

**M.TECH. DEGREE  
CONSTRUCTION TECHNOLOGY AND MANAGEMENT**

**SYLLABUS  
FOR  
CREDIT BASED CURRICULUM  
(With effect from 2014 - 2015)**



**DEPARTMENT OF CIVIL ENGINEERING  
NATIONAL INSTITUTE OF TECHNOLOGY  
TIRUCHIRAPPALLI – 620015 INDIA**

### M. Tech. (Construction Technology and Management)

The total minimum credits required for completing the M. Tech. (Construction Technology and Management) course is 63.

#### SEMESTER I

Code	Course of Study	L	T	P	C
CE751	Construction Planning & Control	3	0	0	3
CE753	Construction Economics & Finance	3	0	0	3
CE755	Contracts & Specifications	3	0	0	3
CE757	Construction Personnel Management	3	0	0	3
	Elective – I	3	0	0	3
	Elective – II	3	0	0	3
CE759	Construction Materials Lab	0	0	3	2
		18	0	3	20

#### SEMESTER II

Code	Course of Study	L	T	P	C
CE752	Construction Methods & Equipment	3	0	0	3
CE754	Construction Quality & Safety Management	3	0	0	3
CE756	Organizational Behaviour	3	0	0	3
	Elective - III	3	0	0	3
	Elective – IV	3	0	0	3
	Elective - V	3	0	0	3
CE760	Construction Software Lab	0	0	3	2
		18	0	3	19

Code	Course of Study	L	T	P	C
CE762/764	Summer Training/ Mini Project	-	-	-	-

#### SEMESTER III

Code	Course of Study	L	T	P	C
CE765	Major Project	-	-	-	12

#### SEMESTER IV

Code	Course of Study	L	T	P	C
CE766	Major Project	-	-	-	12

### ELECTIVES

Code	Course of Study	Credit
CE761	Modern Construction Materials	3
CE762	Functional Efficiency of Buildings	3
CE763	Soil Exploration and Field Test	3
CE764	Disaster Mitigation and Management	3
CE765	Offshore Engineering	3
CE766	Port and Harbor Structures	3
CE767	Airport Planning and Design	3
CE768	Welding Technology	3
CE769	Safety in Material Handling at Construction	3
CE770	Non Destructive Evaluation	3
CE771	Design of Material Handling Equipment	3
CE772	Welding safety in construction Environment	3
CE773	Heating, Ventilation, Air Conditioning (HVAC) Systems and their Applications	3

### ELECTIVES OFFERED FROM OTHER DEPARTMENTS / DISCIPLINES

Code	Course of Study	Credit
CE603	Pavement Materials and Design	3
CE621	Geospatial Techniques	3
CE622	Ground Improvement Techniques	3
CE672	Prefabricated Structures	3
CE678	Structures for Power Plants	3
CE679	Forensic Engineering and Rehabilitation of Structures	3
CE680	Soil Structure Interaction	3
CE681	Advanced Concrete Technology	3
CE684	Analysis of Deep Foundation	3
CE702	Biological Process Design for Wastewater Treatment	3
CE703	Physico chemical Process for Water and Wastewater Treatment	3
CE704	Transport of Water and Wastewater	3
CE714	Solid and Hazardous Waste Management	3
CE716	Environmental Impact Assessment	3
EE601	Advanced Power System Analysis	3
EE602	Power System Operation and Control	3
EE604	High Voltage DC Transmission	3
EE606	Flexible AC Transmission System	3
EE611	Power Conversion Techniques	3
EE621	Renewable Power Generation Technologies	3
EE622	Power System Planning and Reliability	3
EE623	Advanced Power System Protection	3
EE624	Modeling and Analysis of Electrical Machines	3

## **VISION AND MISSION OF THE INSTITUTE**

### **Vision of the Institute**

To provide valuable resources for industry and society through excellence in technical education and research.

### **Mission**

To offer state-of-the-art undergraduate, postgraduate and doctoral programmes

To generate new knowledge by engaging in cutting-edge research

To undertake collaborative projects with academia and industries

To develop human intellectual capability to its fullest potential

## **VISION AND MISSION OF THE DEPARTMENT**

### **Vision of the Department**

Shaping infrastructure development with societal focus

### **Mission**

Developing Professional Civil Engineers

Offering Continuing Education

Interacting with Industry with emphasis on R&D

## **CE751 Construction Planning & Control**

Introduction to Project Management - Work Breakdown Structure, Gantt Charts, Network representation - AOA and AON network diagrams.

Network analysis – Critical Path Method (CPM), Program Evaluation and Review Technique (PERT).

Network crashing - Least cost scheduling, Time-cost trade off, Resource scheduling and leveling.

Project control – Earned Value Analysis, Delay analysis, Linear scheduling method.

Advanced topics – Case studies, Introduction to computer applications.

## **References**

1. Calin M. Popescu, Chotchai Charoenngam, Project Planning, Scheduling and Control in
2. Chitkara, K.K. Construction Project Management: Planning, Scheduling and Control, McGraw Hill Publishing Company, NewDelhi,1998.
3. Chris Hendrickson and Tung Au, Project Management for Construction – Fundamental Concepts for Owners, Engineers, Architects and Builders, Prentice Hall, Pittsburgh, 2000.
4. Halpin, D. W., Financial and Cost Concepts for Construction Management, John Wiley & Sons,New York, 1985.
5. Willis, E. M., Scheduling Construction Projects, John Wiley & Sons, 1986.

## **CE753 Construction Economics & Finance**

Construction economics - Overview of construction economics - time value of money - cash flow diagram - Single payment now compared to a single payment in future (F/P) -Future payment compared to a uniform series of payments (F/A) - one present payment compared to a uniform series of payments (A/P) - arithmetic Gradient G, Geometric gradient.

Financial Returns analysis - Comparing Alternatives - Present Worth Method-Annual payments method- Future worth methods, Rate of Return ( ROR), Incremental Rate of Return ( IROR), Break even analysis , Marginal costing, Cost Benefit analysis.

Accounting methods - Depreciation accounting, income tax accounting, inflation, replacement analysis.

Construction costing - Methods of construction costing- percentage completion method – Fixed contract Pricing- cost plus pricing- Escalation clause- Sources of Finance, Infrastructure financing; Life-cycle costing, Construction cost control; Personnel costs; Equipment costs, Job in directs and markup.

Financial Statement Analysis - Balance sheet and Profit and Loss accounts – ratios analysis, Fund flow statement, Cash flow statement, Working Capital Management, Financial Control - Management accounting;

### **References:**

1. Blank, L.T., and Tarquin, a.J (1988) Engineering Economy, 4<sup>th</sup>Edn. Mc-Graw Hill Book Co.
2. Collier C and GlaGola C (1998) Engineering Economics & Cost Analysis, 3<sup>rd</sup>Edn. Addison Wesley Education Publishers.
3. Patel, B M (2000) Project management- strategic Financial Planning, Evaluation and Control, Vikas Publishing House Pvt. Ltd. New Delhi.
4. Steiner, H.M. (1996) Engineering Economic principles, 2<sup>nd</sup>Edn. Mc-Graw Hill Book Co.

### **CE755 Construction Contracts & Specifications**

Comprehensive study of different types of Tenders, Applications to various works;

Type of contracts, Problems in the operation of contracts;

Claims and disputes; Arbitration case studies;

Professional practices, ethics, duties and responsibilities;

Construction specifications – standard specifications, development, interpretation.

### **References**

1. Gajaria G.T., Laws Relating to Building and Engineering Contracts in India,
2. Jimmie Hinze, Construction Contracts, McGraw Hill, 2001.
3. Joseph T. Bockrath, Contracts and the Legal Environment for Engineers and Architects, McGraw Hill, 2000.
4. Kwaku, A., Tenah, P.E. Jose M.Guevara, P.E., Fundamentals of Construction Management and Organisation, Printice Hall, 1985, M.M.Tripathi Private Ltd., Bombay, 1982.
5. Patil. B.S, Civil Engineering Contracts and Estimates, Universities Press (India) Private Limited, 2006.

### **CE757 Construction Personnel Management**

Elements of Personnel Management, Competency development, Leadership;

Productivity, Assessment tools, Productivity improvement, motivation;

Performance planning and assessment, rewards;

Team Behaviour, Communications, Discipline;

Crisis Management, Case studies.

## References:

1. Carleton Counter II and Jill Justice Coutler, The Complete Standard Handbook of Construction Personnel Management, Prentice-Hall, Inc., 1989.
2. Charles D Pringle, Justin Gooderi Longenecter, Management, CE Merril Publishing Co. 1981.
3. Dwivedi R.S, Human Relations and Organisational Behaviour, Macmillian India Ltd., 2005.
4. Josy.J. Familaro, Handbook of Human Resources Administration, McGraw-Hill International Edition, 1987.
5. Memoria,C.B., Personnel Management, Himalaya Publishing Co., 1997.

## CE759 Construction Materials Lab

Study of properties of building materials; study of testing methods and standard specifications for strength and other properties of building materials; concrete mix design and testing; non-destructive testing methods; Studies on simple building system components

## References:

1. ACI Report 440.2R-02, "Guide for the design and construction of externally bonded RP systems for strengthening concrete structures", American Concrete Institute, 2002.
2. Aitkens , High Performance Concrete, McGraw Hill, 1999
3. Ashby, M.F. and Jones. D.R.H.H. "Engineering Materials 1: An introduction to Properties, applications and designs", Elsevier Publications, 2005.
4. Deucher, K.N, Korfiatis, G.P and Ezeldin, A.S, Materials for civil and Highway Engineers, Prentice Hall Inc., 1998.
5. Mamlouk, M.S. and Zaniewski, J.P., Materials for Civil and Construction Engineers, Prentice Hall Inc., 1999.
6. Santhakumar.A.R., Concrete Technology, Oxford University press, New Delhi
7. Shan Somayaji, Civil Engineering Materials, Prentice Hall Inc., 2001
8. Shetty M.S, Concrete Technology: Theory & Practice, S. Chand& Company Ltd., 2005.

## CE752 Construction Methods & Equipment

Factors affecting selection of equipment and methods – Technical and economic – Construction engineering fundamentals – Analysis of production and output costs;

Methods and equipment for earthmoving;

Equipment for lifting and erection - Material transport - Pile driving – Dewatering;

Concrete construction – Batching – Mixing – Transport – Placement – Finishing – Formwork – Scaffolding – Steel construction – Fabrication and erection;

High rise Buildings – Highways – Bridges -Underground Utilities - Tunnels - Off-shore platforms- Slip form for Chimneys and Cooling Towers;

## References

1. Modern Construction and Ground Engineering Equipment and Methods (Prentice Hall 2nd Edition) by F. Harris
2. Construction Methods and Management: Pearson New International Edition 8<sup>th</sup> Edition Stephens Nunnally
3. Deodhar, S.V. Construction Equipment and Job Planning, Khanna Publishers, New Delhi, 1988.
4. Dr. MaheshVarma, Construction Equipment and its planning and Application, Metropolitan Book Company, New Delhi. 1983.
5. Peurifoy, R.L., Ledbetter, W.B. and Schexnayder, C., Construction Planning, Equipment and Methods, McGraw Hill, Singapore, 2006.
6. Sharma S.C. Construction Equipment and Management, Khanna Publishers, New Delhi, 1988.

## CE754 Construction Quality & Safety Management

Construction quality – Total Quality Management concepts, Quality management philosophies, Statistical quality control, Quality assurance and control, Quality audits, Quality function deployment; Tools – Control charts, Acceptance sampling, Specification and tolerances.

Safety management – Implementation and application of QMS in safety programs, ISO 9000 series, Accident theories, Cost of accidents, Problem areas in construction safety, Fall protection, Incentives, Zero accident concepts, Planning for safety, Occupational health and ergonomics.

## References

1. Dale H. Besterfield, Carol Besterfield-Michna, Glen H. Besterfield, Mary Besterfield-Sacre, Total Quality Management, Pearson Education, Prentice Hall.
2. John L. Ashford, The Management of Quality in Construction, E & F.N.Spon, 1989.
3. Jimmy W. Hinze, Construction Safety
4. Richard J Coble, Jimmy W. Hinze & Theo C Haupt, Construction Safety and Health Management.
5. Quality Management Safety Manual : ISO 9001-2000 BTS-1995.

## CE756 Organizational Behaviour

Leadership in Organizations. Characteristics of Organizations: Organization Structure and Design, Organizational Behaviour, Organizational Culture and climate;

Individuals in Organizations - individual decision-making; Group Dynamics: Group behaviour, Inter-group relation and conflict; Communication;

Motivation and behaviour; Motivation at work; Designing motivating jobs;



Functional and Dysfunctional conflict –conflict management strategies - Principles and Tactics of Negotiation- Factors affecting Intergroup Relations and Managing Intergroup Relations;

Organizational change and Development - Managing Innovation and Technology in changing environments -case studies of OD interventions in mega-construction projects.

## **References**

1. Gregory Moorhead and Ricky W. Griffin, Organizational Behaviour: Managing People and Organizations, 3rd Edition, Houghton Mifflin Company, Boston, 2000
2. Stephen, P Robbins, Organizational Behaviour, 9th edition, Pearson Education Asia, New Delhi, 2001
3. Wendell L French and Cecil H. Bell, Jr., Organization Development: Behavioural Science Interventions for Organization Improvement, 6th edition, Pearson Education Asia, New Delhi, 2001.
4. Jit. S.. Chander, Organizational Behaviour, 3rd edition, Vikas Publishing House Pvt. Ltd., New Delhi, 2005.
5. Dwivedi R.S, Human Relations and Organizational Behaviour, Macmillan India Ltd.,2005.

## **CE760 Construction Software Laboratory**

Spreadsheet applications, Database applications, Project management software, Simulation software, Optimization Software, Visualization software- Construction applications.

## **References**

1. Kenneth C Laudon and Jane Price Laudon, Management Information Systems Organization and Technology, Prentice Hall, 1996.
2. Michael W. Evans and John J Marciniak, Software Quality assurance and Management, John Wiley and Sons, 1987.
3. Ralph H Sprague and Hugu J Watson, Decision Support for Managers, Prentice Hall, 1996.

## **ELECTIVES**

### **CE761 MODERN CONSTRUCTION MATERIALS**

Structure and properties of materials – Review of material science concepts;

Construction materials – Concrete;

Steel – Aluminium – Wood;

Bituminous materials – Polymers and Plastics;

Composite materials – Innovation in materials technology

## References

1. Ashby, M.F. and Jones. D.R.H.H. “Engineering Materials 1: An introduction to Properties, applications and designs”, Elsevier Publications, 2005
2. Duggal, S.K, “Building Materials”, New Age International Publishers Ltd., Delhi.
3. Ganapathy, C. “Modern Construction Materials”, Eswar Press, 2015.
4. Mamlouk, M.S. and Zaniewski, J.P., Materials for Civil and Construction Engineers, Prentice Hall Inc., 1999.
5. Shan Somayaji, Civil Engineering Materials, Prentice Hall Inc., 2001
6. Shetty M.S, Concrete Technology: Theory and Practice, S. Chand & Company Ltd., 2005.

## CE763 SOIL EXPLORATION AND FIELD TEST

Problems and phases of foundation investigations, Geophysical, sounding, drilling and accessible explorations.

Sample requirements, sampling methods and equipment. Handling, preservation and transportation of samples.

Sample preparation, laboratory tests, analysis of results and interpretation.

Importance of in-situ testing. Performing various in situ tests. Precautions and interpretation. Field instrumentation.

Investigation below sea/river bed; offshore investigation; Site evaluation and reporting.

## TEXTBOOKS/References

1. Bowles, J.E, Physical and Geotechnical Properties of Soil, McGraw-Hill Book Company, 1985.
2. Bowles, J.E, Foundation Analysis and Design, McGraw-Hill International edition, 1997.
3. Dunicliff, J. and Green, G.E, Geotechnical Instrumentation for Monitoring Field Performance, John Wiley & Sons, 1982.
4. GopalRanjan and Rao, A.S.R, Basic and Applied Soil Mechanics, Wiley Eastern Limited, 1991.
5. Lunne, T., Robertson, P.K. and Powell, J.J.M, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, 1997.
6. Compendium of Indian Standards on Soil Engineering Parts 1 and II 1987 – 1988

## CE764 DISASTER MITIGATION AND MANAGEMENT

Meaning and types of hazards, disasters and catastrophes – Disaster Management; Earthquakes: causes and effects – measurements - earthquake zones India – vulnerability and micro zonation;- volcanic hazards;

Landslides : Causes and effects – landslide prone zones in India –Cyclone: Origin and types - effects on land and sea – damage assessment; Flooding: Tsunami –Soil Erosion-Drought :Characteristics- Occurrence – Preventive measures;

Emerging approaches in Disaster Management- Pre- disaster stage (preparedness) - Preparing hazard zonation maps, Predictability/forecasting& warning- Preparing disaster preparedness plan- Land use zoning- Disaster resistant house construction- Population reduction in vulnerable areas- Awareness;

Emergency Stage - Rescue training for search & operation at national & regional level-Immediate relief- Assessment surveys- Post Disaster stage-Rehabilitation- Political Administrative Aspect- Social Aspect- Economic Aspect- Environmental Aspect- Mitigation - Role of Media - Monitoring Management- Preventive Measures- A regional survey of Land Subsidence, Coastal Disaster, Cyclonic Disaster& Disaster in Hills with particular reference to India -Ecological planning for sustainability & sustainable development in India-Sustainable rural development;

Soft Solutions for Disaster Management - Case studies - Earthquake, volcano and landslide - Flood prone area analysis and management – risk assessment – cyclones and floods - Drought and desertification

## **References**

1. National Disaster Management Division (2004) Disaster Management in India - A Status Report, Ministry of Home Affairs, Government of India, New Delhi.
2. UNDRO (1995) Guidelines for Hazard Evaluation Procedures, United Nations Disasters Relief Organization, Vienna.
3. Nagarajan, R., (2004) Landslide Disaster Assessment and Monitoring, Anmol Publications, New Delhi.
4. Ramkumar, Mu, (2009) Geological Hazards: Causes, Consequences and Methods of Containment, New India Publishing Agency, New Delhi.

## **CE765 OFFSHORE ENGINEERING**

The Ocean environment - Waves, Currents, Winds, Sea bed Geology, Earthquakes, Floating ice.

Common Structural Systems - Jacket or Tension leg structures, Tower, Caissons, Concrete gravity platforms, Steel, Gravity platforms, FPSOspar platforms, Hybrids, Compliant structures, factors governing selection.

Hydrodynamic loading of large offshore structures - Diffraction theory - Regions of validity - Application - Linear dynamic analysis.

Foundations of offshore structures - Pile foundations, Prediction of axial pile capacity, Bearing capacity of footings, settlement of foundations.

Offshore construction - Drilling techniques, logging methods, location of drill sites, Completion of walls, Marine survey, Welding, Checks on welding and codes, Corrosion and its prevention measures.

## **References**

1. Dawson. T.H.- Offshore Structural Engineering
2. Detnorskeveritas, Rules for the Design, Construction and Inspection of Fixed Offshore Structures.
3. Recommended practice for Planning, Designing, and Construction of Fixed Offshore Structures- American Petroleum Institute.
4. Sarpakaya&Issacson, Fluid loading on structures.

## **CE766 PORT AND HARBOUR STRUCTURES**

Vessel type and size - Types of harbor - Port planning - Layout of ports - Types of breakwater - Design wave height, tide, storm surge - and Tsunami - Naval hydrographic chart and design of entrance channel and turning circle.

Design of breakwater - Types of berthing structures - Loads on berthing structures and codal requirements Berthing force, mooring force and seismic force - Types of fenders - Active and passive earth pressure and differential water pressure - Load combination, WSD and LSD - Analysis of container berth - Analysis of oil jetty - Foundation design of piles - Pile load tests.

Design of caisson and monoliths - Structural design of piles - Construction methodology - Mechanical handling systems - Design for punching shear and design of beams and slab - Tranquility studies and allowable vessel motion.

Coastal erosion and accretion - Design of sea wall and groins - Dry dock – Slipway - Ship lift- Different types of coastal structures and its functions; Types of shore protection structures, Sea water intake structures, Outfalls, Submarine pipelines, breakwaters, Scour protection Structures.

Submarine Pipelines: Basic problems in the design; Environmental Forces; Stability criteria; Selection of Burial Depth; Design principles of submarine pipelines. Scour Protection Structures: Scour prediction and protection around piles, walls and rubble mound structures.

## **References**

1. Port Design - Guidelines and recommendations by C. A. Thoresen, Tapir Publications.
2. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by J. W. Gaythwaite, Van Nostrand.
3. Handbook of Offshore Engineering by S.K. Chakrabarti, Elseviers, 2005.
4. Agerschou, H., Lundgren, H., Sorensen, T., Ernst, T., Korsgaard, J., Schmidt, L.R. and Chi, W.K., (1983). "Planning and Design of Ports and Marine Terminals", A Wiley-Interscience Publication.
5. Perbrun (1983). "Port Engineering" Gulf Publishing Co.

## 6. Shore Protection Manual

### **CE767 AIRPORT PLANNING AND DESIGN**

Aviation Planning - Levels of Planning - Planning Airport Systems under different States - Air Transport Planning in India and in Europe/USA. Airport Master Plan: - Definition and Objectives - Hierarchy of Planning - Elements of Airport Master Plan: - FAA - ICAO Guidelines for Structure of Master Plan - Airport Layout Design - Structure of Master Plan Report - Airport Site Selection.

Airport Capacity - Level of Service - Airside Capacity - Factors Affecting Airside Capacity and Delay - Determination of Runway Capacity and Delay - Annual Service Volume - Preliminary Capacity Analyses - Calculating Aircraft Delay - Taxiway and Gate Capacity - Airport Landside Capacity.

Principles of Airport Layout - Airfield Configuration - Runway Orientation - Wind Rose Analysis - Obstructions to Airspace: - FAA and ICAO Standards - Runway Length - Separation of Parallel Runways - Runway and Taxiway Cross Section - Longitudinal-Grade Design for Runways and Stop-ways - Longitudinal-Grade Design for Taxiways - Taxiway Design - Holding Aprons - Terminal Aprons.

Airport Forecast Methods - General Aviation Forecasts - Airport ground access mode choice modeling process - Use of airport ground access models in airport planning - Integration of airport ground access models in regional planning process. Function of Airport Passenger and Cargo Terminal - Facilities Required at Passenger Terminal - Passenger and Baggage Flow - Elements to Be Considered in Design of Air Freight Terminals.

Airport Pavement Design - Aircraft and Pavement Classification Numbers - Flexible-Pavement Design Methods (India Practice - McLeod Method - FAA Design Procedure - Corps of Engineers Designs) - Rigid-Pavement Design Methods (Indian Practice - Corps of Engineers Designs - FAA design - Joint and reinforcement requirements). Airport Drainage - Estimation of Runoff - Collection and Disposal of Runoff - Subsurface Drainage.

### **References**

1. Geoffrey D. Gosling; Airport ground access mode choice models, Transportation Research Board, Washington, D.C., 2008
2. Norman J. Ashford, Saleh Mumayiz, Paul h. Wright; Airport Engineering Planning, Design, and Development of 21st century Airports, John Wiley & Sons, Inc.,2011
3. Horenjeff Robert; The planning & Design of Airports, McGraw Hill Book Co., 2007  
Yoder, E.J. and Witczak, M.W; Principles of Pavement Design, John Wileyand sons,1975

## **CE768 WELDING TECHNOLOGY**

**INTRODUCTION:** Comparison between casting and welding processes definition of welding as per AWS, advantages and disadvantages of welding. Basic welding positions and joint types.

**GAS AND ARC WELDING:** Gas welding, principle and equipment, applications and selection, arc welding, principle, electrodes, energy source characteristics.

**SPECIAL WELDING PROCESSES (FUSION):** TIG and MIG welding processes, ESW, discussion on LBW, EBW, PAW, Carbon arc welding and Atomic Hydrogen welding, applications and selection.

**SPECIAL WELDING PROCESSES (NON-FUSION):** Resistance welding, friction and ultrasonic welding, diffusion welding, explosion welding – applications and selection.

**WELDING METALLURGY:** Definition, heat affected zone (HAZ), temperature distribution in welding, pre and post heat treatment, weld decay, weldability of steel, Cu, Aluminium.

**INSPECTION AND TESTING OF WELDMENTS:** Welding defects, remedies, destructive test methods, NDT of weldments. Design of Welded Joints: Basic principles, weld symbols, residual stresses and distortion, design of weldments.

**AUTOMATION & CAE in WELDING:** Automation in welding – seam tracking and arc sensing – welding robots. Applications of CAE in modeling welding and temperature distributions.

### **TEXT BOOKS:**

1. Little R L, "Welding and Welding Technology", Tata McGraw Hill, New Delhi, 2004.
2. Parmer R S, "Welding Process and Technology", Khanna Publishers, 1994.

## **CE769 SAFETY IN MATERIAL HANDLING AT CONSTRUCTION**

### **MANUAL MATERIAL HANDLING**

Preventing common injuries, lifting by hand, team lifting and carrying, handling specific shape machines and other heavy objects – accessories for manual handling, hand tools, jacks, hand trucks, dollies and wheel barrows – storage of specific materials - problems with hazardous materials, liquids, solids – storage and handling of cryogenic liquids - shipping and receiving, stock picking, dock boards, machine and tools, steel strapping and sacking, glass and nails, pitch and glue, boxes and cartons and car loading – personal protection – ergonomic considerations.

### **LIFTING TACKLES AND MECHANICAL MATERIAL HANDLING**

Fiber rope, types, strength and working load inspection, rope in use, rope in storage - wire rope, construction, design factors, deterioration causes, sheaves and drums,

lubrication, overloading, rope fitting, inspection and replacement – slings, types, method of attachment, rated capacities, alloy chain slings, hooks and attachment, inspection, safe slinging practices – Testing procedures for wire rope slings, chain slings and lifting tackles like Shackles, eye bolts – Inspection and maintenance of lifting tackles, chain pulley block and slings.

Hoisting apparatus, types - cranes, types, design and construction, guards and limit devices, signals, operating rules, maintenance safety rules, inspection and inspection checklist – conveyors, precautions, types, applications. Powered industrial trucks, requirements, operating principles, operators selection and training and performance test, inspection and maintenance, electric trucks, gasoline operated trucks, LPG trucks – power elevators, types of drives, hoist way and machine room emergency procedure, requirements for the handicapped, types- Escalator, safety devices and brakes, moving walks – man lifts, construction, brakes, Inspection and examination of lift and hoist.

### **References:**

1. Jimmy W. Hinze, Construction Safety, Prentice Hall Inc., 1997.
2. Richard J. Coble, Jimmie Hinze and Theo C. Haupt, Construction Safety and Health Management, Prentice Hall Inc., 2001.

## **CE770 NON DESTRUCTIVE EVALUATION**

SURFACE METHODS -Visual Inspection - Liquid Penetrant Testing - Magnetic Particle Inspection.

VOLUMETRIC METHODS - Electro-Magnetic Methods - Acoustical Methods - Radiographic Methods - Thermal Methods - Optical Methods.

APPLICATIONS IN CONSTRUCTION INDUSTRY - Analysis of quality and durability of materials on building threats, break - downs and catastrophes. Testing of concrete in building structures. Testing of reinforcement in reinforced concrete structures (Radiographic testing and electromagnetic testing). Testing of walls, steel, wood and plastic of civil structures.

### **References:**

1. Non Destructive Testing Handbook

## **CE771 DESIGN OF MATERIAL HANDLING EQUIPMENT**

MATERIAL HANDLING EQUIPMENT -Types, selection and applications

DESIGN OF HOISTS - Design of hoisting elements: Welded and roller chains - Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks - crane grabs - lifting magnets - Grabbing attachments - Design of arresting gear - Brakes: shoe, band and cone types.

DRIVES OF HOISTING GEAR - Hand and power drives - Travelling gear - Rail traveling mechanism - cantilever and monorail cranes - slewing, jib and luffing gear – cog wheel drive - selecting the motor ratings.

CONVEYORS - Types - description - design and applications of Belt conveyors, apron conveyors and escalators; Pneumatic conveyors, Screw conveyors and vibratory conveyors.

ELEVATORS - Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices - Design of fork lift trucks.

#### **References:**

1. Deodhar, S.V. Construction Equipment and Job Planning, Khanna Publishers, New Delhi, 1988.
2. Dr.Mahesh Varma, Construction Equipment and its planning and Application, Metropolitan Book Company, New Delhi. 1983.
3. Peurifoy, R.L., Ledbetter, W.B. and Schexnayder, C., Construction Planning, Equipment and Methods, McGraw Hill, Singapore, 2006.
4. Sharma S.C. Construction Equipment and Management, Khanna Publishers, New Delhi, 1988.

### **CE772 WELDING SAFETY IN CONSTRUCTION ENVIRONMENT**

WELDING AND CUTTING - Welding and Cutting methods - Shielded Metal Arc Welding – Gas Metal Arc Welding – Gas Tungsten Arc Welding – Flux Core Arc Welding – Oxyacetylene Welding and Cutting – Use of acetylene and other gases in cutting.

SPECIFIC HAZARDS AND CONTROL MEASURES - Airborne contaminants - Source and Health Effect of Welding Fumes – Radiation – Electrical hazards – Fire and Explosion – Burns and Exposure to Heat – Compressed and Liquefied Gases – Noise – Lead – Confined space – Falls – Manual Tasks.

EQUIPMENT -Ventilation – Local exhaust ventilation – Forced dilution ventilation – Natural ventilation; Personal Protective Equipment – Maintenance of equipment – Handling, storage and usage of gas cylinders.

#### **References:**

1. <https://www.osha.gov/SLTC/weldingcuttingbrazing/additionalinformation.html>
2. Materials and Processes for NDT Technology “The American Society for Non Destructive Testing”



## **CE773 HEATING, VENTILATION, AIR CONDITIONING (HVAC) SYSTEMS AND THEIR APPLICATIONS**

HEATING SYSTEMS - Forced-air system components – Radiant heating systems – Heat pump equipment (Air source heat pumps, its efficiency – Geothermal heat pump, its efficiency – Furnace equipment, measures of efficiency for furnaces - Electric Integrated Systems - Unvented Fuel-Fired Heaters).

VENTILATION AND INDOOR AIR QUALITY - Supplying outside air from air leaks - Supplying outside air from inlet vents - Supplying outside air via ducted make-up air - Dehumidification-ventilation systems - Heat recovery ventilators – Radon - passive and active radon resistant construction - testing for radon.

AIRCONDITIONING - Air-conditioners – Seer rating – Variable speed units – Installation of air-conditioners.

HVAC SYSTEMS - Sizing – Temperature controls – Zoned HVAC systems – Cooling equipment selections.

## **CE672 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. Promyslow. V., Design and Erection of Reinforced Concrete Structures, MIR Publishers, Moscow 1980.
3. Koncz.T., Manual of Precast Concrete Construction, Vol.I II and III, Bauverlag, GMBH, 1971.
4. Structural Design Manual, Precast Concrete Connection Details, Society for the Studies in the use of Precast Concrete, Netherland Betor Verlag, 1978.

## **CE678 STRUCTURES FOR POWER PLANTS**

Planning, Analysis and design of different types of power plants - Chimneys, Induced draught and Natural draught cooling towers, Turbo generator Foundation, Material handling structures, Intake towers, storage structures and other supporting structures for equipment.

### **References**

1. KamW.Li and A.PaulPriddy., Power Plant System Design by John and Willey Sons Inc. ISBN No - 9780471888475.
2. E.E. Khalil., Power Plant Design An abacus book Energy and Engineering Science Series, ISSN 1042 – 1939. ISBN0856265101, 9780856265105 by Abacus Press 1990.
3. P.C. Sharma ., Power Plant Engineering by S.K.Kataria and Sons 01 Jan 2009.

## **CE679 FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES**

Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability – case studies – learning from failures – causes of distress in structural members – design and material deficiencies – over loading.

Diagnosis and Assessment of Distress: Visual inspection – non- destructive tests – ultrasonic pulse velocity method – rebound hammer technique – ASTM classifications – pullout tests – Bremor test – Windsor probe test – crack detection techniques – case studies – single and multi-storey buildings – Fiberoptic method for prediction of structural weakness. Environmental Problems and Natural Hazards:

Effect of corrosive, chemical and marine environment – pollution and carbonation problems – durability of RCC structures – damage due to earthquakes and flood-strengthening of buildings – provisions of BIS 1893 and 4326.

Modern Techniques of Retrofitting: Structural first aid after a disaster – guniting - jacketing – use of chemicals in repair – application of polymers – ferrocement and fiber concretes as rehabilitation materials – rust eliminators and polymer coating for rebars- foamed concrete- mortar repair for cracks- shoring and underpinning - strengthening by pre-stressing.

Case studies – buildings - heritage buildings- high rise buildings- water tanks – bridges and other structures

### **References**

1. Raikar, R.N., Learning from failures – Deficiencies in Design, Construction and Service R&D Centre (SDCPL), RaikarBhavan, 1987.
2. Dovkaminetzky, Design and Construction Failures, Galgotia Publication, NewDelhi, 2001.
3. Shen-En Chen, R. Janardhanam, C. Natarajan, Ryan Schmidt, Ino-U.S. Forensic Practices - Investigation Techniques and Technology, ASCE, U.S.A., 2010.

4. C. Natarajan, R. Janardhanam, Shen-En Chen, Ryan Schmidt, Ino-U.S. Forensic Practices - Investigation Techniques and Technology, NIT, Tiruchirappalli, 2010.
5. Gary L. Lewis, Guidelines for Forensic Engineering Practice, ASCE, U.S.A., 2003.

## **CE680 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 and 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. Selvadurai, 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.
4. J.W. Bull, Soil-Structure Interaction: Numerical Analysis and Modelling, CRC Press, 1st edition , 1994.

## **CE681 ADVANCED CONCRETE TECHNOLOGY**

Introduction to concrete – Mineral and chemical admixtures – Structure of hydrated cement paste – Transition zone in concrete - Design of concrete mix proportions by ACI and IS 10262:2009 method – Rheological behaviour of fresh concrete - Properties of hardened concrete and their significance.

Strength-Porosity relationship – Failure modes in concrete – Behaviour of concrete under various stress states – Elastic behaviour in concrete - Creep, shrinkage and thermal properties of concrete.

Classification of causes of concrete deterioration – Permeability of concrete – Chloride penetration – Acid attack - Sulfate attack – Alkali-aggregate reaction –

Concrete in sea water – AC impedance test - Corrosion of embedded steel in concrete – Case histories.

Non-Destructive testing: Rebound hammer – Windsor probe – Ultrasonic pulse velocity – Acoustic emission – Pulse-echo method – Initial surface absorption – Radar technique – Infrared Thermography – Quantab test – Portable crack measuring microscope – Cover meter – Resistivity of concrete – Semi-destructive testing.

Concreting under special circumstances – Special materials in construction – Concreting machinery and equipment – Future trends in concrete technology.

## **References**

1. P.KumarMetha and Paulo J.M.Monteiro., Concrete: Microstructure, Properties and Materials, Third edition, McGraw Hill, 2006.
2. Adam. M. Neville., Properties of Concrete, Fourth and Final edition, Wiley Publications, 1996.
3. A.R. Santhakumar, Concrete Technology” Oxford University Press, 2006
4. P.C.Aïtcin, High Performance Concrete, E &FN SPON, 1998.

## **CE684 ANALYSIS OF DEEP FOUNDATION**

Functions and requisites of a foundation - Different types - Choice of foundation type – Types of deep foundation – Types of pile foundations- Factor governing choice of type of pile – Choice of pile materials.

Load carrying capacity of piles by static formulae- Introduction: IS code method- API method-Piles in cohesive and cohesionless soils – Piles in layered cohesive and cohesionless soils – Settlement of single pile – Piles bearing on rock – Piles in fill and Negative skin friction.

Load carrying capacity of piles by dynamic formulae: Introduction- Pile driving formulae- selection of pile hammers- Determination of temporary elastic compression- Driving stresses in piles- Field measurement- Wave equation analysis.

Group action in piled foundations: Introduction- Minimum spacing of piles- group efficiency- Estimation of group bearing capacity- Effect of pile arrangement- Effect on pile groups of installation methods- precaution against heave effect in pile group- Settlement of pile group-Reduce differential settlement in pile group.

Pile subjected to lateral load: Introduction- Lateral resistance of single pile-IS 2911 method for lateral resistance of pile- Broms charts for lateral load analysis- Elastic analysis-p-y curves, use of p-y curves- improving lateral resistance of piles- field test on piles.

## **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.
4. P.C. Varghese, "Foundation Engineering", Prentice-Hall of India, New Delhi, 2005.

## **CE603 PAVEMENT ANALYSIS AND DESIGN**

Types and component parts of pavements, Factors affecting design and performance of pavements. Highway and airfield pavements, Requirements and desirable properties of aggregates, bitumen, emulsion and modified bitumen, Characterization of different pavement materials;

Pavement Design Factors Design wheel load, strength characteristics of pavement materials, climatic variations, traffic - load equivalence factors and equivalent wheel loads, aircraft loading, gear configuration and tyre pressure.

Drainage – Estimation of flow, surface drainage, sub-surface drainage systems, design of sub-surface drainage structures;

Flexible Pavement Design- Empirical, semi-empirical and theoretical approaches, design of highway and airport pavements by IRC, AASHTO Methods, Mechanistic – Empirical design, applications of pavement design software Rigid Pavement Design Types of joints and their functions, joint spacing; design of CC pavement for roads, highways and airports as per IRC, AASHTO, design of joints.

Design of continuously reinforced concrete pavements. Reliability; Use of software for rigid pavement design Pavement Management Distresses in pavements, maintenance of highways, structural and functional condition evaluation of pavements, performance prediction models, ranking and optimization in pavement management.

## **References**

1. Yoder and Witczak, Principles of Pavement Design, John Wiley and Sons
2. Yang. H. Huang, Pavement Analysis and Design, Second Edition, Prentice Hall Inc.
3. Rajib B. Mallick and Tahar El-Korchi, Pavement Engineering – Principles and Practice, CRC Press (Taylor and Francis Group)
4. W.Ronald Hudson, Ralph Haas and Zeniswki , Modern Pavement Management, McGraw Hill and Co
5. Relevant IRC Codes

## **CE611 GEOSPATIAL TECHNIQUES**

Concepts and foundations of remote sensing – energy source EMS – Remote Sensing System – EMR interaction with particulate matter – Spectral Signature curves – Data Acquisition and interpretation – Visual Image Interpretation.

Photogrammetry – Radar, LIDAR, SAR systems Platform/Sensors – Classification – satellite system/sensor parameters – earth resources and meteorological satellites –

microwave remote sensing techniques – Data Processing – Digital Image processing – Characteristics of Digital Satellite Image – ground truthing.

History of Development – Maps – Types of Maps, Projections – Components/Architecture of GIS – Data – Spatial and Non-Spatial – Data Input Sources – Raster and Vector data structures – DBMS – Data Output – Data quality – Sources/ types of errors Data handling in GIS –processing, analysis and Modeling.

Raster and Vector spatial analysis – Density analysis – Spatial autocorrelation – network analysis – nearest neighbor analysis – Surface modeling – DTM – Introduction to Geodesy – Space Geodetic Techniques – GPS.

Application of Remote Sensing, GIS and GPS – Survey, mapping and monitoring – Transportation planning – Infrastructure development – Structural engineering – Geotechnical Engineering – Earthquake Engineering – Environmental studies – Water resources

## **References**

1. Burrough P.A. and Rachel A. McDonell, Principles of Geographical Information Systems, Oxford Publication, 2004.
2. C.P. Lo and Albert K. W. Yeung, Concepts and Techniques of Geographical Information Systems, Prentice–Hall India, 2006.
3. Thomas. M. Lillesand and Ralph. W. Kiefer, Remote Sensing and Image Interpretation, John Wiley and Sons, 2003.
4. Joseph G., Fundamentals of Remote Sensing, University Press, 2005.
5. Panigrahi, N., Geographical Information systems, University Press, 2005.

## **CE614 GROUND IMPROVEMENT TECHNIQUES**

Introduction - Engineering properties of soft – weak and compressible deposits – problems associated with weak deposit – Requirements of ground improvements – introduction to engineering ground modification, need and objectives.

Soil Stabilization Science of soil stabilization – Mechanical modification – Hydraulic modification – Dewatering systems – Chemical modification – Modification by admixtures like lime, Cement, Bitumen etc. – Grouting – Deep jet mixing methods.

Recent Ground improvement techniques stabilization using industrial waste – modification by inclusion and confinement – soil nailing – stone column – compaction piles – dynamic compaction – prefabricated vertical drains – preloading – electro – osmosis – soil freezing vacuum consolidation – deep explosion – dry powdered polymers - enzymes

Soil reinforcement Historical background, RCC – Vidalean concept of reinforced earth – Mechanisms – Types of reinforcements – Soil – Reinforcement – Interaction studies – Internal & External stability criteria – Design Principles of steep reinforced soil slopes – pavements – Embankments on soft soils.

Geo-Synthetics Geo-synthetic clay liner – Construction details – Geo Synthetic Materials – Functions – Property characterization – Testing Methods for Geo – Synthetics – Recent research and Developments. Control of Improvement – Field Instrumentation – design and analysis for bearing capacity and settlement of improved deposits.

### **References**

1. Hausmann, M.R., Engineering Principles of Ground Modification, McGraw – Hill International Editions, 1990.
2. Purushotham Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi
3. Sharma.S.K., Principles, Practice and Design of Highway Engineering, S.Chand& Co. New Delhi,1985.
4. Jones C. J. F. P, Earth Reinforcement and Soil Structures, Butterworths, London.

### **CE702 BIOLOGICAL PROCESS DESIGN FOR WASTEWATER TREATMENT**

Constituents of wastewaters – Sources - Significant Parameter - Fundamentals of Process Kinetics, Zero order, First order, Second order Reactions, Enzyme reactions – Bio reactors – Types - Classification- Design principles.

Design of waste water treatment systems - Primary, secondary and tertiary treatments - Evaluation of Biokinetic Parameters - Activated Sludge and its process - Modifications, Biological Nitrification and denitrification.

Attached Growth Biological Treatment Systems - Trickling Filters - Rotating Biological Contactors Waste stabilization ponds and Lagoons: Aerobic pond, facultative pond, anaerobic ponds - polishing ponds, aerated Lagoons Anaerobic processes - Process fundamentals - Standard, high rate and hybrid reactors, Anaerobic filters - Expanded /fluidized bed reactors - Upflow anaerobic sludge blanket reactors, - Expanded granular bed reactors - Two stage/phase anaerobic reactors - Sludge Digestion, Sludge disposal.

### **References**

1. Benefield, L.D. and Randall C.W. Biological Processes Design for wastewaters, Prentice-Hall, Inc. Eaglewood Cliffs, 1982.
2. Grady Jr. C.P.L and Lin H.C. Biological wastewater treatment: Theory and Applications, Marcel Dekker, Inc New York, 1980.
3. Metcalf & Eddy, Inc. Wastewater Engineering, Treatment and Reuse. 3rd Edition, Tata McGraw-Hill, New Delhi, 2003.

### **CE703 PHYSICO CHEMICAL PROCESS FOR WATER AND WASTEWATER TREATMENT**

Water Quality - Physical, chemical and biological parameters of water - Water Quality requirement - Potable water standards - Wastewater Effluent standards - Water quality indices.

Water purification systems in natural systems - Physical processes - chemical processes and biological processes - Primary, Secondary and tertiary treatment - Unit operations - unit processes.

Mixing, clarification – sedimentation ; Types; Aeration and gas transfer – Coagulation and flocculation, coagulation processes-stability of colloids - destabilization of colloids - destabilization in water and wastewater treatment - transport of colloidal particles, Clariflocculation.

Filtration processes - slow sand filtration- rapid sand filter; mechanism of filtration; modes of operation and operational problems; negative head and air binding; dual and multimedia filtration.

Adsorption, adsorption equilibria - adsorption isotherms, Disinfection – chlorine dioxide; chloramines; ozonation; UV radiation. Ion Exchange - processes, Application Membrane Processes, Reverse osmosis, Ultrafiltration, Electrolysis.

## **References**

1. Weber, W.J. Physicochemical processes for water quality control, John Wiley and sons, Newyork, 1983.
2. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York 1985.
3. Metcalf and Eddy, Wastewater engineering, Treatment and Reuse, Tata McGraw-Hill, New Delhi, 2003.

## **CE704 TRANSPORT OF WATER AND WASTEWATER**

Water storage – Impounding reservoirs – Intakes – pressure conduits – pumps – Economic design of pumps and pumping mains – Pipes – Pipe appurtenances – Water hammer.

Rapson methods, Distribution network analysis- methods of control and prevention of corrosion. Sanitary sewage flow estimation – Sewer materials – Hydraulics of flow in sanitary sewers – Partial flow – Sewer designs – Sewer layouts – Storm drainage.

Storm runoff estimation – Hydraulics of flow in storm water drains – hydraulics of flow in storm water drains-storm water drain materials and section-design of storm water drains.

Maintenance of sanitary sewerage and storm drainage – equipment – corrosion in sewers – prevention and control – Waste water pumping networks, Application of software in design of water supply networks.



## References

1. Manual on water supply and Treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi, 2000.
2. Manual on Sewerage and Sewage Treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi, 2000.

## CE711 SOLID AND HAZARDOUS WASTE MANAGEMENT

Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management Waste generation rates – Composition- Hazardous Characteristics – TCLP tests – waste sampling- Source reduction of wastes – Recycling and reuse.

Handling and segregation of wastes at source – storage and collection of municipal solid wastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations - labeling and handling of hazardous wastes.

Waste processing – processing technologies – biological and chemical conversion technologies –Composting - thermal conversion technologies-energy recovery – incineration – solidification and stabilization of hazardous wastes - treatment of biomedical wastes.

Disposal in landfills - site selection - design and operation of sanitary landfills- secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring – closure of landfills – landfill remediation.

Legislations on management and handling of municipal solid wastes, hazardous wastes, and biomedical wastes. Elements of Integrated waste management.

## References

1. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, Integrated Solid Waste Management, McGraw- Hill, New York, 1993
2. CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental

## EE601 ADVANCED POWER SYSTEM ANALYSIS

Network modeling – Single phase and three phase modeling of alternators, transformers and transmission lines, Conditioning of Y Matrix – Incidence matrix method, Method of successive elimination, Triangular factorization.

Load flow analysis – Newton Raphson method, Fast Decoupled method, AC-DC load flow – Single and three phase methods – Sequential solution techniques and extension to multiple and multi-terminal DC systems.

Fault Studies - Analysis of balanced and unbalanced three phase faults – fault

calculations – Short circuit faults – open circuit faults.

System optimization – strategy for two generator systems – generalized strategies – effect of transmission losses – Sensitivity of the objective function – Formulation of optimal power flow – solution by Gradient method - Newton's method.

State Estimation – method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation.

### References:

1. Grainger, J.J. and Stevenson, W.D. 'Power System Analysis' Tata McGraw Hill, New Delhi, 2003.
2. Hadi Saadat, 'Power System Analysis', Tata McGraw Hill, New Delhi, 2002.
3. Arrillaga, J and Arnold, C.P., 'Computer analysis of power systems' John Wiley and Sons, New York, 1997.
4. Pai M.A., 'Computer Techniques in Power System Analysis', Tata McGraw Hill, New Delhi, 2006.

## EE602 POWER SYSTEM OPERATION AND CONTROL

Economic operation – Load forecasting – Unit commitment – Economic dispatch problem of thermal units – Gradient method - Newton's method – Base point and participation factor method.

Hydro-thermal co-ordination - Hydroelectric plant models – short term hydro thermal scheduling problem - gradient approach – Hydro units in series – pumped storage hydro plants – hydro - scheduling using Dynamic programming and linear programming.

Automatic generation control - Review of LFC and Economic Dispatch control (EDC) using the three modes of control viz. Flat frequency – tie – line control and tie-line bias control – AGC implementation – AGC features - static and dynamic response of controlled two area system.

MVAR control – Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators.

Power system security - Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding - security constrained optimal power flow – Interior point algorithm - Bus incremental costs.

### References:

1. Robert H. Miller, James H. Malinowski, 'Power system operation', Tata McGraw-Hill, 2009
2. Allen J. Wood, Bruce F. Wollenberg, 'Power Generation, Operation and Control', Wiley India Edition, 2<sup>nd</sup> Edition, 2009.
3. Abhijit Chakrabarti & Sunita Halder, 'Power system Analysis - Operation & Control',

PHI, 3<sup>rd</sup> Edition, 2010.

4. T J Miller, 'Reactive Power Control in Electric Systems', Wiley, 1982.

## **EE604 HIGH VOLTAGE DC TRANSMISSION**

Introduction to HVDC transmission, Comparison between HVAC and HVDC systems - economic, technical and reliability, limitations, choice of best topology for HVDC converters, types of HVDC links - mono polar, bipolar and homo polar links, Rectifier operation of Graetz circuit with and without overlap

Inverter operation – analysis with and without overlap. Equivalent circuit model, Combined characteristics of HVDC system, basic means of control – desired features of control, power reversal

Basic controllers - Constant Ignition Angle, Constant Current and Constant Extinction Advance angle control, power control, high level controllers. Converter faults - misfire, arc through, commutation failure. D.C. Reactor design – voltage and current oscillations.

Protection issues in HVDC – DC Circuit breakers, over voltage and over current protection. Characteristic and uncharacteristic harmonics – troubles due to harmonics - harmonic filters - active and passive filters - Reactive power control of converters

Interaction between AC and DC systems. Recent trends in HVDC – VSC based HVDC – Multi - terminal HVDC systems and Hybrid HVDC systems. Back to back thyristor converter system.

## **References**

1. Padiyar, K.R., 'HVDC transmission systems', Wiley Eastern Ltd., 2010.
2. S.Rao, 'EHV-AC, HVDC Transmission and Distribution Engineering', Khanna Publications, 3<sup>rd</sup> Edition, 2012.
3. S.Kamakshiah and V.Kamaraju, 'HVDC Transmission', 1<sup>st</sup> Edition, Tata McGraw Hill, 2011.
4. Kimbark, E.W., 'Direct Current Transmission-vol.1', Wiley Interscience, 1971.
5. Arrilaga, J., 'High Voltage Direct Current Transmission', 2<sup>nd</sup> Edition, Peter Peregrinus Ltd., 1998.

## **EE606 FLEXIBLE AC TRANSMISSION SYSTEMS**

Fundamentals of ac power transmission – transmission problems and needs - emergence of FACTS - FACTS control considerations - FACTS controllers.

Principles of shunt compensation – Variable Impedance type & switching converter

type – Static Synchronous Compensator (STATCOM) configuration – characteristics and control.

Principles of static series compensation using GCSC, TCSC and TSSC – applications - Static Synchronous Series Compensator (SSSC).

Principles of operation - Steady state model and characteristics of static voltage regulators and phase shifters – power circuit configurations.

UPFC – Principles of operation and characteristics - independent active and reactive power flow control - comparison of UPFC with the controlled series compensators and phase shifters.

### References:

1. Song, Y.H. and Allan T. Johns, 'Flexible AC Transmission Systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.
2. Hingorani, L Gyugyi, 'Concepts and Technology of Flexible AC Transmission System', IEEE Press New York, 2000 ISBN–0780334588.
3. Mohan Mathur R. and Rajiv K. Varma, 'Thyristor- based FACTS controllers for Electrical transmission systems', IEEE Press, Wiley Interscience, 2002.
4. Padiyar K.R., 'FACTS controllers for Transmission and Distribution systems' New Age International Publishers, 1<sup>st</sup> Edition, 2007.
5. Enrique Acha, Claudio R. Duarte - Esquivel, Hugo Ambriz - Perez, Cesar Angeles Camacho, 'FACTS – Modeling and simulation In Power Networks' John Wiley & Sons, 2002.

## EE611 POWER CONVERSION TECHNIQUES

DC – Dc converters – Buck converter, boost converter, buck-boost converter, averaged circuit modeling, input-output equations, ripple calculations, filter design.

DC - AC inverters – Single phase VSI, Three phase VSI, Single phase CSI, Three phase CSI, voltage control and harmonic reduction in inverters – standard PWM techniques.

AC – DC converters – Uncontrolled rectifiers, single and three phase fully controlled and semi controlled converters, continuous current conduction, discontinuous current conduction, Reactive compensation, Harmonic compensation techniques AC – AC converters – single phase and three phase circuits employing Phase angle control, on - off control. AC choppers

Loss calculations and thermal management: Device models for loss calculations, ratings, safe operating areas, data sheets, forward conduction loss, switching losses, heat sink design, snubber design drive and protection circuits, commutation circuits, Soft switching

### References:

1. Ned Mohan, Undel and and Robbin, 'Power Electronics: Converters, Application and design', John Wiley and sons. Inc, 3<sup>rd</sup> Edition, 2002.
2. Rashid M.H., 'Power Electronics Circuits, Devices and Applications', Prentice Hall India, 3<sup>rd</sup> Edition, 2004.
3. Singh M.D., Khanch and ani K.B., 'Power Electronics', Tata McGraw Hill, 2<sup>nd</sup> Edition, 2008
4. Uman and L., 'Power Electronics: Essentials & Applications', Wiley India Pvt. Ltd., 2009.

## **EE621 RENEWABLE POWER GENERATION TECHNOLOGIES**

Sun and Earth – Basic Characteristics of solar radiation – angle of sunrays on solar collector – Photo voltaic cell – characteristics - equivalent circuit – Photo voltaic modules and arrays.

PV Systems – Design of PV systems – Standalone system with DC and AC loads with and without battery storage – Grid connected PV systems – Maximum Power Point Tracking.

Wind energy – energy in the wind – aero dynamics – rotor types – forces developed by blades – Aero dynamic models – braking systems – tower - control and monitoring system - design considerations – power curve – power speed characteristics - choice of electrical generators.

Wind turbine generator systems - fixed speed induction generator - performance analysis – semi variable speed induction generator - variable speed induction generators with full and partial rated power converter topologies – isolated systems – self excited induction generator - permanent magnet alternator - performance analysis.

Hybrid energy systems – wind - diesel system – wind - PV system - micro hydro - PV system – biomass – PV – diesel system – geothermal - tidal and OTEC systems.

### **References:**

1. Chetan Singh Solanki, 'Solar Photo voltaics - Fundamentals, Technologies and Applications', PHI Learning Pvt.Ltd., New Delhi, 2011
2. Van Over straeton and Mertens R.P., 'Physics, Technology and use of Photo voltaics', Adam Hilger, Bristol, 1996.
3. John F. Walker & Jenkins.N, 'Windenergy Technology', John Wiley and sons, Chichester, UK, 1997.
4. Frieres LL, 'Wind Energy Conversion Systems', Prentice Hall, U.K., 1990.

## **EE623 ADVANCED POWER SYSTEM PROTECTION**

Basic knowledge on short circuit analysis, digital system and signal processing. General philosophy of protection – Classification and Characteristic function of various protective relays – basic relay elements and relay terminology –

Development of relaying scheme.

Digital Protection of power system apparatus – protection of generators – Transformer protection – magnetizing inrush current – Application and connection of transformer differential relays – transformer overcurrent protection.

Bus – bar protection – line protection – distance protection – long EHV line protection - Power line carrier protection.

Reactor protection – Protection of boosters – capacitors in an inter connected power system.

Digital signal processing – digital filtering in protection relays – numeric protection – testing. Digital filtering in protection relays – digital data transmission – relay hardware – relay algorithms – Concepts of modern coordinated control system.

### References:

1. Lewis Blackburn, J., 'Protective Relaying–Principles and Applications', Marcel Dekkar, INC, New York, 2006.
2. The Electricity Training Association, 'Power System Protection Vol1-4', The IEE, U.K., 2005.
3. C. Russeil Mason, 'The art and Science of Protective Relaying', GE Publishers, 1962.
4. A. T. Johns and S. K. Salman, 'Digital Protection for Power Systems', Peter PeregrinusLtd.,1997.
5. Arun G Padkye and James S Thorp, 'Computer Relaying for Power Systems', John Wiley publications, 2<sup>nd</sup> Edition, 2009.

## EE624 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

Electromagnetic field theory, Vector algebra and fundamentals of all electrical rotating machines.

Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force / torque, example using single and doubly excited system.

Basic Concepts of Rotating Machines – Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine.

Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form; Application of reference frame theory to three phase symmetrical induction and synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames.

Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters Analysis and dynamic modeling of two phase asymmetrical induction machine and

single phase induction machine.

Special Machines - Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self-controlled operation; Analysis of Switch Reluctance Motors.

## References

1. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D. Umans, 'Electric Machinery', Tata McGraw Hill, 5<sup>th</sup> Edition, 1992.
2. R. Krishnan, 'Electric Motor & Drives: Modeling, Analysis and Control', Prentice Hall of India, 2<sup>nd</sup> Edition, 2001.
3. Miller, T.J.E., 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, 1<sup>st</sup> Edition, 1989.

## EE656 MICRO CONTROLLER APPLICATIONS IN POWER CONVERTERS

Use of micro controllers for pulse generation in power converters – Overview of Zero – Crossing Detectors – typical firing / gate – drive circuits – firing / gate pulses for typical single – phase and three - phase power converters - PIC16F876 Microcontroller – device overview – pin diagrams.

PIC16F876 microcontroller memory organization – Special Function Registers -I/O ports – Timers – Capture / Compare / PWM modules (CCP).

Analog to Digital Converter module – Instruction set – instruction description – introduction to PIC micro controller programming – oscillator selection – reset – interrupts – watchdog timer.

Introduction to MPLAB and PICSTART plus –Device Programming using MPLAB and PIC START plus – generation offering / gating pulses for typical power converters.

8051 microcontroller – architecture – addressing modes – I/O ports – instruction sets – simple assembly language programming.

## References:

1. PIC16F87X Datasheet 28/40 – pin 8bit CMOS flash Microcontrollers, Microchip technology Inc., 2001. and MPLAB IDE Quick start guide, Microchip technology Inc., 2007.
2. John B. Peatman, 'Design with PIC Microcontrollers', Prentice Hall, 2003.
3. Myke Predko, 'Programming and customizing the PIC Microcontroller', Tata McGraw Hill, 3<sup>rd</sup> Edition, 2008.
4. M.A. Mazidi, J.G. Mazidi and R.D. McKinlay, 'The 8051 micro controller and embedded systems', Prentice Hall India , 2<sup>nd</sup> Edition, New Delhi, 2007.

## **EE626 POWER SYSTEM RESTRUCTURING AND PRICING**

Introduction – Market Models – Entities – Key issues in regulated and deregulated power markets; Market equilibrium – Market clearing price – Electricity markets around the world.

Operational and planning activities of Genco - Electricity Pricing and Forecasting - Price Based Unit Commitment Design – Security Constrained Unit Commitment design - Ancillary Services for Restructuring – Automatic Generation Control (AGC).

Introduction – Components of restructured system – Transmission pricing in Open - access system - Open transmission system operation; Congestion management in Open - access transmission systems - FACTS in congestion management – Open - access Coordination Strategies; Power Wheeling - Transmission Cost Allocation Methods.

Open Access Distribution - Changes in Distribution Operations - The Development of Competition – Maintaining Distribution Planning.

Power Market Development – Electricity Act 2003 - Key issues and solution; Developing power exchanges suited to the Indian market - Challenges and synergies in the use of IT in power - Competition – Indian power market – Indian energy exchange-Indian power exchange – Infrastructure model for power exchanges - Congestion Management – Day Ahead Market - Online power trading.

### **References:**

1. Loi Lei Lai, 'Power System Restructuring and Deregulation', John Wiley & Sons Ltd., 2001.
2. Mohammad Shahidehpour, Hatim Yamin, 'Market operations in Electric power systems', John Wiley & son Ltd.,2002.
3. LorrinPhilipson, H.LeeWillis, 'Understanding Electric Utilities and Deregulation 'Taylor & Francis, 2006.
4. Mohammad Shahidehpour, Muwaffaq Alomoush, 'Restructured Electrical Power Systems', Marcel Dekker, Inc.,2001.

## **EE630 SMART GRID TECHNOLOGIES**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACT Sand HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt /



VAr control, Fault Detection, Isolation and service restoration, Outage management, High - Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles(PHEV).

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

### References:

1. Stuart Borlase, 'Smart Grid : Infrastructure, Technology and Solutions', CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, 'SmartGrid: Technology and Applications', Wiley, 2012.
3. Vehbi C. Güngör, Dilan Sahin, Taskin Kocak, Salih Ergüt, Concettina Buccella, Carlo Cecati and Gerhard P.Hancke, 'Smart Grid Technologies: Communication Technologies and Standards', IEEE Transactions On Industrial Informatics, Vol.7, No.4, November 2011.
4. XiFang, Satyajayant Misra, Guoliang Xue and Dejun Yang, 'Smart Grid – The New and Improved Power Grid : A Survey', IEEE Transaction on Smart Grids.

## EE631 ELECTRICAL SYSTEMS IN WIND ENERGY

Principle of operation – steady – state analysis – characteristics of GCIGs – operation of GCIGs with different power electronic configurations.

Process of self – excitation – steady – state equivalent circuit of SEIG and its analysis – performance equations – widening the operating speed – range of SEIGs by changing the stat or winding connection with suitable solid state switching schemes – power electronic controllers used in standalone systems.

Need for single – phase operation – typical configurations for the single –phase operation of three - phase GCIGs and SEIGs – steady state equivalent circuit and analysis using symmetrical components.

Different operating modes – steady – state equivalent circuit – performance analysis – DFIG for standalone applications – operation of DFIGs with different power electronic configurations for standalone and grid – connected operation.

Operation of PMSGs – steady – state analysis – performance characteristics - operation of PMSGs with different power electronic configurations for stand alone and grid - connected operation.

### References:

1. Marcelo Godoy Simões and Felix A. Farret, 'Renewable Energy Systems: Design and Analysis with Induction Generators', CRC Press, ISBN 0849320313,2004.
2. Ion Boldea, 'Variable speed Generators', CRC Press, ISBN 0849357152, 2006.
3. S.N. Bhadra, D. Kastha and S. Banerje, 'Wind Electrical Systems', Oxford University Press, 2005.
4. Siegfried Heier, Rachel Waddington, 'Grid Integration of Wind Energy Conversion Systems, 2<sup>nd</sup> Edition', Wiley, June 2006, ISBN:978-0-470-86899-7.
5. Freries LL, 'Wind Energy Conversion Systems', Prentice Hall,U.K.,1990.

## EE633 DISTRIBUTED GENERATION AND MICRO-GRIDS

Need for Distributed generation, renewable sources in distributed generation, current scenario in Distributed Generation, Planning of DGs – Siting and sizing of DGs – optimal placement of DG sources in distribution systems.

Grid integration of DGs – Different types of interfaces - Inverter based DG and rotating machine based interfaces – Aggregation of multiple DG units. Energy storage elements: Batteries, ultra-capacitors, flywheels.

Technical impacts of DGs – Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying – Impact of DGs upon transient and dynamic stability of existing distribution systems.

Economic and control aspects of DGs – Market facts, issues and challenges – Limitations of DGs. Voltage control techniques, Reactive power control, Harmonics, Power quality issues. Reliability of DG based systems–Steady-state and Dynamic analysis.

Introduction to micro – grids – Types of micro – grids – autonomous and non-autonomous grids – Sizing of micro – grids – modeling & analysis – Micro - grids with multiple DGs – Micro – grids with power electronic interfacing units. Transients in micro – grids - Protection of micro – grids – Case studies.

### References:

1. H.Lee Willis, Walter G.Scott, 'Distributed Power Generation –Planning and Evaluation', Marcel Decker Press,2000.
2. M.Godoy Simoes, FelixA. Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.
3. Robert Lasseter, Paolo Piagi, 'Micro - grid: A Conceptual Solution', PESC2004, June2004.
4. F.Katiraei, M.R.Iravani, 'Transients of a Micro - Grid System with Multiple Distributed

Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19 - 23, 2005.

5. Z.Ye, R.Walling, N.Miller, P.Du, K.Nelson, 'Facility Micro - grids', Sub contract report, May2005, General Electric Global Research Center, Niskayuna, NewYork.

## **EE635 ENERGY AUDITING AND MANAGEMENT**

Basics of Energy – Need for energy management – energy accounting - energy monitoring, targeting and reporting – energy audit process.

Energy management for electric motors – Transformer and reactors – capacitors and synchronous machines, energy management by cogeneration – forms of cogeneration – feasibility of cogeneration – electrical inter connection

Energy management in lighting systems – task and the working space – light sources – ballasts – lighting controls – optimizing lighting energy – power factor and effect of harmonics, lighting and energy standards.

Metering for energy management – units of measure – utility meters – demand meters – paralleling of current transformers – instrument transformer burdens – multitasking solid state meters, metering location vs. requirements, metering techniques and practical examples.

Economic analysis – economic models – time value of money – utility rate structures – cost of electricity – loss evaluation, load management – demand control techniques – utility monitoring and control system–HVAC and energy management – economic justification.

### **References:**

1. Barney L. Capehart, WayneC. Turner, and William J. Kennedy, 'Guide to Energy Management', 5<sup>th</sup> Edition, The Fairmont Press, Inc., 2006
2. AmitK.Tyagi, 'Handbook on Energy Audits and Management', The Energy and Resources Institute, 2003.
3. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.