

**B-TECH CIVIL ENGINEERING  
VII SEMESTER**

Code	Subjects
	<b>Theory</b>
<b>CE501</b>	<b>Engineering Economics</b>
<b>CE502</b>	<b>Structural Design-II</b>
<b>CE503</b>	<b>Coastal and Offshore Structures</b>
-	<b>ELECTIVE</b>
-	<b>ELECTIVE</b>
	<b>Practical</b>
<b>CE506</b>	<b>Design and Drawing –I</b>
<b>CE507</b>	<b>Seminar</b>
<b>CE508</b>	<b>Industrial Visits /Training</b>
<b>CE509</b>	<b>Project Work Phase-I</b>

**Elective**

- CE 8 Geotechnical Processes and Application
- CE 9 Geographical Information System
- CE 10 Hydraulic Structures
- CE 11 Finite Element Analysis
- CE 12 Advanced Structural Design - RCC
- CE 13 Failure Analysis and Rehabilitation of Structures
- CE 14 Bridge Engineering
- CE 15 Hydro Power Engineering
- CE 16 Site Investigation Methods and Practices
- CE 17 Highway and Airport Pavement Design
- CE 18 Matrix methods of structural analysis

## **CE 501 ENGINEERING ECONOMICS**

### Unit-I

Introduction to Economics-Flow in an Economy, Law of Supply and Demand, Concept of Engineering Economics - Engineering Efficiency, Economic Efficiency, Scope of Engineering Economics, Elements of Costs, Marginal Cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-Even Analysis, P/V ratio, Elementary Economics Analysis- Material selection for product, Design selection for a product, Building material selection, Process Planning,

### Unit-II

Make or Buy Decision, Value Engineering-Function, Aims, Value Engineering procedure, Interest Formulas and their Applications - Time Value of Money, Single Payment Compound Amount Factor, Single Payment Present Worth Factor, Equal Payment Series Compound Amount Factor, Equal Payment, Series Sinking Fund Factor, Equal Payment Series Present Worth Factor, Equal Payment Series Capital Recovery Factor, Uniform Gradient Series Annual Equivalent Factor, Effective Interest Rate, Examples in all the methods.

### Unit-III

Methods of Comparison of Alternatives- Present Worth Method (Revenue Dominated Cash Flow Diagram, Cost Dominated Cash Flow Diagram), Future Worth Method (Revenue Dominated Cash Flow Diagram, Cost Dominated Cash Flow Diagram), Annual Equivalent Method (Revenue Dominated Cash Flow Diagram, Cost Dominated Cash Flow Diagram), Rate of Return Method, Examples in all the methods

### Unit-IV

Replacement and Maintenance Analysis- Types of Maintenance, Types of Replacement Problem, Determination of Economic Life of an Asset, Replacement of an Asset with a New Asset - Capital Recovery with Return and Concept of Challenger and Defender, Simple Probabilistic Model for items which fail Completely.

### Unit -V

Depreciation - Introduction, Straight Line Method of Depreciation, Declining Balance, Method of Depreciation, Sum-of-the-Years-Digits Method of Depreciation, Sinking Fund Method of

Depreciation/Annuity Method of Depreciation, Service Output Method of Depreciation, Evaluation of Public Alternatives-Introduction, Examples, Inflation Adjusted Decisions-Procedure to Adjust Inflation, Examples on comparison of alternatives and Determination of Economics Life of asset.

### **Text Book**

1. Pannerselvam, R., Engineering Economics, Prentice-Hall of India Pvt. Ltd., New Delhi 2001.

### **Reference Books**

1. Degarmo, E.P., Sullivan, W.G. and Canada, J.R.. Engineering Economy, Macmillan, New York, 1984.

2. Grant, E.L., Ireson, W.G. and Leavenworth, R.S., Principles of Engineering Economy, Ronald Press, New York, 1976.

3. Smith G.W. En :Engineering Economics, Iowa State Press, Iowa, 1973

## **CE 502 STRUCTURAL DESIGN-II**

### **Unit-I**

Types of Steel and their permissible stresses, Design of Joints - Riveted, Bolted and Welded Connections under axial and eccentric loadings.

### **Unit-II**

Compression Members: Design of axially and eccentrically loaded members, Built-up columns, Design of Lacing and Battens, Design of Column Splices.

### **Unit-III**

Tension Members: Design of Axially and Eccentrically Loaded Tension Members – Tension Splices- Design of Lug Angles, Column bases: Design of Column bases, Slab Bases, Gusseted base,

### **Unit-IV**

Design of Beams- Laterally Supported and Unsupported –Web Crippling- Built Up Beams- Design of Gantry Girder, Design of Beam Column Joints.

### **Unit-V**

Design of Plate Girder (both welded and riveted), Wind load calculations - Design of Roof Truss Elements.

### **Text Books**

1. Subramanian.P, Design of steel structures, Oxford Publishers, New Delhi, 2007.
2. Dayaratnam.P, 'Design of Steel Structures', Wheeler & Co Ltd., Allahabad, 1996
3. Raghupathy. M, 'Design of Steel Structures', Tata McGraw Hill Publishing Company Ltd., New Delhi, 1995.
4. Ramachandra, 'Design of Steel Structures', Vol. I & II, Standard book house, Delhi

### **Reference Books**

1. Punmia B.C, Ahok Kumar Jain and Arun Kumar Jain, Comprehensive Design of Steel Structures, Lakshmi publications (P) Ltd., New Delhi, 1998.
- 2 Arya, A.S. and Ajmani, J.L., 'Design of Steel Structures', Nem Chand and Bros, Roorkee, 2000
3. Solmon and Johnson, 'Steel Structures- Design and Behaviour', Intext Educational Publishers, 1971

## **CE 503 COASTAL AND OFFSHORE STRUCTURES**

### **Unit I**

Growth and regulation of Ports: History of Port – Classification of Harbours - Factors affecting the growth of Port. - Requirement of a Harbour - General Planning - Site investigation  
Description of selected Indian ports.

### **Unit – II**

Harbour Planning (Technical): Harbour entrance - Navigational Channel – Depth of harbour – Turning basin – berthing area – Shipping terminal facilities – Essentials of passenger terminal, dry bulk cargo terminal, Liquid bulk cargo terminals and container terminals. Navigational aids – Light house.

### **Unit - III**

Break waters: Types – Selection – Forces and – Design principles of break waters. Berthing structures: Types – Loads – Selection and design principles of berthing structures – Selection and Design principles of Dock fenders and Mooring accessories. Types of dock structures, Dredging.

### **Unit – IV**

Types of offshore structures – selection – function - Physical, environmental and geotechnical aspects of marine and offshore construction – Loads and responses of offshore structures.

## Unit - V

Foundations for offshore structures – Introduction to design and installation of offshore piled platforms, concrete offshore platforms, Moored floating structures and Submarine pipelines

### **Text Books**

1. Gerwick, C., Construction of Marine and Offshore structures, CRC Press.
2. Alonzo Def. Quinn., Design and construction of Port and Marine structures McGraw Hill Book co.
3. Chakrabarti.,S.K., Hand Book of Offshore Engineering (Vols. 1 & 2)” Elsevier Publications

### **CE 506 DESIGN AND DRAWING –I**

Detailed Design and Drawing of the following RCC elements/Structures:

1. Continuous beams and slab systems
2. Isolated footings - for axial load and with moments
3. Combined footings - for axial loads and with moments
4. Cantilever retaining walls
5. Elevated - circular and rectangular water tanks (excluding staging)
6. Slab culvert bridges

### **Reference Books**

1. Jain, A.K., Reinforced Concrete Limit State Design, Nem Chand Brothers, 1990.
2. Sinha. S.N. Reinforced Concrete Design, Tata McGraw Hill, 1988.
3. Varghese, P.C .Limit State Design of Concrete, Oxford IBH, 1983.

### **CE 507 SEMINAR**

Each one of the students will be assigned a Seminar Topic in the current and frontier areas. The student has to conduct a detailed study/survey on the assigned topic and prepare a report. The student will make an oral presentation followed by a brief question and answer session. The Seminar (presentation and report) will be evaluated by an internal assessment committee for a total of 100 marks.

## **CE 508 INDUSTRIAL VISITS /TRAINING**

During the course of study from 3rd to 7th semester each student is expected to undertake a minimum of four industrial visits or undertake a minimum of two weeks of industry/field training. The students are expected to submit a report, which shall be evaluated by an internal assessment committee at the end of seventh semester for 100 marks.

## **CE 509 PROJECT WORK (PHASE-I)**

The objective of the project is to enable the students to work in groups of not more than four members in each group on a project involving analytical, experimental, design or combination of these in the area of Civil Engineering. Each project shall have a guide. The student is required to do literature survey, formulate the problem and form a methodology of arriving at the solution of the problem. The evaluation is based on continuous internal assessment by an internal assessment committee for 100 marks.

## **ELECTIVE**

### **CE 8 GEOTECHNICAL PROCESSES AND APPLICATION**

#### **Unit-I**

Introduction: Need – methods – suitability – Mechanical modification : principle - Surface compaction: Field compaction and equipments, compaction specification and controls. Vibration methods: dynamic consolidation, vibratory rollers, Vibro floatation.

#### **Unit-II**

Drainage methods: Well point systems, deep well drainage, vacuum dewatering system, design of dewatering system – field permeability tests, dewatering by electro osmosis. Preloading, sand drains, wick drains- Thermal methods case studies.

#### **Unit-III**

Grouting: Classification – Methods – Types – grouts – equipments, grouting design and layout, grout monitoring – applications – Case studies.

#### **Unit-IV**

Stabilization: cement stabilization, Lime stabilisation – chemical stabilisation - methods, principles, applications and field control. Stabilization using reinforcement – rock anchor- soil tie backs.

#### Unit-V

Geo synthetics: Geotextiles, Geogrids, Geomembranes, Geonets, Geomats, Geomeshes, principles Design and applications – Case studies.

#### **Text Books**

1. Koerner, R.M., Construction & Geotechnical methods in foundation engineering, MGH, New York,1985
2. Hausmann. M.R. Engineering principles of Ground Modification, McGraw-Hill
3. Purushothama raj. P. Ground improvement techniques, Laxmi Publications (P) Ltd, India

#### Reference Books

1. Bowle's.J.E., Foundation Analysis and design,4th edition,MGL,1998.
2. Jones.C.J.F.P., Earth reinforcement and soil structures, Butter worth &co., London,1985
3. Arora.K.R., Soil mechanics and foundation Engineering,SPD,2001

### **CEE 9 GEOGRAPHICAL INFORMATION SYSTEM**

#### Unit I

Data entry, storage and maintenance Types of data – spatial and non-spatial information, Geographical concepts and terminology, Advantages of GIS. Basic Concepts of GIS, organisation of data in GIS.

#### Unit II

Field data, Statistical data, Maps, Aerial photographs, Satellite data, points, lines and areas features, Vector and Raster data, Advantages and Disadvantages, Data entry through keyboard, digitizers and scanners, digital data. Preprocessing of data – Rectification and registration, Interpolation techniques.

#### Unit III

Data analysis and modeling Spatial analysis – data retrieval – query – Simple analysis –Record – overlay – vector data analysis –raster data analysis – modelling in GIS – digital elevation model – DIM- cost and path analysis –artificial intelligence- expert systems

#### Unit IV

Data output and error analysis Types of output data – display on screen – printer – plotter –other output devices – sources of errors – types of errors –elimination- accuracies

Unit V GIS Application Application areas- resource management – agriculture- soil – water resources management – cadastral records and LIS integrated remote sensing application with GIS- knowledge based techniques – multicriteria evaluation in GIS – introduction to object oriented data base models

### **Text Books**

1. Geo Informational systems –Applications of GIS and related spatial information technologies, ASTER publications co., Chestern ( England) , 1992
2. Burrough , p. a., Principles of GIS for land resources assessment, Oxford publications , 1990
3. Jeffrey Star and John Estes , Geographical information systems – An Introduction, Prentice – Hall inc. ,1990

## **CE 10 HYDRAULIC STRUCTURES**

### Unit-I

Planning and Selection of Dams: Planning , environmental considerations , storage requirements, sedimentation in reservoir, wave height and free board, selection of type of dam. Geological investigation, classification of insitu, rocks for Engineering purposes, foundation treatment ,river diversion works.

### Unit-II

Gravity dams: Definition, forces acting on the dam, nonoverflow and overflow sections, causes of failure , design principles , elementary profile of a dam, high and low dam, stability analysis, temperature control in dams, construction and contraction joints, Galleries in dams.

### Unit –III

Arch Dam: Classification and type , factors affecting layout , simple design criteria – thin cylinder theory trial load analysis, elastic theory, cantilever and Arch analysis. Earth & Rock fill Dams: Types , profile and design principles of earth dams, height and top width, side slopes and its protection, core and casing , cutoff and seepage control , drainage system, construction methods and quality control.

### Unit-IV



Spillways ,sluices and crest gates: Definition and types of spillways , design storm and spillways capacity, energy dissipation, design criteria – design of crest gates and high head gates ,supply and power sluices.

Unit – V

Instrumentation- Embedded instruments in dam section , foundation measurements of dam body , analysis of strain data , automatic control of dam safety.

### **Text Books**

1. Sharma, H.D., Concrete Dams,Metroploitan,2002,
2. Punmia,B.C. and Pande.B.B. Lal, Irrigation and Water power Engineering, Standard Publishers, Ninth edition, 1986.

### **Reference Books**

1. Garg. S.K., Irrigation and Hydraulic structures, Khanna Publishers, 1992.
2. Creager, Justin and Hinds Engineering for dams. Vol I.II.III
3. Das, M.M, Saikia, M.D Irrigation and Water Power Engineering, PHI, Learning (P) Ltd, 2009

## **CE 11 FINITE ELEMENT ANALYSIS**

Unit –I

Need for Numerical Technique – Solutions to Differential Equations –Finite Difference Methods – Limitations Variation and Weighted Residual and Potential energy formulations – Finite Element Method – Basic steps.

Unit –II

Shape functions – convergence Criteria –Geometric Invariance – Pascal’s Triangle – Shape Functions for one Dimensional Structures - Formulation of Element Matrix - Formation of Element Nodal load Vector - Coordinate systems –Global , Local & Natural.

Unit –III

Two dimensional elements – Plane stress – Plane strain – 3,6 Nodded Triangular elements – Rectangular elements – Lagrange and serendipity elements –Isoparmetric elements -shape functions, Element stiffness Matrix – Load vector formulations –Gauss Quadrature rule.

Unit –IV

Basic concepts beam elements –Axisymmetric elements Tetrahedral, hexahedral elements – Formation of shape functions-mesh generation techniques- reduction of band width – static condensation.

Unit –V

Solution Techniques- Gauss elimination –Matrix Decomposition – Based a and Frontal solvers.

Requirements of Pre and post processor in GUI based FE packages.

### **Text Books**

1. Krishnamoorthy,C.S, Finite Element Analysis – Theory and Programming – TMH, New Delhi, 1999
2. Zienkiewicz, O.C, Morgan,K, Finite elements & approximations , John & Sons, 1998.

### **Reference Books**

1. Desai, C.S, Able, R.R. Introduction to the Finite Element Method, Affiliated East West Press, 1972
2. Cook, R.D, Concepts and applications of Finite element Analysis, John Wiley and Sons, 1981

## **CE 12 ADVANCED STRUCTURAL DESIGN - RCC**

Unit-I

Building Frames- Approximate methods – substitute frame analysis- Design of beam column joints - Design of reinforced concrete braced and un-braced walls . Design of flat slabs.

Unit-II

Yield line theory- Equilibrium and Virtual Work method- Analysis and Design of Square, Rectangular and Circular Slabs with different boundary conditions subjected to UDL and Concentrated loads, Hillerborg’s method of design of slabs. Analysis and Design of Grid floors by approximate analysis.

Unit-III

Design of Deep Beams, Design of beams curved in plan.-Design of Silos and Bunkers,

Unit-IV

Redistribution of moments in RC beams- introduction-conditions- advantages- moment curvature relation- ACI guidelines , Design for serviceability Limit states – Design calculations of deflection and crack width as per IS456-2000.

## Unit –V

Requirements for good formwork- Materials for forms- Loads on formwork - - Design of formwork – Introduction to Composite Construction – behavior and design principles. Steel – Concrete Composite Beams, Beams with in – situ slab and pre cast rib

### **Text Books**

1. Purushothaman ,P, Reinforced concrete structural elements : Behavior, analysis and design, Tata Mc Graw , 1986.
2. Varghese P.C, Advanced Reinforced Concrete Design -- Prentice- Hall of India Private Limited , New Delhi, 2002
3. Unnikrishna pillai and Devdas Menon, ‘ Reinforced Concrete Design’, Tata Mc Graw Hill Publishing Company Ltd., New Delhi, 2002

### **References**

1. Shah VL and Karve SR , Advanced Reinforced concrete Design”, Structures Publications Pune , 2002.
2. Sinha S N , Reinforced Concrete Design , Tata Mc Graw Hill Publishing Company Ltd., New Delhi, 1996
3. Johnson R.P. , Composite Structures Vol.-I
4. Punmia B.C., R.C Structures Vol.II, Lakshmi Publication, New Delhi.
5. Shah H.J. , Reinforced concrete Vol. I, Charotar Publishing House, 2005.

## **CE 13 FAILURE ANALYSIS AND REHABILITATION OF STRUCTURES**

### Unit – I

Condition Assessment – Procedure for assessment – survey – Field visits – inspection – Sampling – structural capacity – load testing – condition assessment of structures – NDT methods – Evaluation and health monitoring.

### Unit-II

Agencies causing material deterioration - shrinkage, settlement, weathering, chemical attack, creep, fire, honey combing etc., durability of materials –Safety evaluation of existing structures

### Unit-III

Structural and non structural cracks -Types of structural distress in foundations, roofs, floors, walls etc.

#### Unit-IV

Repair Techniques - Materials for repair – Repair of concrete structures - bridges and water retaining structures – water proofing methods and materials - Non-structural repairs.

#### Unit-V

Factors influencing corrosion of steel – Corrosion protection of steel structures – Masonry deterioration, Biocidal treatment and use of preservatives – Factors influencing deterioration of wood, use of sealants and adhesives and their role in repair of structures.

#### **Text Books**

1. Ransom,W.H., Building Failures, E&FN SPON Ltd., 1981.
2. Perkins.P, Repair, Protection and Waterproofing of Concrete Structures , E & FN SPON, London

#### **Reference Books**

1. Moskvin.V., Concrete and Reinforcement Concrete Deterioration and Protection, MIR Publishers, 1983.
2. Richardson,B.A., Remedial Treatment of Buildings, Construction Press, 1989.

### **CE 14 BRIDGE ENGINEERING**

#### Unit –I

History and Development of Bridges, Classification of Bridges-Investigations for culverts and minor bridge, Investigations for major bridge – Topography, catchment, hydrology, Geotechnical aspects, Construction Resources – Design Flood Discharge-Methods, Linear waterway.

#### Unit – II

Choice of Foundation for piers and abutments –Types - relative suitability. Load on Foundation – Well foundation – types –Design well foundation – Scour Depth – Stability of well foundation - well sinking - methods – Tilt correction – Case studies

#### Unit –III

Loading standards for road and railway bridges- Setting out for piers and abutments, Minor Bridges and Culverts, Single span Bridge, Multispan Bridge, Major/Important Bridges.

#### Unit –IV

Bridge superstructure – supports and centering for RC bridges – erection process of RC girders and steel girder bridges .

Unit –V

Maintenance-Inspection of bridges, Maintenance of substructure girders-Load testing on bridges- Temporary and movable bridges- Re-building of bridges- bridge failure.

### **Text Books**

1. Ponnusamy S, “Bridge Engineering” Tata McGraw Hill Publishing Co., New Delhi , 2008

### **Reference Books**

1. Whitney, C.S, Bridges, Greenwich House,1983

2. Singh, V.P Wells and Caissons, Nemchand & Sons,1979

## **CE 15 HYDRO POWER ENGINEERING**

Unit-I

History and types of water power development: History of water power development - water power development in India - Comparison of water power with thermal, nuclear and wind mills - Classification - High, Medium and Low Head schemes - Run off river plants - Storage power station - Tidal power plant - Recent experiences in wave power development - Underground power plants - Pumped storage schemes - Small and mini Hydropower systems - Power demand - Role of Hydropower in a grid.

Unit-II

Planning and Layout of Hydropower schemes: Investigation connected with hydropower development - Site selection, layout of hydro power plant- Capacity - Load factor and Load curve.

Unit-III

Design of Hydroelectric works: Necessities for the construction of a dam - Selection of type of Dam - Spillway, types and design – In take works, types - Design of Intake transition - Trashrack - Design of power canals and penstocks, penstock joints support structures, Elements of laying penstock lines – Water hammer - Rigid and elastic column theory - Characteristics Methods of determining pressure surges in penstocks –surge tanks

Unit-IV

Selection of suitable type and number of turbines - Layout and spacing of turbines. Types and spacing of turbines, tanks, and design, Power house - Types - Layout and spacing of units.

Economics of Hydropower Installation: Basic factors in economic Analysis -, Cost of Hydroelectric power.

#### Unit-V

Mini Hydropower Systems: Small and min hydropower systems - Site selection, Hydrologic computations, Site development, Environmental Impact - Economic and Financial Feasibility.

#### **Text Books**

1. Bhattacharya, P.K., Water Power Engineering, Khanna Publishers, 2002.
2. Desmukh, M.M., Water Power Engineering, Dhanpat Rai & Sons, 2002.

#### **Reference Books**

1. Brown, G., Hydroelectric Engineering Practice, CPS, 1984.
2. Fritz, J.J, Small and Mini Hydropower Schemes, McGraw Hill, 1984.
3. Creager and Justin, Hydro electric Hand Book, John Wiley.
4. Das, M.M Saikia, M.S Irrigation and water Power Engineering. PHI Learning. Pvt. Ltd,2009

### CE 16 SITE INVESTIGATION METHODS AND PRACTICES

#### Unit- I

Objections, site investigation in Civil Engineering process, problem solving and various stages in site investigation process. Planning and Desk Study - topographic maps, aerial photographs, applications in site investigation and interpretation of aerial photographs, Geological maps, soil and planning maps, site reconnaissance and local enquiries.

#### Unit -II

Geological methods - different stages, Geological exploration methods - General principle distribution of physical field in subsurface - Electrical resistivity, Seismic refraction methods, their principle, methods of survey, correction to field data, Interpretation and limitations. Index and Mechanical properties of rocks, Laboratory and insitu tests.

#### Unit-III

Trial pits, shafts, tunnels, auguring, and different types of drilling methods, their merits and demerits, Bore hole logging techniques (subsurface geophysical exploration) - Need for logging techniques, classification and different types logging methods.

#### Unit - IV

Soil Exploration methods, samples, sampling procedure, sample disturbances, samplers, Factors

controlling spacing and depth of bore hole, Insitu tests, SPT, SCPT, Pressure meter tests, interpretation and application, Laboratory testing, Index properties.

#### Unit - V

Technical Report writing, report format, recommendations for earth work structures, highway excavations and drainage works, dams, check report site preparation, investigation during construction and operation.

#### **Text Books**

1. Joyce, M.D. 'Site Investigation Practice;', ESFN. SPON Publishers, 1982.

#### References Books

1. Hunt, R.E., Geotechnical Engineering Analysis and Evaluation, McGraw Hill Book Company, 1986.

2. Bell, Fundamentals of Engineering Geology, Butterworth and Co., London, 1983.

3. Blyth, F.G.H. and De Freitas, M.H., A Geology for Engineers, Edward - Arnold publishers Ltd., 1984.

4. Legget and Karrow, Hand book of Geology in Civil Engineering, McGraw Hill Publishers, 1983.

### **CE 17HIGHWAY AND AIRPORT PAVEMENT DESIGN**

#### Unit-I

Introduction: Pavement types, components, highway and airport pavements, complexities in pavement design. Design Factors: Sub grade - Significance, soil classification, assessment of strength characteristics, Traffic Loads, Climatic factors - variation in moisture content and applications, wheel load stresses, wheel load configurations in highway and airport pavements, ESWL, repetition of loads and EWL factors,transient loads. Problems.

#### Unit-II

Pavement materials Characterization – introduction. Soil- characterization, tests. Aggregates- tests, batch mixing. Bituminous – types of bitumen, tests. Bituminous mixes– design. Cement – tests, design of PQC. Soil stabilization – introduction, methods of stabilization.

#### Unit-III

Flexible pavement Design Methods: General design approaches; Design methods for highway and airport pavements - Group Index, FAA, CBR, Wyoming, Stabilometer, Triaxial test McLeod and by Burmister's two layer theory. Problems.

#### Unit-IV

Stresses in Rigid Pavements and Design: Stresses due to wheel load and temperature, Westergaard's analysis, ESWL in rigid pavements, spacing of joints in CC Pavements, thickness design method, IRC design method for highway Pavement, Design of expansion and longitudinal joint details.

#### Unit-V

Pavement Evaluation and Testing: Pavement failures; Structural evaluation and strengthening of flexible pavements - CBR and plate load tests, Benkelman beam rebound deflection method, strengthening of rigid pavements, Pavement surface condition evaluation, Testing techniques for flexible and rigid pavements.

#### **Text Books**

1. Sharma, S.K., Principles, Practices and Design of Highway Engg. S.Chand & Co., New Delhi. 2002.
2. Justo, C.E.G, S. K. Khanna, Highway Engineering, S. Chand Publishers, New Delhi, 2006

#### **Reference Books**

1. Partha Chakroborthy and Animesh Das, "Principles of Transportation engineering, Prentice Hall of India Pvt. Ltd., New Delhi – 110001, 2003
2. Michel Sargious, "Pavements and surfacing for Highways and Airports", Allied Science publishers Ltd. London, 2006.
3. Yang Huang, "Pavement analysis and design", Allied Publishers Ltd. London, 2006.
4. Yoder, Principles of Pavement Design, John Wiley & Sons, 2003

### **CE 18 MATRIX METHODS OF STRUCTURAL ANALYSIS**

#### Unit – I

Matrix flexibility method – Transformation of forces – Element flexibility to system flexibility. Analysis of statically indeterminate beams and rigid jointed plane -frames – effect of support settlements and elastic supports.



## Unit – II

Matrix flexibility method Analysis of pin-jointed frames –effects due to lack of fit and temperature changes. Application to space frames – Direct flexibility approach.

## Unit – III

Matrix stiffness method – Transformation of displacements – Elements stiffness to system stiffness – Application to continuous beams – effects of support settlements and elastic supports.

## Unit – IV

Matrix stiffness method — Application to pin-jointed plane frames - support settlements – lack of fit and temperature effect. Analysis of three dimensional pinned frames.

## Unit – V

Special analysis techniques – Condensation, Substructuring – reanalysis techniques – transfer matrix method. Analysis of frames with semi rigid connections.

### **Text Books**

1. Pandit, G.S. and Gupta, S.P., Structural Analysis – A Matrix Approach, Tata McGraw Hill Publishing Co., New Delhi, 1997.
2. McGuire, W., and Gallagher, R.H., Matrix Structural Analysis, Lohn Wiley & Sons, New York, 1998.
3. Rajasekaran, S., and Sankarasubramanian, G., Computational Structural Mechanics, Prentice Hall of India Pvt. Ltd., New Delhi, First Edition 2001.

### **Reference Books**

1. Wang, C.K., “Intermediate Structural Analysis”, McGraw Hill Publishing Co., New York, 1989.
2. Reddy, C.S., “Basic Structural Analysis”, Tata McGraw Hill Publishing Co., New Delhi, 1996.

## **CE 19EXPERIMENTAL MEASUREMENTS AND ANALYSIS**

### Unit I

Displacement and Load measurement devices - Strain gauges, principle, types, performance and uses – principle and applications - Hydraulic jacks and pressure gauges – Electronic load cells – Proving Rings – Calibration of testing Machines.

### Unit II

Vibration measurement -Characteristics of structural vibrations – Linear variable differential transformer (LVDT) – Transducers for velocity and acceleration measurements – Vibration meter – Seismographs – Vibration analyzer – Electro Dynamic Exciters - Display and recording of signals – Digital data Acquisition systems – principles and applications.

#### Unit III

Wind Flow Measurements -Principles of pressure and flow measurements – pressure transducer \ – Wind tunnel and its use in structural analysis – structural modeling.

#### Unit IV

Distress Measurement - Diagnosis of distress in structures – crack observation and measurement –Corrosion of reinforcement in concrete – Half cell construction and potential measurement – resistivity meter - Damage assessment.

#### Unit V

Load testing of structures, Buildings, bridges and towers – Rebound Hammer – Ultrasonic Testing, Principles and applications - Moire fringes – brittle coatings – holography – use of Lasers for structural testing –smart materials.

#### **Reference Books**

1. Sadhu Singh, “Experimental Stress Analysis”, Khanna Publishers, New Delhi, 1996.
- 2 Dalley.J.W. and Riley.W.F., “Experimental Stress Analysis”, Tata McGraw Hill company Ltd. New York, 1991
- 3 Srinath.L.S.et al, “Experimental Stress Analysis”, Tata McGraw Hill company Ltd., New Delhi, 1984
4. Sirohi.R.S., Radha Krishna.H.C., “Mechanical Measurements”, New Age International (P) Limited, 1997
5. Garas.F.K., Clarke.J.L.and Armer.G.S.T., “Structural Assessment”, Butterworths, London, 1987.
6. Bray.D.E., and Stanley.R.K., “Non-Destructive Evaluation”, McGraw Hill Publishing Co., New York, 1989.
7. Ganesan T.P., “Model Analysis of Structures”, Universities Press, Hyderabad, 2000