLAB/Python and validation using hand calculations
5. Analysis of plane-frame using stiffness and flexibility matrix methods using MS Excel/MATLAB/Python and validation using hand calculations
6. Analysis of space truss using matrix methods and STAAD Pro
7. Analysis of space frame using matrix methods and STAAD Pro
8. Analysis of a beam with material nonlinearity STAAD Pro/ MATLAB
9. Buckling analysis of columns – STAAD Pro/ MATLAB

Reference books

- Devdas Menon, "Advanced Structural Analysis", Narosa Publishing House, 2009.

- Amin Ghali, Adam M Neville and Tom G Brown, "Structural Analysis: A Unified Classical and Matrix Approach", Sixth Edition, 2007, Chapman & Hall
- Srinivasan Chandrasekaran, "Advanced Structural Analysis with MATLAB", CRC Press, 2018
- Steen Krenk, "Non-linear Modelling and Analysis of Solids and Structures", Cambridge University Press, 2009
- The MathWorks Inc. (2022). MATLAB version: 9.13.0 (R2022b), Natick, Massachusetts: The MathWorks Inc. https://www.mathworks.com

NSE 503 ADVANCED CONCRETE DESIGN

Unit 1: Fundamental Concepts and Special RC Members

Limit state design philosophy (IS:456, IS:1343), Stress-strain relationships, moment-curvature behavior, Ductility, moment redistribution, serviceability criteria, Deep beams, corbels, torsion (IS:456, SP:16), Slender columns, biaxial bending, Shear walls and beam-column joints

Unit 2: Flat Slabs, Grid Floors & Prestressed Concrete

Analysis and design of flat slabs (Direct Design, Equivalent Frame) Punching shear and detailing, Grid floor systems, Introduction to prestressing: systems, materials, Prestress losses, flexural and shear design, Serviceability and detailing (IS:1343)

Unit 3: Liquid Retaining & Industrial Concrete Structures

Design of water tanks (circular and rectangular, elevated and underground), Crack control, hydrostatic pressures, and uplift considerations, Design of bunkers and silos (Janssen's & Airy's theory), Chimneys and staging, Equipment foundations: loads and design principles

Unit 4: Shells, Folded Plates & Earthquake-Resistant Design

Membrane theory: shell action fundamentals, Cylindrical, conical shells, domes, Folded plates: analysis and detailing, Seismic design of RC structures (IS:13920), Ductile detailing, capacity design principles, Seismic performance and assessment

Unit 5: Durability, Advanced Materials & Software Applications

Durability of concrete: deterioration, protection, Code provisions (IS:456, IS:10262), Corrosion control and crack management, High-performance concrete (HPC), fiber-reinforced concrete (FRC), self-compacting concrete (SCC), Introduction to FEM for RC structures (ETABS, ABAQUS, ANSYS), Case studies and student presentations

Reference books

- IS:456 – *Code of Practice for Plain and Reinforced Concrete*
- IS:1343 – *Code of Practice for Prestressed Concrete*
- Varghese, P.C. – *Advanced Reinforced Concrete Design*
- Pillai, U., & Menon, D. – *Reinforced Concrete Design*
- Krishna Raju – *Prestressed Concrete*
- Park & Paulay – *Reinforced Concrete Structures*
- SP:34 – *Handbook on Concrete Detailing*
- Timoshenko & Woinowsky-Krieger – *Theory of Plates and Shells*

Software and Tools (Recommended)

- **ETABS / SAFE** – Structural Analysis and Design
- **ABAQUS / ANSYS** – Finite Element Modeling
- **AutoCAD / Revit** – Detailing and Drafting

NMA 551 NUMERICAL METHODS FOR STRUCTURAL ENGINEERING

Unit 1

Solutions of linear equations: Direct method – Cramer's rule, Guass – Elimination method- Gauss – Jordan elimination – Triangulation (LU Decomposition) method – Iterative methods Jacobi – Iteration method – Gauss – Siedel iteration, Successive over –relaxation method. Eigen values and eigen vectors: Jacobi method for symmetric matrices- Given's method for symmetric matrices Householder's method for symmetric matrices-Rutishauser method of arbitrary matrices – Power method.

Unit 2

Interpolation: Linear Interpolation - Higher order Interpolation - Lagrange Interpolation – Interpolating polynomials using finites differences- Hermite Interpolation -piece-wise and spline Interpolation.

Unit 3

Finite Difference and their Applications: Introduction- Differentiation formulas by Interpolating parabolas – Backward and forward and central differences- Derivation of Differentiation formulas using Taylor series- Boundary conditions- Beam deflection – Solution of characteristic value problems- Numerical solution to spatial differential equations – Application to Simply Supported Beams, Columns & rectangular Plates.

Unit 4

Numerical Differentiation: Difference methods based on undetermined coefficients- optimum choice of step length– Partial differentiation. Numerical Integration: Method based on interpolation-method based on undetermined coefficient – Gauss – Lagrange interpolation method- Double integration using Trapezoidal and Simpson's method – Newmark's Method and Application to Beams – Calculations of Slopes & Deflections.

Unit 5

Ordinary Differential Equation: Euler's method – Backward Euler method – Midpoint method – single step method, Taylor's series method- Boundary value problems, Initial Value problems. Applications to simple harmonic motions.

Reference books

1. Numerical Methods for Scientific and Engineering Computations. M. K. Jain- S. R. K. Iyengar – R. K. Jain Willey Eastern Limited. New Age International (p) Ltd., Publishers, Reprint 2004, ISBN: 81-224-1461-3 56789101112.
2. Numerical Methods for Engineering Problems by N. Krishna Raju and K. U. Muthu, M.C. Millan Publishers, New Delhi
3. Numerical Methods for Engineers Stevan C. Chopra, Raymond P. Canal Mc. Graw Hill Book Company. April 2009
4. C Language and Numerical methods by C. Xavier – New Age International Publisher. Reprint March 2012 ISBN: 978-81-224-1174-4.
5. Computer based numerical analysis by Dr. M. Shanta Kumar, Khanna Book publishers New Delhi.

NSE 509 REPAIR AND MAINTENANCE OF CONCRETE STRUCTURES

Unit 1

General: Introduction, Cause of deterioration of concrete structures, Significance and fundamentals of corrosion, Carbonation-induced and chloride-induced corrosion, Types of reinforcement – Bare steels, Metallic and non-metallic coated rebars, TM - Ring Test, Corrosion in prestressed concrete.

Unit 2

Deterioration of cementitious systems: Introduction, Durability, Performance based specifications for durable Concrete, Durability issues in concrete, sulphate attack, biofouling and acid attack, Frost attack, freeze-thaw and alkali-silica reaction, Shrinkage and creep, Fire attack, abrasion and erosion.

Unit 3

Maintenance and Repair Strategies : Importance of Maintenance, Preventive measures on various aspects, Condition assessment of concrete structures: Exposure conditions, visual inspection, Testing of concrete, Mechanical and corrosion testing of rebars, Surface preparation and protective treatment, Coatings on concrete infrastructures, Waterproofing of concrete structures.

Unit 4

Structural strengthening & stabilization - Load effects and introduction, Beams and slabs, Columns & walls, Joints and connections, Injection grouts for concrete repair, Cathodic protection in concrete structures - Lab and field studies.

Unit 5

Examples of Repair to Structures: Repairs to overcome low member strength, Deflection, Cracking, Chemical disruption, weathering wear, fire, leakage, marine exposure, Case studies on structural repair, Structural repair of prestressed concrete systems.

Reference books

- Concrete Repair and Maintenance" by Peter H. Emmons, R.S. Means Company, Kingston, MA, USA
- Dov Kominik – Repair of Concrete Structures
- Sidney, M. Johnson "Deterioration, Maintenance and Repair of Structures".
- Maintenance Repair & Rehabilitation & Minor Works of Buildings" P.C. Varghese, PHI Learning Pvt. Ltd., New Delhi
- R.T.Allen and S.C. Edwards, "Repair of Concrete Structures"-Blakie and Sons
- IS:13311, IS:456, IS:15988

NSE 511 SITE INVESTIGATION AND FOUNDATION DESIGN

Unit 1

Advanced Site Investigation Techniques

Principles and planning of subsurface exploration, soil and rock sampling methods, groundwater investigation techniques, and preparation of geotechnical reports for civil

engineering projects.

Unit 2

In-Situ Testing and Geophysical Characterization

Application of advanced in-situ tests (SPT, CPT, PMT, DMT, PLT, VST) and geophysical methods (seismic refraction, resistivity) to evaluate soil properties for foundation design and ground characterization.

Unit 3

Principles of Foundation Design

Theoretical background on soil behavior under loading, estimation of design parameters,

and introduction to foundation design methodologies including WSD, USD, and LSD.

Unit 4

Foundation Design for Shallow and Deep Foundations

Design considerations and analysis methods for shallow and deep foundations including bearing capacity, settlement, lateral loads, and group effects in accordance with IS codes.

Unit 5

Case Histories, Site Hazards, and Professional Practice

Evaluation of real-world case studies involving foundation failures, understanding site hazards and their mitigation, and discussing geotechnical engineering practices in industrial and infrastructure projects.

Reference books

- Das, B. M. (2018). Principles of Foundation Engineering, 9th ed., CengageLearning, Boston, MA.
- Bowles, J. E. (1997). Foundation Analysis and Design, 5th ed., McGraw-Hill, New York.
- Roy, M. (2024). Geotechnical and Foundation Engineering Practice in Industrial Projects, Springer Nature, Singapore. https://doi.org/10.1007/978-981-97-1385-7
- Ou, C. Y., Yang, K. H., Teng, F., Chiou, J. S., Lu, C. W., Li, A. J., Ching, J., and Liao, J. T. (2024). Fundamentals of Foundation Engineering, CRC Press, Boca
- Raton, FL. https://doi.org/10.1201/9781003350019
- Kurian, N. P. (1992). Design of Foundation Systems: Principles and Practices, Narosa Publishing House, New Delhi, India.

- Tomlinson, M. J., and Woodward, J. (2015). Pile Design and Construction Practice, 6th ed., CRC Press, Boca Raton, FL.
- Craig, R. F. (2004). Craig's Soil Mechanics, 7th ed., Spon Press, London.
- Kramer, S. L. (1996). Geotechnical Earthquake Engineering, Prentice Hall,Upper Saddle River, NJ.
- Reese, L. C., and Van Impe, W. F. (2001). Single Piles and Pile Groups Under
- Lateral Loading, 2nd ed., CRC Press, Boca Raton, FL.
- Poulos, H. G., and Davis, E. H. (1980). Pile Foundation Analysis and Design,
- Wiley, New York.
- Terzaghi, K., Peck, R. B., and Mesri, G. (1996). Soil Mechanics in Engineering
- Practice, 3rd ed., Wiley-Interscience, New York.
- Coduto, D. P., Yeung, M. R., and Kitch, W. A. (2016). Geotechnical Engineering: Principles and Practices, 2nd ed., Pearson Education, Boston.

NSE 513 DESIGN OF CONCRETE BRIDGES

Unit 1

Introduction to bridges: historical development, requirements, site selection, components, classification

Loads on bridges: types of loads, Liveloads as per IRC 6, Limit states

Review of limit state design for bending shear and torsion.

Unit 2

Slab bridges: Behavior, Effective length, Effective width, IRC 112 Provisions, Load calculations, Design for flexure and shear, Check for serviceability limit states, Control of cracking and deflection.

Unit 3

Box Culvert: Analysis of Box culvert, Culvert full and empty conditions, calculations of deadload, liveload, earth pressure and surcharge,Critical sections, Bending moment and shear force and axial force diagrams, Design for flexure and shear, Check for serviceability limit states.

Unit 4

Tee Beam Bridges: Types of Tee beam bridges, Components, Analysis of two way slabs under concentrated loads, Courbon's method, Design of deck slab, cantilever slab, and longitudinal girder, design of cross beams

Unit 5

Bearings and Substructures: Bearing function and types, Design of elastomeric bearing, Abutments and piers – types, load calculation, forces and moments, check for stresses

Reference books

- "Essentials of Bridge Engineering"- D Johnson Victor, Oxford & IBH Publishing Co New Delhi
- "Design of Concrete Bridges"-Praveen Nagarajan, Wiley, 2020
- "Design of Bridges"- N Krishna Raju, Oxford & IBH Publishing Co New Delhi
- "Principles and Practice of Bridge Engineering"- S P Bindra Dhanpat Rai & Sons New Delhi
- IRC 6 – 1966 "Standard Specifications And Code Of Practice For Road Bridges"- Section II Loads and Stresses, The Indian Road Congress New Delhi
- IRC 21 – 1966 "Standard Specifications And Code Of Practice For Road Bridges"- Section III Cement Concrete (Plain and reinforced) The Indian Road Congress New Delhi
- IS 456 – 2000 "Indian Standard Plain and Reinforced Concrete Code of Practice"- (Fourth Revision) BIS New Delhi

- IS 1343 – "Indian Standard Prestressed Concrete Code of Practice"- BIS New Delhi
- Raina V.K., "Concrete Bridge Practice"- Tata McGraw Hill
- Bakht B & Jaeggar, "Bridge Analysis Simplified"- McGraw Hill 3 Ponnuswamy. S, "Bridge Engineering"- Tata McGraw Hill.

NSE 515 DESIGN OF HYDRAULIC STRUCTURES

Unit 1

Introduction: Hydraulic structures for water resources projects. Types of hydraulic structures, storage, diversion, conveyance and distribution structures, capacity of a reservoir, reservoir silting, types of dams

Unit 2

Hydraulic structures on permeable foundations: Seepage theories, Khosla's theory, design of diversion head works and other structures on permeable foundations

Unit 3

Embankment Dams: Types, design considerations, seepage analysis and control, stability analysis, and construction techniques.

Arch Dams: Types, thin cylinder theory, Introduction to methods of design

Unit 4

Gravity Dams: Forces acting on failure of a gravity dam, stress analysis, elementary profile, design of gravity dam, other functional features of a gravity dam.

Unit 5

Dam Outlet Works: Types of outlet structures, ogee spillway, chute spillway, siphon spillway, side channel spillway, Labyrinth and Piano-key weir.

Reference books

- Arora K.R., Irrigation, Water Power and Hydropower Engineering, Standard Book Publishing, New Delhi, 2018, 5th Edition
- Modi, P. M., Irrigation Water Resources and Hydropower Engineering, Standard Book Publishing Company, New Delhi, 2014, 9th Edition
- Novak, P. and Nalluri, C., Hydraulic Structures, Taylor & Francis, 2007, 4th Edition
- Asawa G.L., Irrigation and Water Resources Engineering, New Age International Publishers, New Delhi, 2006
- Singh, B., and Varshney, R.S., Embankment Dam and Engineering, Nem Chand and Brothers, 2004
- Singh B., and Sharma, H.D., Earth and Rockfill Dams, Saritha Prakashan, 1976
- Peterka, A.J, Hydraulic Design of Stilling Basins and Energy Dissipators, USBR Engineering Monographs No. 25". 1984
- Creager, W.P. Justin D, and Hinds, J., Engineering for Dams Vol. I, II and III.
- Kushalani, K.B., Irrigation (practice and design) Vol. III and IV.
- Nalluri C., " Hydraulic Structures" Taylor & Francis,2001
- Garg S.K, Irrigation Engineering and Hydraulic Structures, Khanna Publishers, 2006.

NSE 517 THEORY OF PLATES AND SHELLS

Unit 1

Review of mechanics of solids, stress, strain, constitutive relationships,

Introduction to theory of plates - Plate theories, Governing equations, Reduced stiffness, Plate stiffness.

Unit 2

Theory of rectangular plates, Navier's and Levy's methods for rectangular plates, Theory of circular plates, axi-symmetrical bending

Unit 3

Approximate methods for bending of plate, Buckling of thin plate, Approximate methods for buckling of thin plate

Unit 4

Introduction to shell structures and shell geometry, Membrane theory for surface of revolution, Membrane theory of pressure vessels

Unit 5

Membrane analysis for cylindrical shell roof, General theory of cylindrical shell

Reference Books

- Timoshenko, S.P. Theory of Plates and Shells, Mc Graw Hill Book Company, New York, USA (1959).
- Rudolph Szilard. Theories and Application of Plate Analysis, John Wiley & Sons, USA (2004).
- Shames, I.H., and Dym, C.L., Energy and Finite Element Methods in Structural Mechanics, New Age International Publishers, 2003.

SECOND SEMESTER COURSES

NSE 502 FINITE ELEMENT METHOD

Unit 1

Introduction, Boundary value problems and solution methods, Direct approach – example, advantage and limitations. Calculus of variation, Strong form and weak form, equivalence between strong and weak forms,

Rayleigh-Ritz method. quadrature in three dimensions, examples. Method of weighted residuals – Galerkin and Petrov-Galerkin approach,

Unit 2

FE formulations - Axially loaded bar, governing equations, discretization, derivation of element equation, assembly, imposition of boundary condition and solution, examples.

Finite element formulation for Euler-Bernoulli beams and Timoshenko beams. Finite element formulation for plane trusses and frames computer implementation.

Unit 3

Finite element formulation for two-dimensional problems - completeness and continuity, different elements (triangular, rectangular, quadrilateral etc.), shape functions, Gauss quadrature technique for numerical integration.

Finite element formulation for two-dimensional scalar field problems; Iso-parametric formulation Application to Heat conduction and torsion problems

Unit 4

Finite element formulation for two-dimensional problems in linear elasticity; Formulation, examples and computer implementation, Implementation issues - locking, reduced integration, B-Bar method - introduction.

Unit 5

Finite element formulation for three-dimensional problems; Different elements, shape functions, Gauss quadrature in three dimensions, examples.

Reference books

- Reddy, J. N. (2005). *An introduction to the finite element method* (3rd ed.). McGraw-Hill
- Zienkiewicz, O. C., Taylor, R. L., & Zhu, J. Z. (2013). *The finite element method: Its basis and fundamentals* (7th ed.). Elsevier.
- Bathe, K. J. (1996). *Finite element procedures*. Prentice Hall.
- Cook, R. D., Malkus, D. S., Plesha, M. E., & Witt, R. J. (2002). *Concepts and applications of finite element analysis* (4th ed.). Wiley.
- Logan, D. L. (2016). *A first course in the finite element method* (6th ed.). Cengage Learning.
- Chandrupatla, T. R., & Belegundu, A. D. (2012). *Introduction to finite elements in engineering* (4th ed.). Pearson

NSE 504 STRUCTURAL DYNAMICS

Unit 1

Introduction: Types of dynamic loads; Elements of dynamic systems; motivation for structural dynamics.

Dynamics of Single Degree-of-Freedom Structures: Equation of motion, Free vibration of single degree of freedom systems – damped and undamped; Forced vibration under harmonic loadings, Dynamic response functions, Force transmission, and vibration isolation.

Unit 2

SDOF response to periodic and arbitrary loads. Duhamel Integral

Numerical Evaluation of Dynamic Response of SDOF Systems: Time domain analysis: finite difference methods; Frequency domain analysis: basic methodology.

Earthquake Response of SDOF Systems: Earthquake excitation, response history and construction of response spectra; Response spectrum characteristics

Unit 3

Multi Degree of Freedom Systems - Basics: Dynamic equations of equilibrium, static condensation; Symmetric plan and plan-asymmetric systems.

Free Vibration Response of MDOF Systems: Undamped systems: natural modes and their properties; Modal analysis; Numerical solution for the eigenvalue problem;

Free vibration response for undamped systems; Free vibration analysis of systems with damping.

Unit 4

Dynamic Analysis of Linear MDOF Systems: Response history for earthquake excitations using modal analysis; Response spectrum analysis for peak responses; Proportional damping, Caughey damping.

Unit 5

Generalized Single Degree of Freedom Systems: Basic concepts, mass-spring system; Lumped mass systems; Systems with distributed mass and elasticity; Rayleigh's method, shape function selection.

Introduction to Dynamics of Continuous Systems: Equations of motions for axial and flexural vibrations of a beam; Free vibration analysis; Forced vibration analysis using modal superposition method

Reference books

- Chopra, A. K. (2017). *Dynamics of Structures: Theory and Applications to Earthquake Engineering* (5th ed.). Pearson Education.
- Paz, M., & Leigh, W. (2004). *Structural Dynamics: Theory and Computation* (5th ed.). Springer.
- Clough, R. W., & Penzien, J. (2003). *Dynamics of Structures* (3rd ed.). Computers and Structures, Inc.

- Rajasekaran, S. (2009). *Structural Dynamics of Earthquake Engineering: Theory and Application Using MATLAB*. CRC Press.
- Meirovitch, L. (1986). *Elements of Vibration Analysis* (2nd ed.). McGraw-Hill.
- Craig, R. R., Jr., & Kurdila, A. J. (2006). *Fundamentals of Structural Dynamics* (2nd ed.). Wiley.
- Weaver, W., Timoshenko, S., & Young, D. H. (1990). *Vibration Problems in Engineering* (5th ed.). Wiley.
- Thomson, W. T., & Dahleh, M. D. (1998). *Theory of Vibration with Applications* (5th ed.). Prentice Hall.

NSE 506 DESIGN OF TALL BUILDINGS

Unit 1

Design Criteria: Design philosophy, loading, sequential loading, and materials – high performance concrete, fiber reinforced concrete, lightweight concrete, design mixes. Loading and Movement: Gravity loading: Dead and live load, methods of live load reduction, Impact, Gravity loading, Construction loads

Unit 2

Wind loading: static and dynamic approach, Analytical and wind tunnel experimentation method. Earthquake loading: Equivalent lateral force, modal analysis, combinations of loading, working stress design, Limit state design, Plastic design.

Unit 3

Behavior of Various Structural Systems: Factors affecting growth, Height and structural form; High rise behavior, Rigid frames, braced frames, in-filled frames, shear walls, coupled shear walls, wall-frames, tubular, cores, Futigger – braced and hybrid mega system.

Unit 4

Analysis and Design: Modeling for approximate analysis, accurate analysis and reduction techniques, analysis of building as total structural system considering overall integrity and major subsystem interaction, analysis for member forces; drift and twist, computerized general three dimensional analyses.

Unit 5

Stability of Tall Buildings: Overall buckling analysis of frames, wall frames, approximate methods, second order effects of gravity of loading, P-Delta analysis, simultaneous first order and P-Delta analysis, Transnational, Torsional instability, out of plane effects, stiffness of member in stability, effect of foundation rotation. Structural elements: sectional shapes, properties and resisting capacities, design, deflection, cracking, pre-stressing, shear flow. Design for differential movement, creep and shrinkage effects, temperature effects and fire.

Reference books

- Taranath B.S, "Structural Analysis and Design of Tall Buildings"- McGraw Hill
- Wilf gang Schuller, "High rise building structures"- John Wiley
- Bryan Stafford Smith & Alexcoull, "Tall building structures Analysis and Design"- John Wiley
- T.Y Lin & D.Stotes Burry, "Structural concepts and system for Architects and Engineers"- John Wiley
- Lynn S.Beedle, "Advances in Tall Buildings"- CBS Publishers and Distributors.
- Dr. Y.P. Gupta – Editor, "Proceedings National Seminar on High Rise Structures-Design and Construction practices for middle level cities"- New Age International Limited

NSE 512 SPECIAL CONCRETES: DEVELOPMENT AND APPLICATIONS

Unit 1

Components of modern concrete and developments in the process and constituent materials: Role of constituents, Development in cements and cement replacement materials, pozzolona, fly ash, silica fume, rice husk ash, recycled aggregates, chemical admixtures. Mix proportioning of Concrete: Principles and methods.

Unit 2

Light Weight concrete: Introduction, classification, properties, strength and durability, mix proportioning and problems. High density concrete: Radiation shielding ability of concrete, materials for high density concrete, mix proportioning, properties in fresh and hardened state, placement methods.

Unit 3

Ferro cement: Ferrocement materials, mechanical properties, cracking of ferrocement, strength and behaviour in tension, compression and flexure, Design of ferrocement in tension, ferrocement constructions, durability, and applications.

Unit 4

Fibre reinforced concrete: Fibre materials, mix proportioning, distribution and orientation, interfacial bond, properties in fresh state, strength and behavior in tension, compression and flexure of steel fibre reinforced concrete, mechanical properties, crack arrest and toughening mechanism, applications.

Unit 5

High Performance concrete: constituents, mix proportioning, properties in fresh and hardened states, applications and limitations. Ready Mixed Concrete-QCI-RMCPC scheme requirements, Self Compacting Concrete, Reactive powder concrete, and bacterial concrete

Reference books

- Neville A.M, "Properties of Concrete", Pearson Education Asia, 2000
- P. Kumar Mehta, Paul J.N. Monterio, CONCRETE: Microstructure, Properties and Materials", Tata McGraw Hill
- A.R.Santhakumar, (2007) "Concrete Technology"-Oxford University Press, New Delhi, 2007
- Gambhir "Concrete Technology" TMH.
- Short A and Kinniburgh.W, "Light Weight Concrete"- Asia Publishing House, 1963
- Aitcin P.C. "High Performance Concrete"-E and FN, Spon London 1998
- Rixom.R. and Mailvaganam.N., "Chemical admixtures in concrete"- E and FN, Spon London 1999
- Rudnai.G., "Light Weight concrete"- Akademiaikiado, Budapest, 1963
- http://qcin.org/CAS/RMCPC/

NSE 514 EARTHQUAKE RESISITANT DESIGN OF STRUCTURES

Unit 1

Seismic Hazard Assessment: Engineering Seismology, Definitions, Introduction to Seismic hazard, Earthquake phenomenon, Seism tectonic and seismic zoning of India-Earthquake monitoring and seismic instrumentation, Characteristics of strong ground motion,

Estimation of earthquake parameters, Micro zonation

Unit 2

Effect of Lateral load on Buildings: Rigid diaphragm effect, Centre of mass and center of stiffness, Torsional coupled and uncoupled systems, Distribution of lateral force for One storey and Multiple stories building.

Structural Configuration for earthquake resistant design: Concept of plan irregularities, Soft storey, Torsion in buildings. Design provisions for these in IS-1893. The effect of infill masonry walls on frames. Modelling concepts of infill masonry walls. Behavior of masonry building during earthquake, failure patterns.

Unit 3

Concept of earthquake resistant design: Review of latest Indian seismic code IS 1893:2000 (part-1) and IS 4326 Provisions for buildings, Earthquake design philosophy, Seismic Analysis by seismic coefficient and response spectrum methods, Time History Analysis using software.

Unit 4

Earthquake resistant design of buildings: IS 13920 Provisions for ductile detailing of RC building – beams, columns, and beam-columns and joints.

Unit 5

Earthquake analysis of elevated water tank, Codal provisions for ground supported and elevated water tanks, impulsive and convective mass of water, Calculation of time period, Base shear, Base moments, Hydrodynamic pressure and sloshing wave height.

Reference books

- Agrawal Pankaj & Shrikhande Manish, "Earthquake Resistant Design of Structures" 1st Edition, Prentice Hall of India Pvt Ltd, New Delhi, 2004.
- Farzand Naeim & Van Nostrand Reinmhold, "The Seismic Design", Handbook, New York, 1989
- Pauley & Priestly, "Seismic design of reinforced concrete and masonry buildings", John Wiley & Sons, 1992.
- Park R and Paulay Y., "Reinforced Concrete Structures", John Wiley & Sons, 1975.
- Ghose S. K., "Earthquake Resistance Design of Concrete Structures", SDCPL – R&D Center, New Mumbai 73.
- IS 1893:2016, "Criteria for Earthquake Resistant Design of Structures "
- IS 13920:2016, "Ductile Design and Detailing of Reinforced Concrete Structures"

NSE 516 ADVANCED STEEL DESIGN

Unit 1

Laterally Unrestrained Beams: Lateral Buckling of Beams, Factors affecting lateral stability, IS 800 code provisions, Design Approach. Lateral buckling strength of Cantilever beams, continuous beams, beams with continuous and discrete lateral restraints, Mono- symmetric and non- uniform beams – Design Examples. Concepts of -Shear Center, Warping, Uniform and Non-Uniform torsion.

Unit 2

Beam- Columns in Frames: Behaviour of Short and Long Beam - Columns, Effects of Slenderness Ratio and Axial Force on Modes of Failure, Biaxial bending, Strength of Beam Columns, Sway and Non-Sway Frames, Strength and Stability of rigid jointed frames, Effective Length of Columns-, Methods in IS 800 - Examples

Unit 3

Steel Beams with Web Openings: Shape of the web openings, practical guide lines, and Force distribution and failure patterns, Analysis of beams with perforated thin and thick webs, Design of laterally restrained castellated beams for given sectional properties, Vierendeel girders (design for given analysis results)

Unit 4

Cold-formed steel sections: Techniques and properties, Advantages, Typical profiles, Stiffened and unstiffened elements, Local buckling effects, effective section properties, IS 801& 811 code provisions- numerical examples, beam design, column design.

Unit 5

Fire resistance: Fire resistance level, Period of Structural Adequacy, Properties of steel with temperature, Limiting Steel temperature, Protected and unprotected members, Methods of fire protection, Fire resistance ratings- Numerical Examples.

Reference books

- N. Subramanian, "Design of Steel Structures", Oxford,IBH
- Duggal.S.K., Design of Steel structures. Srinath. L.S., Advanced Mechanics of Solids, Tata M Publishing Co ltd., New Delhi cGraw-Hill
- IS 1641, 1642,1643
- IS 800: 2007, IS 811
- INSDAG Teaching Resource Chapter 11 to 20: www.steel-insdag.org

NSE 518 MAINTENANCE AND REHABILITATION OF STRUCTURES

Unit 1

Introduction Maintenance, rehabilitation, repair, retrofit and strengthening, need for rehabilitation of structures. Cracks in R.C. buildings Various cracks in R.C. buildings, causes and effects Maintenance Maintenance importance of maintenance, routine and preventive maintenance. Damages to masonry structures Various damages to masonry structures and causes

Unit 2

Repair materials Various repair materials, Criteria for material selection, Methodology of selection, Health and safety precautions for handling and applications of repair materials Special mortars and concretes Polymer Concrete and Mortar, Quick setting compounds Grouting materials Gas forming grouts, Salfoalumate grouts, Polymer grouts, Acrylate and Urethane grouts. Bonding agents Latex emulsions, Epoxy bonding agents. Protective coatings Protective coatings for Concrete and Steel FRP sheets

Unit 3

Damage diagnosis and assessment Visual inspection, Non Destructive Testing using Rebound hammer, Ultra sonic pulse velocity, Semi destructive testing, Probe test, Pull out test, Chloride penetration test, Carbonation, Carbonation depth testing, Corrosion activity measurement Substrate preparation Importance of substrate/surface preparation, General surface preparation methods and procedure, Reinforcing steel cleaning.

Unit 4

Crack repair Various methods of crack repair, Grouting, Routing and sealing, Stitching, Dry packing, Autogenous healing, Overlays, Repair to active cracks, Repair to dormant cracks. Corrosion of embedded steel in concrete Corrosion of embedded steel in concrete, Mechanism, Stages of corrosion damage, Repair of various corrosion damaged of structural elements (slab, beam and columns)

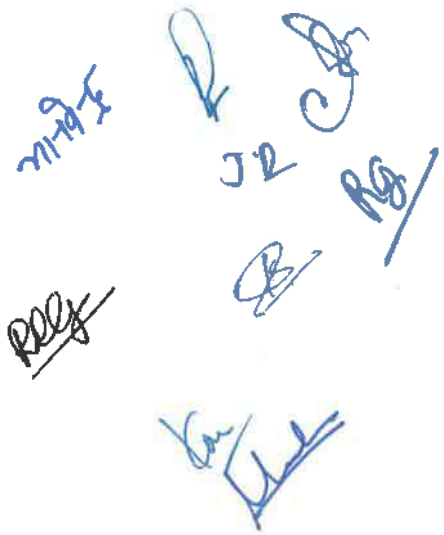
Unit 5

Jacketing Jacketing, Column jacketing, Beam jacketing, Beam Column joint jacketing, Reinforced concrete jacketing, Steel jacketing, FRP jacketing. Strengthening Strengthening, Beam shear strengthening, Flexural strengthening

Reference books

- Repair and protection of concrete structures by Noel P.Mailvaganam, CRC Press,1991.
- Concrete repair and maintenance Illustrated by Peter.H.Emmons, Galgotia publications Pvt. Ltd., 2001.
- "Earthquake resistant design of structures" by Pankaj agarwal, Manish shrikande, PHI, 2006.

- Failures and repair of concrete structures by S.Champion, John Wiley and Sons, 1961.
- Diagnosis and treatment of structures in distress by R.N.Raikar Published by R & D Centre of Structural Designers and Consultants Pvt.Ltd, Mumbai.
- Handbook on repair and rehabilitation of RCC buildings, CPWD, Government of India.
- Handbook on seismic retrofit of buildings, A. Chakrabarti et.al., Narosa Publishing House, 2010.



NSE 520 ANALYSIS OF DEEP FOUNDATIONS

Unit 1: Introduction to Deep Foundations

Types of deep foundations; load transfer mechanism; general behavior under axial and lateral loads; soil-pile interaction concepts; selection of deep foundation type based on soil and loading.

Unit 2: Deep Foundation Design Based on In-Situ Tests (Including Comparative Analysis of International Design Codes)

SPT, CPT, PMT, and DMT for estimating pile capacity and deformation. Use of in-situ data in empirical and semi-empirical design. IS, Eurocode 7, API RP 2A, and FHWA methods for design. Comparative analysis of international codes.

Unit 3: Deep Foundation Design for Offshore Structures

Types of offshore foundations – monopiles, suction piles, caissons. Marine soil characteristics. Wave and current effects. Design standards such as API, ISO. Geotechnical design approaches and safety requirements for offshore foundations.

Unit 4: Laterally Loaded Piles

Mechanics of laterally loaded piles. Broms method for short and long piles. p–y curve based analysis. Elastic continuum and finite difference methods. Lateral load tests and interpretation.

Unit 5: Dynamic Analysis of Deep Foundations

Dynamic loads and their effect on deep foundations. Machine foundation response. Seismic loading and liquefaction. Wave equation analysis. Dynamic impedance functions. Interpretation of dynamic pile load test results.

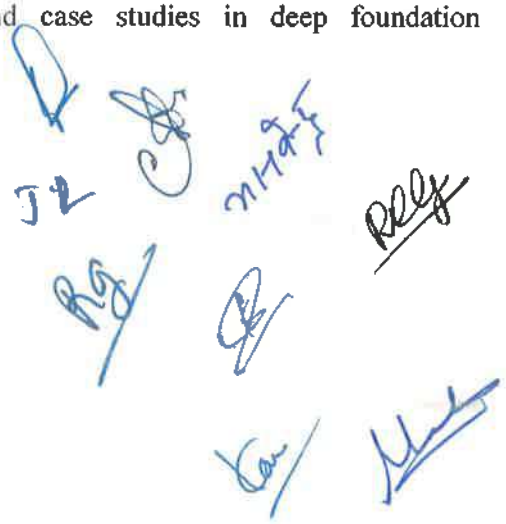
Reference books

- Das, B. M. (2018). "Principles of Foundation Engineering", 9th ed., Cengage Learning.
- Poulos, H. G., and Davis, E. H. (1980). "Pile Foundation Analysis and Design", Wiley.
- Tomlinson, M. J., and Woodward, J. (2015). "Pile Design and Construction Practice", 6th ed., CRC Press.
- Bowles, J. E. (1997). "Foundation Analysis and Design", 5th ed., McGraw-Hill.
- Coduto, D. P., Kitch, W. A., and Yeung, M. R. (2016). "Geotechnical Engineering:
- Principles and Practices", Pearson Education.
- IS 2911 (Part 1 to 4): Design and construction of pile foundations – Code of Practice, BIS, New Delhi.
- IS 2950: Design and construction of raft foundations, BIS, New Delhi.
- Eurocode 7: Geotechnical Design – Part 1: General rules (EN 1997-1:2004).
- API RP 2A: Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms.

- FHWA-NHI-16-072: Design and Construction of Driven Pile Foundations, Federal Highway Administration, USA.
- ISO 19901-4: Offshore structures – Geotechnical design and site investigations, ISO, Geneva.

Software and Tools

- https://www.fhwa.dot.gov – Federal Highway Administration (USA) publications and tools.
- https://bsi.knect365.com/eurocode-7/ – Eurocode 7 guides and technical background.
- https://www.api.org/ – American Petroleum Institute standards and offshore design manuals.
- https://www.rocscience.com – Software for deep foundation analysis (Settle3, LPILE, etc.).
- https://pilebuck.com – Practical guides and case studies in deep foundation construction.



THIRD SEMESTER COURSES

NSE 601 SOIL STRUCTURE INTERACTION

Unit 1: Fundamentals of Soil–Structure Interaction

Introduction to soil–structure interaction (SSI). Types of interaction: kinematic and inertial. Soil and structural behavior under SSI. Classification of SSI problems. Contact interfaces and boundary conditions. Effect of soil compliance and structure flexibility. Modelling Approaches: direct and substructure methods.

Unit 2: Static SSI and Elastic Modeling Approaches

Elastic continuum theory. Winkler, Pasternak, and Vlasov models. Analysis of beams and plates on elastic foundation. Contact pressure under rigid and flexible footings. Use of simplified subgrade models in structural systems. Comparison of analytical and field-based solutions.

Unit 3: Dynamic SSI and Seismic Response

Dynamic loads and their transmission through soil. Dynamic stiffness, damping, and impedance functions. Spring-dashpot models. Seismic SSI and foundation resonance. Rocking and uplift behavior. Time-domain and frequency-domain analysis. Liquefaction and ground motion modification. Code-based design criteria.

Unit 4: Numerical Modeling of Soil–Structure Interaction

Finite element method for SSI problems, Soil constitutive models (Mohr–Coulomb, Hardening Soil, UDSM). Interface and boundary conditions. Simulation of footings, retaining walls, and pile systems in PLAXIS 2D/3D. Dynamic and static modeling using OpenSees/ANSYS. Validation and result interpretation.

Unit 5: SSI in Complex Structures and Design Applications

SSI considerations in retaining walls, tunnels, culverts, and buried pipes. Soil–pavement–structure interaction. Effects of backfill and embedment. Long-term settlement and consolidation in SSI. SSI failures and mitigation. Practical guidelines and recommendations from IS, ASCE, and Eurocodes.

Reference books

- Wolf, J. P. (1985). "Dynamic Soil–Structure Interaction". Prentice-Hall, Englewood Cliffs, NJ.
- Kramer, S. L. (1996). "Geotechnical Earthquake Engineering". Prentice Hall, Upper Saddle River, NJ.
- Muir Wood, D. (2004). "Geotechnical Modelling". CRC Press, Boca Raton, FL.
- Choudhury, D., El-Zahaby, K. M., & Idriss, I. (2019). "Dynamic Soil–Structure
- Interaction for Sustainable Infrastructures". Springer International Publishing, Cham.
- Orense, R. P., Chouw, N., & Pender, M. J. (2010). "Soil–Foundation–Structure Interaction". CRC Press, Boca Raton, FL.
- Gülkan, P., & Clough, R. W. (1993). "Developments in Dynamic Soil–Structure Interaction". Springer Netherlands, Dordrecht.

- ASCE/SEI 7-16. (2016). "Minimum Design Loads and Associated Criteria for Buildings and Other Structures". American Society of Civil Engineers, Reston, VA.
- ASCE/SEI 41-17. (2017). "Seismic Evaluation and Retrofit of Existing Buildings". American Society of Civil Engineers, Reston, VA.
- IS 1893 (Part 1):2016. "Criteria for Earthquake Resistant Design of Structures". Bureau of Indian Standards, New Delhi.
- IS 5249:1992. "Determination of Dynamic Properties of Soil". Bureau of Indian Standards, New Delhi.
- IS 2720 (All Parts). "Methods of Test for Soils". Bureau of Indian Standards, New Delhi.
- Eurocode 8. (2004). "Design of Structures for Earthquake Resistance – Part 5: Foundations, Retaining Structures and Geotechnical Aspects". European Committee for Standardization, Brussels.
- API RP 2A-WSD. (2000). "Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design". American Petroleum Institute, Washington, D.C.
- FEMA P-2091. (2020). "A Practical Guide to Soil–Structure Interaction". Federal Emergency Management Agency.
- https://www.fema.gov/sites/default/files/documents/fema-p-2091-soil-structure-interaction.pdf
- NIST GCR 12-917-21. (2012). "Soil–Structure Interaction for Building Structures".
- National Institute of Standards and Technology. https://www.nist.gov/publications/soil-structure-interaction-building-structures
- Structure Magazine. (2020). "A Practical Guide to Soil–Structure Interaction". https://www.structuremag.org/article/a-practical-guide-to-soil-structure-interaction/

NSE 603 STABILITY OF STRUCTURES

Unit 1

Fundamentals of Elastic Stability: Variational methods in elastic problems, Approximate methods in elasticity, Stability of rigid body systems: one-degree- and two-degree-of-freedom systems, Snap-through and systems with imperfect geometry.

Unit 2

Column and Beam-Column Stability: Eigenvalue problems in elastic buckling, Buckling of columns with various end conditions, Basic equations for beam-columns, Analysis of beam-columns under different loading and boundary conditions

Unit 3

Stability of Frames and Energy Methods: Stability analysis of frames, Matrix and finite element framework for frame stability, Energy-based methods for elastic buckling, Buckling of bars on elastic foundations

Unit 4

Plates, Shells, and Torsional Buckling: Torsion of thin-walled open sections and torsional buckling, Buckling of circular arches and rings, Governing differential equations for plate buckling, Buckling of rectangular plates (energy method), Symmetrical buckling of cylindrical shells and governing equations

Unit 5

Nonlinear and Advanced Stability: Nonlinear stability of columns, von Kármán theory for plates and shells, Post-buckling behavior and imperfection sensitivity, Introduction to modern computational and experimental methods in buckling

Reference books

- Timoshenko, S.P. & Gere, J.M. (1961) – *Theory of Elastic Stability*, 2nd Ed., McGraw-Hill / Dover Publications.
- Bazant, Z.P. & Cedolin, L. (2010) – *Stability of Structures: Elastic, Inelastic, Fracture and Damage Theories*, 2nd Ed., World Scientific.
- Chajes, A. (1974) – *Principles of Structural Stability Theory*, Prentice Hall.
- Brush, D.O. & Almroth, B.O. (1975) – *Buckling of Bars, Plates, and Shells*, McGraw-Hill.
- Bleich, F. (1952) – *Buckling Strength of Metal Structures*, McGraw-Hill.
- Ventsel, E. & Krauthammer, T. (2001) – *Thin Plates and Shells: Theory, Analysis, and Applications*, Marcel Dekker.
- Wang, C.M., Wang, C.Y., & Reddy, J.N. (2005) – *Exact Solutions for Buckling of Structural Members*, CRC Press.
- Singer, J., Arbocz, J., & Weller, T. (2002) – *Buckling Experiments: Experimental Methods in Buckling of Thin-Walled Structures*, Wiley.

- Megson, T.H.G. (2019) – *Structural and Stress Analysis*, 3rd Ed., Butterworth-Heinemann.
- Kassimali, A. (2011) – *Matrix Analysis of Structures*, Cengage Learning.

NSE 605 STRUCTURAL HEALTH MONITORING

Unit 1

Introduction to SHM and Structural Deterioration-Definition, objectives, and importance of SHM, Types of structural damages and deterioration mechanisms, Failure modes in civil structures, Overview of SHM systems and components

Unit 2

Non-Destructive Techniques – Introduction, Localised and global applications, Ultrasonic testing, Acoustic emission, Infrared thermography, Magnetic and radiographic methods

Unit 3

Vibration based health monitoring – Overview, Sensors and Data Acquisition - Types of sensors: strain gauges, accelerometers, fiber optic sensors, piezoelectric sensors, Instrumentation and data acquisition systems, Wired vs wireless monitoring systems, Sensor placement strategies

Unit 4

Signal Processing and Feature Extraction - Basics of signal processing: filtering, noise reduction, FFT, wavelet transform, Feature extraction techniques: statistical features, modal parameters, damage indices, Machine learning and AI applications in SHM: supervised and unsupervised learning, pattern recognition, Data interpretation and decision-making

Unit 5

SHM applications in bridges, buildings - Case studies on successful SHM implementations, Reliability and validation of SHM systems, Future trends: smart materials, wireless sensor networks, IoT, real-time monitoring

Reference Books

- Farrar, C. R., & Worden, K. (2012). *Structural health monitoring: A machine learning perspective*. Wiley.
- Balageas, D., Fritzen, C. P., & Güemes, A. (2006). *Structural health monitoring*. ISTE Ltd. & Wiley.
- Doebling, S. W., Farrar, C. R., Prime, M. B., & Shevitz, D. W. (1998). *Damage identification and health monitoring of structural and mechanical systems from changes in their vibration characteristics: A literature review* (Report No. LA-13070-MS). Los Alamos National Laboratory.
- Relevant journal publications
- Chang, P. C., Flatau, A. B., & Liu, S. C. (2003). *Health monitoring of structural materials and components: Methods with applications*. Wiley.
- Sohn, H., Farrar, C. R., Hemez, F. M., Czarnecki, J. J., & Shunk, D. D. (2003). *A review of structural health monitoring literature: 1996–2001* (Report No. LA-13976-MS). Los Alamos National Laboratory.
- Inman, D. J., Farrar, C. R., Lopes Jr, V., & Steffen Jr, V. (2005). *Damage prognosis: For aerospace, civil and mechanical systems*. Wiley.

NSE 607 VIBRATION CONTROL

Unit 1

Introduction to Vibration Control - Quantitative description of vibration, Factors affecting vibration levels, Strategies for vibration control, Basic system parameters and modelling techniques

Unit 2

Vibration Reduction at the Source-Balancing of rigid and flexible rotors, Field balancing techniques, Detuning and decoupling methods, Control of vortex-induced vibrations

Unit 3

Passive Vibration Control Techniques - Structural design for vibration control, Selection of materials with damping properties, Viscous and Coulomb damping -Viscoelastic materials and their dynamic properties, Constrained layer damping and its applications

Unit 4

Passive Vibration Control Techniques (ctnd) - Dynamic vibration absorbers, Tuned mass dampers, Self-tuned pendulum neutralizers, Gyroscopic and impact absorbers, Vibration isolation, complex stiffness

Unit 5

Introduction to active vibration control systems, Piezoelectric sensors and actuators, Feedback and feedforward control strategies, Use of smart materials for vibration control

Reference books

- Mallik, A. K. and Chatterjee, S., (2014) *Principles of active and passive vibration control*. Affiliated East-West Press.
- Preumont, A.(2011). *Vibration control of active structures* (3rd ed.). Springer.
- Mead, D. J. (1998) *Passive vibration control*. Wiley.

NSE 609 PLANNING AND MANAGEMENT OF BUILDING PROJECTS

Unit 1

Introduction to Project, its Stages, and Construction Project management: Project, Organization, Need for management of building/construction projects, Principles and Objectives of Project Management, brief understanding about study areas in Project Management. Types of Construction Projects. Project, program and portfolio management.

Unit 2

BASICS OF PROJECT MANAGEMENT: Project Life Cycle, Types of projects, Phase of the project, project management and its relevance, stakeholders of a project, structure of project organization, management levels, Fail,ures and success of a project.

Unit 3

ROLES OF PROJECT MANAGER: Roles & Responsibilities of Project/ Construction Managers, Scope Management Construction: Scope Planning, Definition, Verification and Control Project Management Stages: Project planning, project scheduling and project controlling. leveling, allocation

Unit 4:

PROJECT PLANNING& SCHEDULING: Introduction, Time Cost and Resource management, project planning, Work Breakdown Structure (W.B.S.), Planning terminologies, Network Theories CPM, PERT, Project crashing.

Unit 5

PROJECT MONITORING AND CONTROL: Introduction, Scope verification & control, Schedule control , Cost control ,Quality control ,Performance reporting, Risk control and contract administration.

Reference Books

- Association for Project Management, 2012.A PM body of knowledge. Buckinghamshire: Association for Project Management.
- Guide, A., 2017. Project Management Body of Knowledge (PMBOK®GUIDE).Project Management Institute.
- Dr. K.G. Krishnamurthy and S. V. Ravindra, 2008. Construction and Project Management.
- Hendrickson, C., Hendrickson, C.T. and Au, T 1989. Project management for construction: Fundamental concepts for owners, engineers, architects, and builders, Chris Hendrickson.

- Punmia, B.C. and Khandelwal,K.K.,2002.Project Planning and Control with PERT&CPM. Firewall media.
- Jha, K.N., 2015.Construction Project Management: Theory and Practice. Pearson Education India.
- Chitkara, K.K., 1998.Construction project management. Tata McGraw-Hill Education.

OSE 601 PRINCIPLES AND APPLICATIONS OF BUILDING SCIENCE

Unit 1 - Introduction to Building Sciences

Overview and scope of building sciences, Interaction between architecture, structural engineering, and building physics, Functional requirements of buildings: strength, stability, serviceability, and durability, Environmental influences on building performance.

Unit 2 – Heat and Moisture Transfer in Buildings

Modes of heat transfer – conduction, convection, and radiation, Thermal insulation and energy conservation techniques, Vapour barriers and condensation control, Design for thermal comfort – indices and measurement, Case studies of energy-efficient buildings.

Unit 3 – Lighting and Visual Comfort

Principles of day lighting and artificial lighting, Daylight factor and design considerations, Visual comfort parameters and glare control, Integration of natural and artificial lighting systems, Role of building orientation and façade design.

Unit 4 – Acoustics and Sound Control

Fundamentals of sound propagation and its measurement, Sound insulation and absorption in buildings, Design of acoustic enclosures and auditoriums, Noise control from mechanical and environmental sources.

Unit 5 – Fire and Life Safety Engineering

Principles of fire dynamics and fire-resistant design, Behavior of structural components under elevated temperature, Fire protection systems and egress planning, Building codes and standards related to fire safety (NBC, IS 1641–1648 series).

Reference books

- Koenigsberger et al., *Manual of Tropical Housing and Building*, Orient Longman.
- N.K. Jain, *Building Physics – Heat, Air and Moisture*, McGraw-Hill Education.
- David W. Croome, *Environmental Design – CIBSE Guide*, Butterworth-Heinemann.
- S.P. Gupta & S.L. Gupta, *Building Science and Materials*, S. Chand Publishing.
- National Building Code of India, BIS, Latest Edition.
- SP 41: *Handbook on Functional Requirements of Buildings (Other than Industrial Buildings)*, BIS.
- CIBSE Guides (Heating, Lighting, Ventilation).
- IS 3792, IS 3362, IS 1641–1648 – BIS Standards on Fire and Thermal Design.

OSE 603 OPTIMIZATION TECHNIQUES FOR ENGINEERS

Unit 1

Introduction, Optimal problem formulation-design variables, constraints, objective function and variable bounds, Application examples- truss, transit schedule, chemical reactions, etc

Unit 2

Single-variable optimization algorithms: Optimality Criteria, Bracketing Methods. Region Elimination Methods, Point Estimation methods, Gradient based methods

Unit 3

Multivariable optimization algorithms: Optimality Criteria, Direct Search Method, Gradient-based methods

Unit 4

Constrained Optimization Algorithms: Kunh Tucket Conditions, Transformation methods, Sensitivity Analysis, Direct Search for Constrained minimization, Linearized search techniques, Generalised reduced gradient method, Gradient projection method.

Unit 5

Specialised Algorithms: Integer Programming, Geometric Programming

Non-traditional Optimisation Algorithms: Genetic Algorithms, Simulated Annealing

Reference books

- Deb, K. (2012). *Optimization for engineering design: Algorithms and examples* (2nd ed.). PHI Learning Pvt. Ltd.
- Belegundu, A. D., & Chandrupatla, T. R. (2019). *Optimization concepts and applications in engineering* (2nd ed.). Cambridge University Press.
- Nash, S. G., & Sofer, A. (2008). *Linear and nonlinear programming* (2nd ed.). McGraw-Hill.

Software and tools

- Python Software Foundation. Python Language Reference, version 3.8. Available at http://www.python.org
- The MathWorks Inc. (2022). MATLAB version: 9.13.0 (R2022b), Natick, Massachusetts: The MathWorks Inc. https://www.mathworks.com

OSE 605 INFRASTRUCTURE ASSET MANAGEMENT

Unit 1

Overview and need for Infrastructure Asset Management: Deterioration and performance of infrastructure systems over time, Concepts in maintenance and rehabilitation of infrastructure Basic economics for infrastructure management, Stakeholders and life cycle of infrastructure assets, Case Studies.

Unit 2

Decision Framework for Infrastructure Asset Management: Generic IAM process and framework, Data requirements and prioritization for IAM, Handling missing data and qualitative data in decision-making, Role of information and performance indicators

Unit 3

Decision Framework for Infrastructure Asset Management (ctnd): Performance modeling concepts, Maintenance roles and strategies, Budget planning and programming, Life-Cycle Cost Analysis (LCCA): Concepts and applications, Components of LCCA: Agency, User, and Social Costs, Network-level vs Project-level analysis, Maintenance and Rehabilitation (M&R) needs assessment, Budget allocation and prioritization strategies, Case Studies: Bridge management system, Pavement manage system

Unit 4

System Considerations and Sustainability: Reliability, maintainability, and service life concepts, Systems thinking and system-of-systems modelling, Sustainable Infrastructure Management, Resilient Infrastructure Systems, Importance of maintenance for sustainability and resilience.

Unit 5

Deterioration mechanisms in RC structures: Carbonation, Chloride-induced corrosion Corrosion as a durability and performance issue, Monitoring of RC structures: Condition assessment and performance prediction, Inspection and Non-Destructive Testing (NDT) methods, Maintenance strategies and planning for concrete infrastructure

Reference books

- Hudson, W. R., Haas, R., & Uddin, W. (2015). Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation, and Renovation. McGraw-Hill.
- Grigg, N. S. (2019). Infrastructure Engineering and Management. Wiley.

- Frangopol, D. M., & Liu, M. (2019). Bridge Maintenance, Safety, Management, Resilience and Sustainability. CRC Press.
- Broomfield, J. P. (2006). Corrosion of Steel in Concrete: Understanding, Investigation and Repair. CRC Press.
- Emmons, P. H. (2018). Concrete Repair and Maintenance Illustrated: Problem Analysis, Repair Strategy, Techniques. CRC Press.
- Kirk, S. J., Dell'Isola, A. J., & Molenaar, K. R. (2020). Life-Cycle Costing for Facilities. Wiley.
- Bull, J. W. (Ed.). (2015). Life Cycle Costing: For the Analysis, Management and Maintenance of Civil Engineering Infrastructure. Whittles Publishing.
- Federal Highway Administration (FHWA). Bridge and Pavement Management Systems Manuals. U.S. DOT.
- ISO 55000 Series – Asset Management Standards.
- OECD (2001). Asset Management for the Roads Sector.
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