## SEMESTER I

## MA751 APPLIED MATHEMATICS

Polar co-ordinates - Expressions of gradient of scalar point function -divergence and curllof a vector point function in orthogonal curvilinear co-ordinates - Summation convention tensors - Quotient law - Chrioleffel symbols - Inverse of a matrix - Eigen values and Eigen vectors of matrix - Quadratic form - Hermition form - Canonical form.
Maxima and minima of functions of two variables - Lagrange Multipliers - Functional - Externals -Euler-Lagrange Equation - Solution in power series by the method of Frobenious - Legendre and Bessel equations
Fourier, Bessel and Legendre series and functions - Two dimensional wave equations - Transverse vibrations of rectangular and circular membranes
Two dimensional heat flow in transient state - Three dimensional heat flow in transient state - Laplace equations - Steady state temperature distribution in solid spheres and spherical shells.

### References

1. Grewal B.S, Higher Engineering Mathematics, Khanna publishers, 1997.
2. Venkataraman, M.K., Higher Mathematics for Engineers, National Publishing Co., 1986.

## CE651 THEORY OF ELASTICITY AND PLASTICITY

Basic concepts of deformation of deformable bodies- Notations of stress and strain in a 3D field Transformations of stresses and strains in Cartesian and polar co-ordinates- Equilibrium equations in two and three dimensions in Cartesian co-ordinates.
Plane stress and plane strain problems - Two dimensional problems in Cartesian co-ordinates as applied in beam bending, using Airy's stress function - Polar co-ordinates. Equations of equilibrium and compatibility-Two dimensional problems in polar co-ordinates-Stress concentration in holes.
Energy principle -theorem of minimum potential energy and complementary potential energy-
Torsion of various shaped bars- Prandtl's membrane analogy- energy method- Torsion of rolled Profiles- Stress concentration at re-entrant corners.
Introduction, yield criteria for metals, graphical representation of yield criteria, Flow laws of plastic mass, Plastic strain relations-Application to thick cylinders - Hollow spheres -Torsion.

### References

1. Timoshenko and Goodier, Theory of Elasticity, McGraw-Hill, 2006.
2. Wang, Applied Elasticity, Dover Publications Inc. Newyork.1985.
3. W.F. Chen and D.J. Pan., Plasticity for Structural Engineers, Springler Verlag 1998.

## CE652 MATRIX METHODS OF STRUCTURAL ANALYSIS

Generalised Measurements - Degrees of freedom - Constrained Measurements - Behaviour of structures - Principle of superposition- Stiffness and flexibility matrices in single, two and n-co-ordinates - Structures with constrained measurements.

Stiffness and flexibility matrices from strain energy - Betti's law and its applications- Determinate and indeterminate structures - Transformation of element matrices to system matrices - Transformation of system vectors to element vectors.
Flexibility method applied to statically determinate and indeterminate structures –
Choice of redunants -Transformation of redundants-Internal forces due to
thermal expansion and lack of fit.
Displacement method - Internal forces due to thermal expansion and lack of fit - Application to symmetrical structures - Code system in the stiffness methods - Computer program for the code system - Comparison between stiffness and flexibility methods.
Analysis by substructures using the stiffness method and flexibility method with tridiagonalization- Analysis by Iteration method - frames with prismatic members - non-prismatic members.

**References**

1. Moshe, F., Rubenstein, Matrix Computer Analysis of Structures, Prentice Hall, New York, 1966.
2. Kanchi, Matrix Structural Analysis, Wiley Eastern Ltd., Newdelhi 1981.
3. Rajasekaran S, Computational Structural Mechanics, Prentice Hall of India. New Delhi, 2001.

## CE653 STRUCTURAL DYNAMICS

Introduction to Dynamic analysis - Elements of vibratory systems and simple Harmonic Motion- Mathematical models of SDOF systems - Principle of Virtual displacements - Evaluation of damping resonance.
Fourier series expression for loading - (blast or earthquake) - Duhamel's integral - Numerical methods - Expression for generalised system properties - vibration analysis Rayleigh's method - Rayleigh - Ritz method.
Evaluation of structural property matrices - Natural vibration - Solution of the Eigen value problem - Iteration due to Holzer and Stodola
Idealisation of multi-storeyed frames - analysis to blast loading - Deterministic analysis of earthquake response - lumped SDOF system
Differential equation of motion - Beam flexure including shear deformation and rotatory inertia - Vibration analysis using finite element method for beams and frames

**References**

1. Mario Paz, and William Leigh, Structural Dynamics, CBS, Publishers, 1987.
2. Roy R Craig, Jr., Structural Dynamics, John Wiley & Sons, 1981.
3. A.K. Chpora "Dynamics of Structures Theory and Application to Earthquake Engineering" Pcarson Education, 2001.

## CE654 STRUCTURAL ENGINEERING LABORATORY

Model Analysis - Use of various types of strain gauges - Mechanical and Electrical strain gauges - Casting and testing of R.C. and pre-stressed concrete beams and study of their behaviour-Experiments in 2-D photo elasticity - properties of concrete ingredients – concrete mix design - strength tests on concrete.

## SEMESTER – II

## CE655 STABILITY OF STRUCTURES

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 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 bucklings – critical loan on plates for various boundary conditions – Energy method – Finite difference method.

### References

1. Timoshenko and Gere. Theory of elastic stability, McGraw Hill Book Company, 1981
2. Alexandar Chajes, Principles of Structural Stability Theory, Prentice Hall, New Jersey, 1980
3. Iyenger, N.G.R. Structural Stability of columns and plates, Affiliated East west press Pvt Ltd., 1990.
4. Bleich F. Buckling Strength of metal structures, McGraw Hill 1991.

## CE656 FINITE ELEMENT METHOD

Differential equilibrium equations - strain displacement relation - linear constitutive relation - special cases- Principle of stationary potential energy - application to finite element methods. Some numerical techniques in finite element Analysis

Displacement models - convergence requirements. Natural coordinate systems - Shape function. Interpolation function- Linear and quadratic elements - Lagrange & Serendipity elements- Strain displacement matrix - element stiffness matrix and nodal load vector

Two dimensional isoparametric elements - Four noded quadrilateral elements - triangular elements- Computation of stiffness matrix for isoparametric elements - numerical integration (Gauss quadrature) -Convergence criteria for isoparametric elements.

Assemblage of elements – Direct stiffness method- Special characteristics of stiffness matrix - Boundary condition & reaction - Gauss elimination and $LDL^T$ decomposition- Basic steps in finite element anlaysis.

Analysis of framed Structures- 2D truss element - 2D beam element. Analysis of plate bending: Basic theory of plate bending - displacement functions - plate bending Elements. Plane stress and plane strain analysis: Triangular elements - Rectangular elements

### References

1. Krishnamoorthy, C.S, Finite Element Analysis Theory & Programming, McGraw- Hill, 1995.
2. Desai C.S and Abel, J.F., Introduction to the finite element Method, Affiliated East west Press Pvt. Ltd. NewDelhi 2000.

## CE657 THEORY OF PLATE AND SHELLS

Simple bending of Plates-Assumptions in thin plate theory-Different relationships- Different Boundary Conditions for plates- Plates subjected to lateral loads – Navier's method for simply supported plates – Levy's method for general plates – Example problems with different types of loading.
Circular plates subjected to Axi-symmetrical loads–concentrated load, uniformly distributed load and varying load – Annular circular plate with end moments.
Rayleigh-Ritz method – Application to different problems – Finite difference method – Finite element methodology for plates-Orthotropic Plates
Bending of anisotropic plates with emphasis on orthotropic plates – Material Orthotropy – Structural Orthotropy - Plates on elastic foundation.
Shells- Classification of shells - Membrane and bending theory for singly curved and doubly curved shells - Various approximations - Analysis of folded plates

**References**

1. Rudolph Szilard, Theory and Analysis of Plates*,* Prentice Hall, New Jercy 1986.
2. Stephen .P. Timoshenko & Woinowsky Krieger, Theory of Plates and Shells*,* Mc Graw Hill, 1984.

## CE658 CAD IN STRUCTURAL ENGINEERING

Computer Aided Drafting **-** Basic 2D objects – line, polyline, circle, ellipse – Dimensioning – Preparation of plan, elevation and section drawings of simple structural objects – Introduction to 3D - DBMS concepts - Civil Eng. Databases – Data entry & Reports. Spreadsheet concepts – Worksheet calculations in Civil Engineering - Regression & Matrix Inversion. Development of C programs to solve problems using numerical techniques

1. Roots of an equation using Newton – Raphson method.
2. Solution of linear simultaneous equations using Gauss elimination.
3. Matrix inversion using GJ method
4. Linear regression line of given points.
5. Curve fitting using Polynomial Regression.
6. Eigen value extraction power method

Computer methods of structural analysis - Finite Element programming - Analysis through application packages. Design of steel and RC Structural elements.

**References**

1. Rajaraman, V., Computer Oriented Numerical Methods, Prentice – Hall of India, 2004.

### Elective (I Semester)

## CE661 ADVANCED CONCRETE TECHNOLOGY

Aggregates classification- Testing Aggregates, fibres. Cement, grade of Cement, chemical composition, Hydration of Cement, Structure of hydrated Cement, Special Cement, Water, Chemical and Mineral Admixtures.

Principles of Concrete mix design, methods of Concrete mix design, Design of high strength and high performance concrete.
Rheological behaviour of fresh Concrete- Properties of fresh and hardened concrete- Strength, Elastic properties, Creep and Shrinkage, Variability of concrete strength. Non destructive testing and quality control, Durability, corrosion protection and fire resistance.
Modern trends in concrete manufacture and placement techniques, Methods of transportation, Placing and curing-extreme whether concreting, Special concreting methods, Vacuum dewatering of concrete-Under water concreting.
Light weight Concrete, Fly-ash Concrete- Fibre reinforced Concrete, Polymer Concrete, Epoxy resins and screeds for rehabilitation- properties and application.

**References**

1. Krishnaraju, N., Advanced Concrete Technology, CBS Publishers, 1985.
2. Nevile, A.M., Concrete Technology, Prentice Hall, Newyork, 1985.
3. A.R. Santhakumar, :Concrete Technology" Oxford University Press, 2006

## CE662 ANALYSIS OF DEEP FOUNDATION

Functions and requisites of a foundation - Different types - choice of foundation type – types of deep foundation – types of pile factor governing choice of type of pile – choice of pile materials General considerations – piles in cohesive soil – piles in cohesionless soils – piles in intermediate between sands and clays – piles in layered cohesive and cohesionless soils – the settlement of single pile – piles bearing on rock – piles in fill.
Group action in piled foundations – pile groups in cohesive soils - pile groups in cohesionless soils – pile groups terminating in rock – pile groups in filled ground – effects on pile groups of installation methods – precautions against heave effects in pile groups – pile groups beneath basements – the optimization of pile groups to reduce differential settlements in clay.
The occurrence of lateral loading – Single vertical piles subjected to lateral loads – calculating the ultimate resistance to lateral loads – bending and buckling of partly embedded single vertical piles – the deflection of vertical piles – Elastic analysis of laterally loaded vertical piles – The use of p-y curves – Effect of method of pile installation on behavior under lateral loads and moments applied to pile head – the use of pressure meter test to establish p-y curves – lateral loads on raking piles – lateral loads on groups of piles – effect of adjacent surcharge loading on pile groups
Berthing structures and jetties – Loading on piles from berthing impact forces – mooring forces on piles – wave forces on piles – wave forces on piles – current forces on piles – wind forces on piles – forces on piles from floating ice – materials for piles in jetties and dolphins – Fixed offshore platforms – general design philosophy – ship berthing and mooring forces – wave forces – current forces – wind forces – floating and sheet ice – Earthquakes – pile design for jacket type structures

**References**

1. J.E. Bowles, "Foundation Analysis and Design", McGraw Hill, 1996.
2. M.J. Tomlinson, "Pile Design and Construction Practice", E & FN Spon, 1987.
3. Braja M. Das., "Principles of foundation Engineering", Thomson Asia Pte , 1987, London Ltd., Singapore, 2005, A viewpoint publication.

## Electives (II Semester)

## CE663 MAINTENANCE AND REHABILITATION OF STRUCTURES

Quality assurance for concrete construction as built concrete properties strength, permeability, thermal properties and cracking.
Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection
Definitions: Maintenance, repair and rehabilitation, Facets of and importance of Maintenance Preventive measures on various aspects Inspection, Assessment procedure for evaluating a damaged structure causes of deterioration-testing techniques.
Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, ferro cement, Fiber reinforced concrete.
Rust eliminators and polymers coating for rebars during foamed concrete, mortar repair for cracks, shoring and underpinning.

### References

1. Raikar, R.N., Learning from failures – Deficiencies in Design, Construction and Service – R&D Centre (SDCPL), Raikar Bhavan, 1987.
2. Allen R.T., and Edwards S.C, Repairs of Concrete Structures, Blaike and Sons, U.K.1987.

## CE664 DESIGN OF STEEL AND STEEL-CONCRETE COMPOSITE STRUCTURES

Design of members subjected to lateral loads and axial loads - Principles of analysis and design of Industrial buildings and bents - Crane gantry girders and crane columns - Analysis and design of steel towers - Design of industrial stacks - Self supporting and guyed stacks lined and unlined.
Types of connections, Design of framed beam connections, Seated beam connection, Un-stiffened, Stiffened Seat connections, Continuous beam – to - beam connections and continuous beam–to–column connection both welded and bolted.
Cold formed Steel Sections - Types of cross sections - Local buckling and post buckling - Design of compression and Tension members - Beams - Deflection of beams - Combined stresses and connections.
Introduction to composite design – shear connectors – types of shear connectors – degrees of shear connections – partial and full shear connections – composite sections under positive bending – negative bending – propped conditions – un-propped conditions – deflection of composite beams.
Introduction – Composite slabs – profiled sheeting – sheeting parallel to span – sheeting perpendicular to span - Types of Composite columns – design of encased columns – design of in-filled columns – axial, uni-axial and bi-axially loaded columns. Composite shear wall – double skinned composite deck panels – composite trusses – composite frames – composite plate girders.

### References

1. Arya, A.S., Design of Steel Structures, New Chand & Brothers, New Delhi 1982.

2. R.P. Johnson, "Composite Structures of Steel & Concrete", Blackwell Scientific publications, UK, 1994.
3. Necessary Indian & Eurocodes.

## CE665 FAILURE ANALYSIS OF STRUCTURES

Causes of failure – Types of failure – why, what, how – durability of materials – Landmark case – Performance and shape inadequacy – statistics and reliability – life cycle assessment.
Structural failure –material and load effects – environment effect - Non-structural and structural repairs –Biocidal treatment and use of preservatives –deterioration of wood
Macro micro level failures – component and sub-system failures - failure theories – analytical models – cases and type of problem in components –safety evaluation.
Structural systems–case studies – pin-jointed steel systems – rigid jointed frames – concrete walls arches – reinforced concrete beams and frames – shells –repair of concrete bridge and water retaining structures.
Bridge maintenance techniques –The refurbishment of buildings, legal responsibilities – Case studies – Definition of smartness –sensors – automatic and adaptive systems – smart components

**References**

1. Rasnom, W.H., Building Failures, E&F, N. SPON Ltd., 1980.
2. Moskvin V, Concrete and Reinforced Structures – Deterioration and Protection, Mir Publishers, Moscow, 1980.

## CE666 SEISMIC DESIGN OF STRUCTURES

Engineering seismology – rebound theory – plate tectonics – seismic waves – earthquake size and various scales – local site effects – Indian seismicity – seismic zones of India – theory of vibration – near ground and far ground rotation and their effects.
Seismic design concepts – EQ load on simple buildings – load path – floor and roof diaphragms – seismic resistant building architecture – plan configuration – vertical configuration – pounding effects – mass and stiffness irregularities – torsion in structural system
Provision of seismic code (IS1893 & IS 13920) – Building systems – frames – shear wall – braced frames – layout design of Moment Resisting Frames (MRF) – ductility of MRF – Infill walls – Non-structural elements
Calculation of EQ load – 3D modeling of building systems and analysis (theory only) Design and detailing of frames, shear wall, and frame walls
Cyclic loading behavior of RC steel and pre-stressed concrete elements - modern concepts – base isolation – Adoptive systems – case studies

**References**

1. Pankaj Agarwal and Manish ShriKhande, Earthquake Resistant Design of Structures, Prentice- Hall of India, 2007, New Delhi
2. Bullen K.E., Introduction to the Theory of Seismology, Great Britain at the University Printing houses, Cambridge University Press 1996.
3. Relevant code of practices.

## ELECTIVES (To be substituted whenever needed)

## 1. PREFABRICATED STRUCTURES

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.

### References

1. Hass, A.M. Precast Concrete Design and Applications, Applied Science Publishers, 1983.
2. Promyslolw, V Design and Erection of Reinforced Concrete Structures, MIR Publishers, Moscow 1980.

## 2. SMART STRUCTURES AND APPLICATIONS

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.

### References

1. Srinivasan, A.V. and Michael McFarland, D., Smart Structures: Analysis and Design, Cambridge University Press, 2000.
2. Yoseph Bar Cohen, Smart Structures and Materials 2003, The International Society for Optical Engineering 2003.

## 3 PRESTRESSED CONCRETE STRUCTURES

Principles of prestressing - Materials of prestressing - Systems of prestressing - Loss of prestress - Deflection of Prestressed Concrete members.
Slabs - Pre-tensioned and Post-tensioned beams - Design for flexure, bond and shear - IS code provisions - Ultimate flexural and shear strength of prestressed concrete sections - Design of end anchorage zones using IS code method.
Composite beams - Analysis and design.Partial prestressing - non-prestressed reinforcements.

Analysis of Continuous beams - Cable layout - Linear transformation - Concordant cables. Design of compression members and tension members.Circular prestressing - Water tanks - Pipes - Analysis and design - IS Codal provisions.

**References**

1. Lin. T.Y., Burns, N.H., Design of Prestressed Concrete Structures, John Wiley & Sons, 1982.
2. RajaGopalan N. Prestressed Concrete, Narosa Publishing House, New Delhi, 2002.

## 4. DESIGN OF TALL BUILDINGS

Design philosophy – Loading - Sequential loading, materials.
High risk behaviour, Rigid frames, braced frames, infilled frames, shear walls, coupled shear walls, wall – frames, tubulars, cores, futrigger - braced and hybrid mega system.
Approximate Analysis, Accurate Analysis and Reduction Techniques - Analysis of building for member forces - drift and twist - Computerised general three dimensional analysis.
Structural elements- design, deflection, cracking, prestressing, shear flow-Design for differential movements, creep and shrinkage effects, temperature effects and fire.
Overall buckling analysis of frames, wall – frames–second order effects of gravity of loading–simultaneous first order and P-delta analysis Translational - torsional instability, out of plum effects

**References**

1. Bryan Stafford smith and Alex coull, Tall Building Structures – Analysis and Design, John Wiley & sons, 2006.

## 5. FRACTURE MECHANICS

Definition of stress intensity factor, Fracture toughness Energy release rate, Critical Energy release rate Crack mouth opening displacement, R-Curve and J integral Basic reasons for fracture mechanics approach for concrete, Limitations of linear elastic fracture mechanics for concrete. Non linear fracture method Fracture energy and size effect.

**References**

1. David Broek, Elementary Engineering Fracture Mechanics, Sijthoff and Noordhaff, Alphen Aan Den Rijn, The Netherlands, 2001.
2. Analysis of Concrete Structure by Fracture Mechanics, Ed L. Elfgren and S.P. Shah, Proc of Rilem Workshop, Chapman and Hall, London, 2001.

## 6 STRUCTURES IN DISASTER PRONE AREAS

Philosophy for design to resist Earthquake, Cyclone and flood –By-laws of urban and Semi-Urban areas-Traditional and modern structures
Response of dams, bridges, buildings – Strengthening - Testing and evaluation – Classification of structures for safety point of view

Methods of strengthening for different disasters – Qualification test.
Use of modern materials their impact on disaster reduction – Use of modern analysis, design and construction techniques optimization for performance.
Damage surveys – Maintenance and modifications to improve hazard resistance – Different types of foundation and its impact on safety – Ground improvement techniques.

**References**

1. Allen, R.T. and Edwards, S.C., Repair of Concrete Structures, Blakie and Sons, 1980.
2. Moskvin V, Concrete and Reinforced Structures – Deterioration and Protection, Mir Publishers, Moscow, 1980.

## 7 ADVANCED CONCRETE STRUCTURES

The nature of concrete, stress-strain relationships of concrete, stress-strain relationships of reinforcing steel, stress block parameters. Failure criteria for concrete.
Behaviour of concrete flexural members, general equations for calculation of moment capacities at ultimate limit state and at limit state of local damage, flexural rigidity, calculation of deflection, redistribution of moments, design examples.
Axially loaded compression members combines axial load and uniaxial bending. Interaction diagrams, combined axial load and biaxial bending, slender compression members, design example using I.S.456-2000.
Shear cracking of ordinary reinforced concrete members, web reinforcement, design examples, shear in tapered beams. Development length of reinforcement, anchorage. Significance of Torsion, Torsional resistance of concrete beams, reinforcement for torsion, design examples.
General principles, effective depths, detailing of reinforcement, design of main reinforcement, design of transverse reinforcement, conditions at loads and at supports. yield line theory.

**References**

1. Varghese P.C, Design of Reinforced Concrete Structures, Prentice hall of India, 2004.
2. Krishnamurthy, K.T, Gharpure S.C. and A.B. Kulkarni – Limit design of reinforced concrete structures, Khanna Publishers, 1985.

## 8 SOIL-STRUCTURE INTERACTION

Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behaviour, Time dependent behaviour.
Beam on Elastic Foundation- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness. Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.
Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.

Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. An introduction to soil-foundation interaction under dynamic loads

**References**

1. Selva durai, A. P. S, Elastic Analysis of Soil-Foundation Interaction, Elsevier, 1979.
2. Poulos, H. G., and Davis, E. H., Pile Foundation Analysis and Design, John Wiley, 1980.
3. J.E. Bowles, "Foundation analysis and design", McGraw Hill 1996.

## 9. RANDOM VIBRATIONS AND STRUCTURAL RELIABILITY

Review of probability: probability space, random variables, functions of random variables, sequence of random variables and limit theorems for sums, products and extremes. Review of random processes: stationarity, ergodictiy, power spectrum and autocovariance. Calculus of random processes. Input-output relations for linear systems. Stochastic steady state. Level crossing and first passage problems. Extreme value distributions. Reliability index based analyses: FORM and SORM. Monte Carlo simulations and variance reduction. Reliability of existing structures.

**References**

1. N C Nigam, 1983, Introduction to random vibrations, MIT Press, Boston.
2. A Papoulis, 1993, Probability, random variables and stochastic processes, McGraw-Hill, NY.
3. R E Melchers, 1999, Structural reliability analysis and prediction, John Wiley, Chichester.

## 10 DESIGN OF BOILER STRUCTURES

Type of boilers: Top supported - Utility boilers- Tower type- Two pass system- Once through boiler- Bottom supported - Industrial boilers-Bi drum
Layout configuration-Front mill layout-Rear mill layout- Side mill layout-column configuration for 210MW-250MW-500MW and lower capacity boilers.
Boiler Structure Structural components- Columns-beams-vertical bracings- ceiling structure including ceiling girders-girder pin connection-horizontal truss work-platforms- weather protection structure-stair ways-mid landing plat forms-handrails - floor grills-post and hangers -inter connection platforms- lift structure-mill maintenance plat form structure-duct supports-furnace guide supports-Eco coil handling structure-ID system structure-Fan handling structure.
Drum lifting Structure: Design loads: Dead loads – pressure parts-ducts-fuel pipe-platform-critical pipe - lining and insulation- silencer- weather protection roof-side cladding-cable tray and pipe rack
Live load-wind load-seismic load-guide load-temperature load-customer load- handling loads-contingency load etc.,
Foundation analysis-Foundation materials-main columns-auxiliary columns-horizontal beams-vertical bracings-MBL concept-horizontal truss work-girder-pin connection- ceiling

main girders-cross girders-pressure parts support beams-ceiling truss work- drum floor-stairs-mid landing plat forms-hand rails-floor grills-fasteners

Platform Structure: Access platforms required for ducts, equipment, and furnace etc-Air heater supports-Fuel pipe support-Duct support- Primary & Secondary air ducts - Bus duct-SCAPH-Flue gas duct supports.

Buck stay beams-key channel - leveller guides-vertical buckstay-furnace guide- corner connections-link ties-hanger tie rods-hanger spring - hopper truss work -goose neck truss work -wind box truss work-expansion measurement instrument

**References**

1. Subramanian N, Design of Steel Structures, Oxford University Press, New Delhi 2008.
2. Arya A.S., Design of Steel Structures, Newchand & Brothers, Newdelhi 1982.
3. Punmia B.C., Comprehensive design of steel structures, Lakshmi Publications, Newdelhi 2000.
4. IS800 – Code of Practice for general construction in steel
5. IS875 (Part 1 -5) Code of Practice for design loads for buildings and structures
6. IS1893 – Criteria for earthquake resistance design of structures.