

Academic Programme Guide
of
Master of Engineering
Construction Technology & Management
(Civil Engineering)

*Based on Choice Based Credit System (CBCS)/
Elective Course System (ECS)*



CHITKARA
UNIVERSITY

w.e.f.

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1. GENERAL INFORMATION

M.E. in Construction Technology and Management is aimed at shaping the enrolled students' managerial skills in the field of engineering, and prepare them for working as Strategists who can efficiently fulfil the production, commercial, and technological demands of an organization. The scholars will have the required knowledge to work in industries and will also be able to take up research in related and interdisciplinary areas. M.E. program of Civil Engineering at Chitkara University develops professionals who are highly proficient to serve the industry and or be a successful entrepreneur in the construction sector.

2. ELIGIBILITY FOR ADMISSION

The student seeking admission in 3 years ME CTM program should have passed B. E./ B. Tech / AMIE in Civil Engineering with a minimum of 50% marks from the Government / UGC recognized University. The admission is based purely on merit and also following the reservation policy as decided by the State of Himachal Pradesh. Students who qualified GATE exam will be given preference.

3. PROGRAMME OVERVIEW

CTM (Construction Technology and Management) programme is an interdisciplinary program that focuses on the knowledge & skills required for the planning, coordination and successful implementation of large Projects such as design and construction of structures and buildings, ship structures, aircraft, dams, roads, and bridges etc. It is a fusion of engineering and management. The M.E. program in Construction Technology and Management gives the students an insight into scientific principles involved in the successful execution and management of construction projects. This programme is coordinated by Civil Engineering department, for developing management executives in construction industries. The programme includes courses like Construction Planning & Control, Contracts & Specification, Construction Economics & Finance, Construction Methods & Equipment, Construction Quality & Safety Management, Organizational Behaviour etc. Latest technological trends and hands on computer training in construction management are integral part of the program. All the courses are designed with professional outlook towards the development of engineering and

managerial skills of the graduates. The M.E. Degree in CTM will be awarded under the banner of Civil Engineering department.

3.1 Programme Educational Objectives (PEO)

The objective of the M.E. CTM Programme focuses mainly on preparing engineers capable of entering and developing successfully in the workplace or on pursuing research studies not only in India but also in foreign companies and institutions in areas related to discipline. The broad objective of the programme is a focus on making students competent in the subject domain and be an active contributor to the society:

PEO01	To pursue professional career in the constantly changing field of construction, Engineering, Technology and Management
PEO02	To contribute to knowledge base through teaching and research.
PEO03	To equip graduates with knowledge, capable of managing various construction projects with expertise as a team member as well as leader.
PEO04	To provide excellent education producing technically competent, globally employable engineers who will be leaders in the chosen field.
PEO05	To undertake research in conventional and advanced technologies fulfilling the needs and challenges of modern society.
PEO06	To provide consultancy services and develop partnerships with society, industry and public organizations.

3.2 Programme Outcomes (PO)

The Programme is designed to provide the knowledge and skills needed to become an effective engineer in a variety of organizational settings. It is a broad-based, career advancement degree, rather than technical training for a particular job within an organization. On completion of the M.E. CTM Programme, one shall be able to:

PO1	Exhibit the planning, organization, execution, and legal skills of a construction manager.
PO2	Compare construction management technologies, innovations, and processes

PO3	Evaluate the logistics underlying construction systems and devise strategies for managing these complexities.
PO4	Demonstrate the financial, managerial, and cognitive acumen of a leader in the construction industry.
PO5	Evaluate how the legal, economic, and social relationships between contracting, the building trades, and the regulatory environment inform construction management.
PO6	Analyse how issues of cost, safety, and design impact project development and implementation.
PO7	Apply global, ethical, and sustainability perspectives to construction management knowledge.

4. DURATION

The duration of the ME Modular program is three years. The end-term examination is conducted at the end of each module.

Normal duration of the degree program	Maximum time allowed for completion of the Program
3 years	5 years

5. COURSE SCHEME M.E. (CONSTRUCTION TECHNOLOGY & MANAGEMENT)

Semester-1			
Code	Title of the Course	L-T-P	Credits
MCT6201	Construction and Environment	4-0-0	4
MCT6302	Research Methodology	4-0-0	4
MCT6304	Software use in Construction Management	4-0-0	4
Total		12	12

Semester-2			
Code	Title of the Course	L-T-P	Credits
MCT4102	Management of Scaffolding & Safety in construction	4-0-0	4
MCT4104	Human Resource Management	4-0-0	4
MCT4108	Principles and Practices of Management	4-0-0	4
	Elective-I	4-0-0	4
Total		16	16

Semester-3			
Code	Title of the Course	L-T-P	Credits
MCT4129	Advance Construction Methods & Technology	4-0-0	4
MCT4130	Concrete & Steel Construction Technology	4-0-0	4
	Elective-II	4-0-0	4
Total		12	12

Semester-4			
Code	Title of the Course	L-T-P	Credits
MCT4135	Fire Protection Services & Maintenance management of Buildings	4-0-0	4
MCT4136	Maintenance & Repair of Concrete Structure	4-0-0	4
Total		8	8

Semester-5			
Code	Title of the Course	L-T-P	Credits
MCT4116	Thesis	----	20
Total			20

Cumulative Credits at the end fourth year: 12+16+12+8+20 = 68 Credits

Department Elective			
Course Code	Title of Course	L+T+P (Hours / Week)	Credits
Elective I			
MCT4117	Construction Management	4-0-0	4
MCT4119	Disaster Reduction and Management	4-0-0	4
MCT4121	Field Exploration and Geotechnical Processes	4-0-0	4
MCT4123	Geographic Information Systems	4-0-0	4
MCT4125	Ground Improvement and Geo synthetics	4-0-0	4
MCT6104	Construction Economics & Financial Management	4-0-0	4
MCT4103	Rural Construction Technology	4-0-0	4
MCT4105	Material & Equipment Management	4-0-0	4
MCT4126	Bridge Engineering	4-0-0	4
Elective II			
MCT4128	Pavement Design, Construction & Maintenance	4-0-0	4
MCT6303	Advance Construction Engineering	4-0-0	4
MCT4113	Construction Quality Management	4-0-0	4
MCT4131	Fire Safety & Hazard Engineering	4-0-0	4
MCT4132	Foundation Design & Construction	4-0-0	4
MCT4133	Hydraulic Structure, Design & Construction	4-0-0	4
MCT6204	Construction Technology	4-0-0	4
MCT4118	Maintenance of Building Structures	4-0-0	4
MCT4122	Green Buildings & Services	4-0-0	4
MCT4127	Special Construction Methods & Technology	4-0-0	4
MCT4124	Intelligent Transportation Systems	4-0-0	4

6. Course details:

Semester – I

Course Code	Course Name	L-T-P	Credits
MCT6201	Construction and Environment	4-0-0	4

Course Learning Outcomes (CLO):

CLO1: Students will be able to explain the major principles of environmental impact assessment in India.

CLO2: Students will be able to access different case studies/examples of EIA in practice.

CLO3: Students will develop an understanding of the basic principles underlying international environmental law, particularly the concept of sustainable development.

CLO4: Students will be able to understand the implications of the production, resource management, and environmental impact of solid waste and Industrial waste management.

CLO5: Understand and evaluate the global scale of environmental problems.

Course Outlines:

Evolution of EIA Concepts – Methodologies – Screening- Scoping- Base line studies- Mitigation – Matrices - Check List. Rapid and comprehensive EIA Legislative and Environmental Clearance procedures in India- Predication tools for EIA. Assessment of impacts Air – Water – Soil- Noise- Biological. Documentation of EIA Environmental management Plan- Post Project monitoring- Environmental Audit- Life cycle Assessment – EMS – case studies in EIA.

Environment and pollution Control Laws: Rules and regulations & Laws governing Energy, Conservation in India & developed Nations Energy Conservation Act 2001, Revisions and present state of implementation standardization & Labelling, Electricity Act 2003, Revisions and present status of implementation. Global Environmental Policies: Modelled nations Framework Convention on Climate change (UNFCCC), Protocol, Conference of Parties (COP), Clean Development Mechanism (CDM), Prototype Carbon Funds (PCF), Carbon credits and its trading, Benefits to developing countries. Solid Waste: Sources, Classification and Regulatory Framework: Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management. Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, nuclear wastes - lead acid batteries, electronic wastes, plastics and fly ash. Solid Waste Characterization and Source Reduction: Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes – Hazardous Characteristics – TCLP tests – waste sampling and characterization plan - Source reduction of wastes –Waste exchange - Extended producer responsibility - Recycling and reuse. Industrial Wastewater Management: Sources and types of industrial wastewater- Environmental impacts- Regulatory requirements- generation rates- characterization. Prevention vs Control of Industrial Pollution – Source reduction techniques- Waste Audit- Evaluation of pollution prevention options. Disposal of effluent on land- Quantification, Characteristics and disposal of sludge.

Recommended Book(s):

1. Environmental Impact Analysis Handbook, Rau J.G. and Wooten D.C. (Ed), McGraw Hill Book Company. (2015)
2. CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, (2000).
3. Solid Waste Engineering, William A. Worrell, P. Aarne Vesilind and Cengage Learning, (2012).
4. Environmental Law in India, 3rd ed., Leelakrishnan P. Lexis Nexis, India, (2008).
5. Wastewater Treatment for Pollution Control and Reuse, Arceivala S.J., Asolekar McGraw Hill., (2006)

Course Code	Course Name	L-T-P	Credits
MCT6302	Research Methodology	4-0-0	4

Course Learning Outcomes:

CLO1: Develop basic computer skills necessary for the conduct of research.

CLO2: The primary characteristics of quantitative research and qualitative research has been discussed to intensifying employability.

CLO3: Students should be able to identify a research problem stated in a study.

CLO4: Develop the ability of advanced data analysis techniques.

CLO5: Understand the classification of data, benefits and drawbacks of data.

Course Outlines:

Introduction to research - meaning of research, type of research, process of research, Sources of research problems, Criteria/Characteristics of a good research problem, Errors in selecting a research problem, formulation of research hypothesis, search for caution. Developing a research - proposal format of research proposal Individual research proposal, Institutional research proposal Significance, objectives, methodology, funding for the proposal, different funding agencies, framework for planning. Literature survey: Definition of literature and literature survey Need of literature survey, sources of literature, elements and objectives of literature survey, style of literature survey, and strategies of literature survey. Data collection, measuring, scaling and sampling – classification of data, Benefits and drawbacks of data, evaluation of data, quantitative methods of data collection, methods of qualitative research Sampling: sampling size, sampling strategy, attitude measurement and scaling, types of measurements, criteria of good measurements, classification of rocks. Preliminary data analysis - Testing of hypothesis – concepts and testing, analysis of variance techniques. Introduction to non-parametric tests - Validity and reliability, approaches to qualitative and quantitative data analysis. Advanced data analysis techniques – correlation and regression analysis, Introduction to factor analysis, discriminate analysis, cluster analysis, multidimensional scaling, Descriptive statistics, inferential statistics, multi-dimensional measurements and factor analysis. Report writing – Need of effective documentation, importance of report writing, types of report, report structure, report formulation, plagiarism. Presentation of research – Research briefing, Presentation style, impact of presentation, elements of effective presentation, writing of research paper, presenting and publishing paper, patent procedure.

Recommended Book(s):

1. “HANDBOOK OF RESEARCH METHODOLOGY” by Dr. Shanti Bhushan Mishra and Dr. Shashi Alok (2017)
2. “Research Methodology” by Panneerselvam (2012)
3. “Research Methodology: Methods and Techniques” by C.R. Kothari (2004)
4. “Research Methodology” by Ranjit Singh (2006)

Course Code	Course Name	L-T-P	Credits
MCT6304	Software use in Construction Management	4-0-0	4

Course Learning Outcomes:

CLO1: Apply the fundamentals of software construction as outlines in this course to an actual software development project.

CLO2: Demonstrate by example the key construction life cycle models.

CLO3: Evaluate and provide examples of the key construction technologies in a typical software construction project.

CLO4: Interpret key practical construction considerations such as design languages, coding, testing, quality and reuse.

CLO5: Students will be effectively able to develop the skills for employability enhancement.

Course Outlines:

Primavera: - primavera is an enterprise project portfolio management software. It includes project management, product management, collaboration and control capabilities, and integrates with other enterprise software such as Oracle and SAP's ERP systems. MX Road: - is a proven, powerful, and concise method of creating any 3D surface. It automates much of the design detailing process, thus saving your time. You can quickly find design alternatives to achieve the ideal road system. STAAD.Pro: - STAAD stands for Structural Analysis and Design. STAAD.Pro software is widely used in analysing and designing structures – buildings, bridges, towers, transportation, industrial and utility structures. Designs can involve building structures including culverts, petrochemical plants, tunnels, bridges, piles; and building materials like steel, concrete, timber, aluminium, and cold-formed steel.

REVIT: - Autodesk's Revit Architecture is a Building Information Modelling software tool for architects, structural engineers, engineers, and contractors. It allows users to design a building and its components in 3D, annotate the model with 2D drafting elements and access building information from the building models database.

Recommended Book(s):

1. "Learning Bentley Staad.Pro V8I for Structural Analysis" by Sham Tickoo (2015)
2. "Construction Scheduling with Primavera P6" by Jongpil Nam (2016)
3. "Rapid Development" by Steve McConnell (2016)
4. "Autodesk Revit for Architecture Certified User Exam Preparation" by Daniel John Stine (2013)

Semester – II

Course Code	Course Name	L-T-P	Credits
MCT4102	Management of Scaffolding & Safety in construction	4-0-0	4

Course Learning Outcomes:

CLO1: Upkeep, storing and stacking methods of tools, materials used for domain specific works.

CLO2: Emergency safety control measures and actions to be taken under emergency situation.

CLO3: Skill development to plan shuttering work within defined scope of work.

CLO4: Work according to personal health, safety and environment protocol at construction site:

CLO5: Scaffolder’s training and working methods are the way for employability.

Course Outlines:

Introduction to Scaffolding & Scaffolding Terminology, Tube, fittings & boards, Safe ladder access and egress, Scaffolder’s training and working methods, Bracing and tying scaffolds, Fan boards and public protection, Mobile, static and loading towers, Birdcage scaffolds, Beams and bridging beams, Various types of system scaffolding, how to carry out a scaffolding inspection, Scaffold tagging systems, Scaffold inspection exercise, Knowledge test and assessment. Concept of safety: Factors affecting safety: Physiological, Psychological and Technological. Planning for safety provisions. Structural safety. Safety in construction operations – Safety of accidents on various construction sites such as buildings, dams, tunnels, bridges, roads, etc. safety at various stages of construction. Prevention of accidents. Safety measures. Safety in use of construction equipment e.g., vehicles, cranes, hoists and lifts etc. safety of scaffolding and working platforms. Safety while using electrical appliances. Explosives used. Site management with regard to safety recommendations. Training for safety awareness and implementation. Formulation of safety Manuals. Safety legislation, standards/codes with regard to construction. Quality vs. Safety. Case Studies.

Recommended Book(s):

1. “A complete guide and best practices on Scaffolding Safety under IS, BS and OSHA Standard, which is absolutely a must read by Indian Industrialist and Safety” by Gaurav Kumar Singh (2016)
2. “A Guide to Scaffold Use in the Construction Industry” by OSHA, U.S. Department of Labor (2014)
3. “Simplified Scaffold Engineering and Construction: Good Scaffolding Structure is a Safe Access to the Heart of Life” by Remigius Izuchukwu Igweoji C (2016)
4. “CONSTRUCTION SAFETY: Industrial Safety and Environment” by S. Suresh Raja (2014)

Course Code	Course Name	L-T-P	Credits
MCT4104	Human Resource Management	4-0-0	4

Course Learning Outcomes:

CLO1: Demonstrate an understanding of key terms, theories/concepts and practices within the field of HRM.

CLO2: The students will gain thorough knowledge in the field of job analysis and designing and this will add to the academic qualification to achieve the employability.

CLO3: The students will enhance the skills on employee welfare and working conditions that shape their ethical behavior.

CLO4: Provide innovative solutions to problems in the fields of HRM.

CLO5: Be able to identify and appreciate the significance of the ethical issues in HR

Course Outlines:

Introduction to Human Resource Management-Introduction, Concept of Human Resource Management Scope of Human Resource Management, Function of Human Resource Management, Role of HR Executives. Human Resource Planning and Development, Organization and Hierarchy, Concept and Process of HRP, Factors Affecting HRP, Recruitment and Selection Process, techniques, Recruitment: Sources and Methods, Selection: Selection Process, Selection Tests, Types and Nature of Interviews, Role Playing and Case Study on Selection Process, Tests and Interview

Job Analysis and Designing, Uses and Process of Job Analysis, Job Description and Job Specification, Job Designing: Job Enrichment, Job Enlargement, Induction and Internal Mobility, Induction Programme, Need and Scope of Internal Mobility: Transfer, Promotion, Demotion, Job Evaluation, Concept of Job Evaluation, Objectives, Techniques, Advantages and Limitations, Introduction to Competency, Training and Development (8 hours), Need for Grievance Redressal Procedure, Employee Welfare and Working Conditions, Concept of Employee Welfare, Welfare Measures, Types, Employee Welfare Responsibility, the Business Benefits of Employee Welfare Activities.

Recommended Book(s):

1. Human Resource Management, 11th Edition International Student Version. By David A. DeCenzo, Stephen P. Robbins and Susan L. Verhulst, Wiley, (2013)
2. Human Resource Management: Text and Cases, Aswathappa K., 8 th Edition, McGraw Hill Education, India (2017)
3. Human Resource Management”, Dessler G. and Varkkey B., 14 th Edition, Pubs: Pearson India. (2015)
4. Human Resource Management: Text and Cases., 12thEdition, Pubs: Pearson India. (2011)

Course Code	Course Name	L-T-P	Credits
MCT4108	Principles and Practices of Management	4-0-0	4

Course Learning Outcomes:

CLO1: Skill developments to understand the concepts related to Business.

CLO2: Demonstrate the roles, skills and functions of management.

CLO3: Analyse effective application of PPM knowledge to diagnose and solve organizational problems and develop optimal managerial decisions.

CLO4: Understand the complexities associated with management of human resources in the organizations and integrate the learning in handling these complexities.

CLO5: To enhance team working and leadership skills to facilitate employability.

Course Outlines:

Management & Evolution of management thought: Concept - definitions - significance - is Management a Science or an art. Evolution of management thoughts - basic managerial, Contribution made by Taylor, Gantt, Gilbreth, Fayol, Weber, Elton Mayo, Chester Bernard, Likert and McGregor, Peter F. Drucker, M.E. Porter, functions-social responsibilities of management - professional management - managerial ethics, Organizational Environment. Planning: Concept - definitions - significance - elements - principles - process-premises - different types (including strategic planning) - forecasting techniques (qualitative & quantitative) - planning failures - limitations of planning - decision making: steps - types -bounded rationality - Management by objectives. Scientific Management, Human Behavior, Mathematical School, Systems Approach of Management Organization: Concept - definitions - significance - principles - process - determinants of organization structure-departmentation (different types) - delegation of authority - decentralization of authority. Responsibility, accountability, Steps to make delegation effective. Motivation: Concept - definitions - significance - different approaches to motivations. Leadership & Decision Making: Concept-definition-significance-difference approaches to leadership (including situational approach). Importance and steps in Decision Making, Decision making under certainty-programmed decisions, decision-making under uncertainty, non-programmed decisions, decision tree, group aided decisions, Brain storming. Communication & Coordination: Concept-definition-significance-process-types-barriers to communication-effective communication. Need, factors which make coordination difficult, techniques to ensure effective coordination. Controlling: Planning-control relationship, process and techniques of control, Human response to control, Types of Control- Feed forward control concurrent Control (Real Time Information & Control), and Feedback Control.

Recommended Book(s):

1. “Principles and Practices of Management” by Partho S. Sengupta (2010)
2. “Principles and Practices of Management and Organizational Behaviour” by Chandrani Singh (2016)
3. “Management” by Stoner J A and Freeman R E (2014)
4. “Principles and Practices of Management” by Kaul Vijay Kumar (2016)

Semester - III

Course Code	Course Name	L-T-P	Credits
MCT4129	Advance Construction Methods & Technology	4-0-0	4

Course Learning Outcomes:

CLO1: To analyze various approaches to construction in relation to their historical and cultural context.

CLO2: Skill development to work in the field of selection of piles, coffer dams, quality control of ground water in excavations to produce the employability.

CLO3: To enhance the skills to analyze and design R.C.C. slab, wall, beam and columns.

CLO4: Function effectively as a skilled member of an engineering team and enhance employability development.

CLO5: Discuss professional responsibility in light of social context of engineering problems.

Course Outlines:

Pile Foundations: Introduction, uses, selection of pile, types of piles, pile spacing, group of piles, efficiency of group of piles, pile cap and pile shoe, load tests on piles, pile driving, pulling of piles, loads on piles, causes of failures of piles, pile driving formulas. Cofferdams: Definition, uses, selection of coffer dams, types of coffer dams, design D. Lesson planning features of coffer dams; leakage prevention, economic height. Caissons: Definition, uses, construction material, types of caissons, loads on caisson, design features of caissons, floating of caissons, cutting edges, sinking of caisson, tilting of caisson, caisson diseases. Control of Ground Water in Excavations: Methods- pumping, well points, bored wells, electro-osmosis, injections with cement, clays and chemical, freezing process, vibro-flotation. Temporary Works: Form work for R.C.C. wall, slab, beam and column, Centring for arches of large spans and dams, design features for temporary works, Slip formwork, false work for bridges, Specialty form work. Construction of Earthquake Resistant Buildings: Planning of earthquake resistant building, Construction of walls –provision of corner reinforcement, Construction of beams and columns. Base isolation. Special Structures: Tall structures, spatial structures, pre-stressed structures.

Suggested Books:

1. “Advanced Construction Technology” by Mr Roy Chudley (2006)
2. “Advance Construction Technology Civil Engineering Book” by Satya Prakashan (2016)
3. “Advanced Construction Technology” by Atul Prakashan (2013)
4. “Advanced Construction of Buildings” by Stephen Emmitt (2010)

Course Code	Course Name	L-T-P	Credits
MCT4130	Concrete & Steel Construction Technology	4-0-0	4

Course Learning Outcomes:

- CLO1: Learn the basic elements of a steel structure
 CLO2: Learn the fundamentals of structural steel fasteners.
 CLO3: Able to design basic elements of steel structure like tension members, compression members, beams and beam-columns.
 CLO4: Able to design column splices and bases.
 CLO5: To enhance the skills to analyze and design of simple bolted and welded connections.

Course Outline:

Principles of concrete mix design: Concrete materials; mix proportioning and early age properties, strength, permeability and durability. Concrete mix design procedures by: IS/ACI British Standards, mix design procedures using fly ash, fibers and design of high-performance concrete. Properties and techniques of construction for concrete: Admixtures, polymers, epoxy resins, pozzolanic materials and fly ash, fibre reinforced concrete, light weight concrete, heavy weight concrete, foam concrete, high performance concrete. Special concrete Operations, shotcrete, grouting, guniting, under water concreting, hot and cold weather concrete, pump able concrete, ready mixed concrete. Construction techniques for reinforced concrete Elements - materials, principles and procedures for beams, slabs, columns, foundations, walls and tanks, design and fabrication of formwork for R.C.C elements, features of slip forming and precautions, details of special shuttering required for lining of tunnel, procedures and precautions. Inspection and quality control of concrete construction Stages, principles, Checklist, statistical controls, procedures. Materials, classification and properties of steel structures: Structural steel sections and data.

Structural Steel Detailing: Symbols, layout drawings, shop detail drawings, assembly marking. Structural steel fabrication: Methods, tools, equipment and practices, Punching, Reaming and drilling, cutting operations, fittings, fasteners, bolting, riveting and welding, Assembly, inspection, cleaning, sand blasting and painting: Transportation of fabricated components, Storage and handling. Erection of steel structures: Erection equipment, erection tools, methods of erection, section sequence field, connections, detailing to facilitate erection. Specifications, Estimating and costing steel work, Fire protection of steel construction, Maintenance and repair of steel structures.

Recommended Book(s):

1. Jain A.K., (2009) 'Reinforced Concrete Design - Limit State Method', Nem Chand Brothers, Roorkee.
2. Sinha S.N., (2002). 'RC Design', Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
3. Gu, Xianglin, Jin, Xianyu, Zhou, Yong. (2016), “Basic Principles of Concrete Structures”, Springer-Verlag Berlin Heidelberg, China.
4. Setareh, Mehdi, Darvas, Robert, (2017), “Concrete Structures”, Springer International Publishing, Switzerland.

Semester – IV

Course Code	Course Name	L-T-P	Credits
MCT4135	Fire Protection Services & Maintenance management of Buildings	4-0-0	4

Course Learning Outcomes:

CLO1: Differentiate between the various types of extinguishing agents.

CLO2: Learn the knowledge of fire behavior to preventing fire and to suppressing fire.

CLO3: Knowledge about existing global frameworks and existing agreements for employability and skill development.

CLO4: Apply the knowledge of fire behavior to increasing the margin of safety of the firefighter.

CLO5: Acquire the knowledge maintenance management.

Course Outline:

Fire Protection: Process of combustion in fire, Effect of fire load & ventilation condition on enclosure fire, growth and decay of fire in enclosure. Concepts of fire resistant and severity, Effect of fire on materials. Simple Design of elements for given fire resistance. Planning, Fire detection & suppression systems, Smoke venting, Lifts & Vertical Transportation: arrangement of lifts and Design for optimum service condition. Building Services as a system, Capacity of storage and sizing, control system etc. & intelligent building. HVAC System: Design Consideration. Basic psychometrics, Air conditioning process & system. Methods of Air Conditioning. Water Supply, Hydraulic design, Storage Distribution, Component of cold & hot water supply system. Waste water & Drainage systems: Fixture units & Design of system and elements of electrical services. Definition, Role of building maintenance in construction process, maintenance generators, Expression of Standards, selection of level of maintenance and fixing standards. Planned maintenance: schedule & contingency maintenance, levels of planning, planned inspection. Maintenance cycle, maintenance profile, repair & replacement models, statistical methods, decision models, optimal renewal cycle, budgeting, effect of design on maintenance, Diagnosis, appraisal, structural defects & various methods of repair.

Recommended Book(s):

1. “Fire Protection Services and Maintenance Management of Building” by Prof. Prof. B Bhattacharjee (2016)
2. “Fire safety in buildings” by V.K. Jain (2007)
3. “Fire Protection Engineering in Building Design” by Jane I. Lataille (2003)
4. “Handbook of Building Materials for Fire Protection” by Harper, Charles A. (2003)

Course Code	Course Name	L-T-P	Credits
MCT4136	Maintenance & Repair of Concrete Structure	4-0-0	4

Course Learning Outcomes (CLO):

CLO1: Explain the causes of damages occurred in the given structures.

CLO2: Select the relevant repair techniques for the damages in the given civil structures with justification.

CLO3: Explain the relevant repair methods for cracks in RCC structures.

CLO4: Develop skills to judge the limitations of the design methods used.

CLO5: To acquire skills in retrofitting and enhance employability development.

Course Outline:

Maintenance and its classifications, repair, retrofitting, re-strengthening, rehabilitation and restoration. Necessity, objectives and importance of maintenance and repairs. Factors influencing the maintenance and repairs, advantages and limitations of maintenance and repairs. Approach of effective management for maintenance and repairs. Periodical maintenance, maintenance manual containing building plan, reinforcement details, material sources, maintenance frequency, pre and post monsoon maintenance. Causes of damages due to distress, earthquake, wind, flood, dampness, corrosion, fire, dilapidation, termites. Systematic approach of damages detection, various aspects of visual observations for detection of damages. Tests on damaged structures: rebound hammer, ultrasonic pulse velocity, rebar locator, cover gauge, crack detection microscope, chloride test, sulphate attack, pH measurement, half-cell potential meter. Causes of wall cracks due to bulging of wall, shrinkage, bonding, shear and tension, differential settlement of foundation, thermal movement and vegetation. Probable crack location such as junction of main & cross wall, junctions of RCC column & wall, junction of slab & Wall cracks in masonry joints. Stages of repair: material removal and surface preparation, fixing suitable formwork, bonding/passivating coat and repair applications. Repair techniques: grouting, patch spalling replacement or delaminating and epoxy bonded mortar. Repairing methods for minor & medium cracks include epoxy injection, grooving & sealing, shotcrete, stitching, grouting and guniting. Repairing methods for major cracks (width more than 5 mm) include fixing mesh across cracks, dowel bars, RCC band and installing ferro-cement plates at corners and propping.

Recommended Book(s):

1. “Repair and Rehabilitation of Concrete Structures” by Modi Poonam I. and Patel Chirag N. (2016)
2. “Maintenance, Repair & Rehabilitation & Minor Works of Buildings” by Varghese (2014)
3. “Building Repair and Maintenance Management” by Gahlot P.S. (2015)
4. “A Textbook of Reliability and Maintenance Engineering” by Alakesh Manna (2011)

Semester – V

Course Code	Course Name	L-T-P	Credits
MCT4116	Thesis	----	20

MCT4117	Construction Management	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Create construction project schedules and analyse professional decisions based on ethical principles.
CLO2: Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.
CLO3: Create a construction project safety plan and cost estimates.
CLO4: Analyse construction documents for planning and management of construction processes and analyse methods, materials, and equipment used to construct projects.
CLO5: To draft skills beneficial for construction contracts and strengthening employability.

Course Outlines:

Introduction: Definition, functions and scope of construction management; scientific methods of management; construction team. Construction Contracts and Specifications: Types of construction contracts; contract documents; specifications; general and special conditions; contract management; arbitration and settlement. Construction Planning and Network Techniques: Pre-tender planning; contract planning; planning and scheduling construction jobs by bar charts; Planning and scheduling construction jobs by critical path network techniques; allocation of resources; techniques of development and analysis of PERT/CPM networks for building project, bridge project and industrial shed constructions; updating of network; examples and case studies; Computer software for network analysis. Time-cost Optimization: Direct cost, indirect cost, total cost; purpose, stages and methods of cost control techniques of time cost optimization; examples and case studies. Site Layout: Principles governing site lay out; factors effecting site lay out; preparation of site lay out. Supervision, Inspection and Quality Control: Supervisor's responsibilities; keeping records; control of field activities handling disputes and work stoppages; storage and protection of construction materials and equipment; testing and quality control. Purpose of inspection: Inspection of various components of construction; reports and records; statistical quality control. Project Management: Feasibility study; project reports; progress reports; monitoring and controlling project activities.

Recommended Book(s):

1. "Best for Learning How to Bid: Defensive Estimating: Protecting Your Profits" by William Asdal (2017)
2. "Construction Scheduling" by Jay S. Newitt (2009)
3. "Construction Management and Planning" by B. Sengupta and H. Guha (1995)
4. "Digital Construction Management" by Akhilesh Srivastava (2017)

MCT4119	Disaster Reduction and Management	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Acquire the knowledge disaster management.
CLO2: Understand the vulnerability of ecosystem and infrastructure due to a disaster.
CLO3: Acquire the knowledge of disaster management Phases.
CLO4: Understand the hazard and vulnerability profile of India.
CLO5: Knowledge about existing global frameworks and existing agreements for employability and skill development.

Course Outlines:

Introduction To Disaster: Concepts of Hazard, Vulnerability, Risks, Natural Disasters (earthquake, Cyclone, Floods, Volcanoes), and Man Made Disaster (Armed conflicts and civil strip, Technological disasters, Human Settlement, Slow Disasters (famine, draught, epidemics) and Rapid Onset Disasters(Air Crash, tidal waves, Tsunami) Risks, Difference between Accidents and Disasters, Simple and Complex Disasters, Refugee problems, Political, Social, Economic impacts of Disasters, Gender and Social issues during disasters, principles of psychosocial issues and recovery during emergency situations, Equity issues in disasters, Relationship between Disasters and Development and vulnerabilities, different stake holders in Disaster Relief. Refugee operations during disasters, Human Resettlement and Rehabilitation issues during and after disasters, Inter-sectoral coordination during disasters, Models in Disasters. Approaches To Disaster Risk Reduction: Disaster Risk Reduction Strategies, Disaster Cycle, Phases of Disaster, Preparedness Plans, Action Plans and Procedures, Early warning Systems Models in disaster preparedness, Components of Disaster Relief-(Water, food, sanitation, shelter, Health and Waste Management), Community based DRR, Structural non-structural measures in DRR, Factors affecting Vulnerabilities, , Mainstreaming disaster risk reduction in development, Undertaking risk and vulnerability assessments, Policies for Disaster Preparedness Programs, Preparedness Planning, Roles and Responsibilities, Public Awareness and Warnings, Conducting a participatory capacity and vulnerability analysis, , Sustainable Management, Survey of Activities Before Disasters Strike, Survey of Activities During Disasters, DRR Master Planning for the Future, Capacity Building, Sphere Standards. Rehabilitation measures and long-term reconstruction. Psychosocial care provision during the different phases of disaster. Disaster Risk Management In India: Hazard and Vulnerability Profile India,, Disaster Management Indian scenario, India’s vulnerability profile, Disaster Management Act 2005 and Policy guidelines, National Institute of Disaster Management, , National Disaster Response Force (NDRF)National Disaster Management Authority, States Disaster Management Authority, District Disaster Management Authority Cases Studies : Bhopal Gas Disaster, Gujarat Earth Quake, Orissa Super-cyclone, south India Tsunami, Bihar floods, Plague Surat, Landslide in North East, Heat waves of AP& Orissa, 278 Cold waves in UP.

Recommended Book(s):

1. Singh B.K., (2008), Handbook of Disaster Management: Techniques & Guidelines, Rajat Publication.
2. Ghosh G.K., (2006), Disaster Management, APH Publishing Corporation
3. Disaster Medical Systems Guidelines. Emergency Medical Services Authority, State of California, EMSA no.214, June (2003)
4. Inter-Agency Standing Committee, IASC (2007). IASC Guidelines on Mental Health and Psychosocial Support in Emergency Settings. Geneva: IASC.

MCT4121	Field Exploration and Geotechnical Processes	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

CLO1: To enhance skills to identify the origin of soil and to identify different types of soil.

CLO2: To appreciate the use of modern technology in the field of geotechnical engineering.

CLO3: Understand and apply the Principle of Effective Stress to a range of typical geotechnical problems in order to predict the ground response under different conditions of loading, soil type and groundwater states.

CLO4: To understand the concept of slope stability.

CLO5: Design the main geotechnical works involved in a landfill to value up the skills.

Course Outlines:

Planning for Subsurface Exploration: Introduction, Objectives of Site Investigation, Planning for Subsurface Exploration Fact finding and Geological survey, Reconnaissance, Preliminary Exploration, Detailed Exploration.

Methods of Site Exploration: Classification of investigation method, Classify the Site Investigation in another way, Methods of site exploration, Information Extraction from site investigation topography. Direct Methods of Exploration: General, Test/Trial pit. Boring Methods of Exploration: Displacement boring, wash boring, Auger boring, rotary drilling, and Percussion drilling. Soil sampling and Samplers: Soil samples, Disturbed samples, undisturbed samples, Requirement of good sampling process. In situ Tests: Penetrometer Tests; Standard penetration test, Static cone penetration test, Dynamic cone penetration test. Geophysical Exploration: Methods of Geophysical Exploration, General Overview, Different methods of geophysical explorations, Electrical resistivity method, Seismic refraction method.

Recommended Book(s):

1. Craig, R.F., (1983). 'Soil Mechanics' by ELBS and Van Nostrand Reinhold Co. Ltd., Berkshire.
2. Taylor, (1949), "Fundamentals of Soil Engineering", John Wiley & Sons.
3. Holtz, R. D., Kovacs, W. D., & Sheahan, T. C. (1981). An introduction to geotechnical engineering (Vol. 733). Englewood Cliffs, NJ: Prentice-Hall.
4. Das, B. M., & Sobhan, K. (2013). Principles of geotechnical engineering. Cengage learning.

MCT4123	Geographic Information Systems	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

CLO1: Demonstrate proficiency in the use of GIS tools to create maps that are fit-for-purpose and effectively convey the information they are intended to.

CLO2: Apply mathematical concepts, including statistical methods, to data to be used in geospatial analysis.

CLO3: Gather and process original data using a Global Positioning System (GPS) or other Global Navigation Satellite Systems (GNSS).

CLO4: To enhance the skills to deal with data sources and data entry procedures.

CLO5: Generate the way to employability and entrepreneurship.

Course Outlines:

Overview of the course; Overview of GIS: Definitions, components, applications GIS Data Models, Projections and Coordinate Systems, Data Sources and Data Entry, Digitizing, GPS, Remote Sensing, Attribute Data: Queries and Analysis; Spatial Data: Spatial Queries and Basic Spatial Analysis, Intermediate Spatial Analysis, Data Quality, Implementation Issues and the Future of GIS.

Recommended Book(s):

1. "Concepts and Techniques of Geographic Information Systems" by Chor Pang Lo (2009)
2. "Fundamentals Of Remote Sensing" by George Joseph and C Jeganathan (2017)
3. "Remote Sensing and GIS" by Basudeb Bhatta (2016)
4. "Text Book of Remote Sensing and Geographical Information Systems" by M. Anji Reddy (2016)

MCT4125	Ground Improvement and Geo synthetics	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Student will learn about various ground improvement techniques available, how to design them and implement them in field.
- CLO2:** To appreciate the use of modern technology in the field of geo synthetics engineering.
- CLO3:** To enhance skills to identify the origin of soil and to identify different types of soil.
- CLO4:** To understand the various physical and engineering characteristics of different types of soil.
- CLO5:** Understand and apply the Principle of Effective Stress to a range of typical geotechnical problems in order to predict the ground response under different conditions of loading, soil type and groundwater states.

Course Outlines:

Principles of ground improvement, mechanical modification. Properties of compacted soil. Hydraulic modification, dewatering systems, preloading and vertical drains, electro-kinetic dewatering, chemical modification, modification by admixtures. Stabilization using industrial wastes, grouting, soil reinforcement principles, properties of geosynthetics, and applications of geosynthetics in bearing capacity improvement. Slope stability, retaining walls, embankments on soft soil, and pavements, filtration, drainage and seepage control with geosynthetics, geosynthetics in landfills, soil nailing and other applications of geosynthetics.

Recommended Book(s):

1. "Ground Improvement Techniques and Geosynthetics" by T Thyagaraj (2016)
2. "Ground Improvement and Geosynthetics" by Jie Han (2014)
3. "Ground Improvement and Geosynthetics" by Anand J. Puppala (2010)
4. "Ground Improvement Techniques" by P. Purushothama Raj (2005)

MCT6104	Construction Economics & Financial Management	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Apply valuation principles to calculate the future value and the present value of a series of cash flows.
- CLO2:** Identify cost classifications based on how the cost will be used: whether for preparing external reports, predicting cost behaviour, assigning costs to cost objects, or decision making.
- CLO3:** Understand various methods of depreciation and learn advantages and disadvantages of such methods.
- CLO4:** To apply different tools and techniques for assessing a company's performance, such as financial ratios, cash flow an analysis and forecasting techniques and to enhance team working and leadership skills to facilitate employability.
- CLO5:** Inflation Taxes, Financial statements and operation costs incorporate mandatory employability skills.

Course Outline:

Costing of construction works: Different methods of costing, analysis of rates, items of work; Contingencies and Work charged establishment, Purpose & Principles of Valuation. Cost Estimating: Types of Estimates, Approximate estimates – Unit estimate, Factor estimate, Cost indexes, parametric estimate, and Life cycle cost. Engineering Economics: Basic principles – Time value of money, quantifying alternatives for decision making, Cash flow diagrams, Equivalence – Single payment in the future (P/F, F/P), Present payment compared to uniform series payments (F/A, A/F), Arithmetic gradient, Geometric gradient. Comparison of alternatives by Present worth and Future worth method. Depreciation, Inflation and Taxes: Depreciation, Inflation, Taxes. Equipment Economics: Equipment costs, Ownership and operation costs, Buy/Rent/Lease options, Replacement analysis. Financial Management: Construction accounting, Chart of Accounts, Financial statements – Profit and loss, Balance sheets, financial ratios, Working capital management.

Recommended Book(s):

1. “Construction Management and Finance” by Abebe Dinku (2016)
2. “Social Accounting Matrix for India: Concepts, Construction and Applications” by K Basanta Pradhan (2006)
3. “Industrial Megaprojects: Concepts, Strategies, and Practices for Success” by Edward W Merrow (2016)
4. “Construction and Project Management for Engineers, Architects, Planners and Builders” by K G Krishnamurthy (2008)

MCT4103	Rural Construction Technology	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Evaluate various properties of the basic construction materials such as un-burnt bricks, mud, stones.
CLO2: Evaluate various planning and concepts of appropriate technology for skill development.
CLO3: Develop the skills to work on garbage disposal system and design of low cost waste disposal system to produce employability.
CLO4: To perform various quality control tests for various Civil Engineering materials by performing different tests on materials.
CLO5: To impart the principles of Biogas technology and earthquake resistant measures focusing on employability.

Course Outline:

Rural Development Planning and Concept of Appropriate Technology: Scope; development plans; various approaches to rural development planning; concept of appropriate technology. Rural development programme/ projects. Rural Housing: Low-cost construction materials for housing; Architectural considerations for individual and group housing; Composite material - ferro-cement & fly ash, autoclaved calcium silicate bricks and soil-stabilized un-burnt brick; Plinth protection of mud walls; design consideration and construction of: non-erodable mud plaster, Water-proof and fire-retardant roof treatment for thatch roofs. Pre-cast stone masonry; rat-trap bond for walls; Panels for roof, ferro-cement flooring / roofing units; Earthquake resistant measures for low-cost houses. Water Supply and Rural Sanitation: Sources of water. BIS & WHO water standards. Quality, Storage and distribution for rural water supply works; basic design principles of treatment-low cost water treatment technologies; Hand pumps-types, installation operation, and maintenance of Mark-II hand pumps; conservation of water; rainwater harvesting; drainage in rural areas, design of low cost waste disposal systems; design and construction of low cost latrines: 2 pit pour flush water seal, VIP latrines, septic tank etc; Biogas technology; low cost community & individual Garbage disposal systems, Ferro-cement water storage tanks. Low-Cost Roads and Transport: Broad categories of Pavement Layers, types of Granular Sub-Bases and Bases, Bituminous Construction, Surface Treatments for roads in rural areas. Detailed features and Quality Control of Modified Penetration Macadam, Soil Stabilization, Lime, Lime-Flyash and Cement Treated Course. Crusher-run-Macadam. Use of local materials. Flexible Pavement: Design factors, Basic Principles, Guidelines for Surfacing for Rural Road. CBR method for Design of Flexible Pavement. Low-Cost Irrigation: Design Consideration and construction of tube-well, drip & sprinkler irrigation systems. Watershed and catchments area development - problems and features of watershed management, watershed structures.

Recommended Boo(s):

1. "Roads and Resources: Appropriate Technology in Rural Construction in Developing Countries" by G.A. Edmonds (2016)
2. "Field Engineering: A guide to construction and development work in rural areas" by Peter Stern (1983)
3. "Concrete Construction for Rural Communities" by Roy A Seaton (2000)
4. "Rural Water Supply: A Practical Handbook on The Supply of Water & Construction of Waterworks For Small Country Districts" by Allan Greenwell (2015)

MCT4105	Material & Equipment Management	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Identify, study, compare, and evaluate alternatives, select and relate with a good supplier.
CLO2: Analysing the materials in storage, handling, packaging, shipping distributing and standardizing.
CLO3: Enhances skills in managing the drilling, blasting and tunnelling equipment.
CLO4: Identifying the scope for integrating materials management function over the logistics and supply chain operations.
CLO5: Materials analysis can be done with a design perspective for products and services with new materials (in existing products) or new products (from existing materials).

Course Outline:

Introduction: Construction economy; Factors affecting the selection of construction equipment; rolling resistance, effect of grade on required tractive effort, effect of altitude and temperature on the performance of internal combustion engines, drawbar pull, rimpull and acceleration, owning and operating cost of equipment. Earth Moving Equipment: Crawler and wheel tractors-their functions, types and specifications; grade-ability, bull dozers and their use; tractor pulled scrapers, their sizes and output; effect of grade and rolling resistance on the output of tractor pulled scrapers; earth loaders; placing and compacting earth fills. Power shovels - functions, selection, sizes, shovel dimensions and clearances, output, Draglines – functions types, sizes, output, Clamshells; Safe lifting capacities and working ranges of cranes; Hoes, trenching machines, types and production rates calculation of production rates of equipment; examples. Hauling Equipment: Trucks; capacities of trucks, balancing the capacities of hauling units with the size of excavator; effect of grade and rolling resistance on the cost/performance of hauling equipment. Drilling, Blasting and Tunnelling Equipment: Definition of terms, bits, jackhammers, drifters, wagon drills, churn drills, piston drills, blast hole drills, shot drills, diamond drills; Tunnelling equipment; selecting the drilling method and equipment; selecting drilling pattern; rates for drilling rock, air compressors. Piling Equipment: Pumping equipment in construction, Classification of pumps; Selection of pumps –Air-operated centrifugal type sump pumps; performance of centrifugal pumps; well point system. Compaction Equipment: Roller class: sheep's foot rollers, pneumatic tyre rollers, steel wheel rollers, vibrating rollers, grid type rollers-their applications. Economic Considerations in the procurement and use of construction equipment; Time value of money; ROR and IROR analysis; depreciation; costing of construction equipment operation.

Recommended Book(s):

1. “A. K Datta, Materials Management, Ed. (2005), Prentice-Hall of India Pvt. Limited, New Delhi, India.
2. “Operations & Supply Management”, Richard B Chase, Ravi Shankar, F Robert Jacobs & Nicholas J Aquilano; McGraw-Hill Publishing Company Ltd. (2012)
3. “Materials Management System”, Brown, R. B., John Wiley & Sons, New York. (2010)
4. “Materials Management: An Integrated Approach”, Gopalakrishnan, P. & Sundaresan, M., Prentice-Hall of India. (2007)

MCT4126	Bridge Engineering	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** To understand the load-carrying capacity of various types of bridges, upon learning the structural responses to different kinds of loads.
- CLO2:** To design short and medium span bridges, with confidence using existing codes of practice, taking into account of the structural strength, service life and durability.
- CLO3:** Develop skills to judge the limitations of the design methods used.
- CLO4:** To acquire skills in basic bridge design and enhance employability development.
- CLO5:** Aerodynamic stability considerations; special durability measures; provisions for inspection and maintenance.

Course Outlines:

Introduction: Definition; components of a bridge; classification; importance of bridges. Standard Specifications for Road Bridges: Indian Roads Congress Bridge Code; width of carriageway; clearances; loads to be considered; dead load; I.R.C. standard live load; impact effect; application of live load on decks; wind load; longitudinal forces; centrifugal forces; horizontal forces due to water current; Buoyancy effect; earth pressure; temperature effects; seismic force. Reinforced concrete Bridges: General arrangement and suitability: T-beam bridges; Balanced cantilever bridges; Continuous girder bridges; Rigid frame bridges; Arch bridges; Steel bridges (Familiarization with MOST specifications and drawings). Sub-Structure: Design of piers and abutments (Masonry & R.C.C). Foundations: Types of foundations; Open; Piled and Well foundations; including construction details. Pile Foundations: Suitable Pile types for bridges, Pile Installation, Carrying capacity of bored and cast- in-situ pile, Well Foundations various Components and brief description, Well Cap, Stability of a single well. Bearings, Joints, and Handrails: Different types of bearings, joints and handrails.

Construction and Maintenance of Bridges. Quality Assurance, Construction Method (brief) Steel bridges, Long span concrete bridge, Traditional method, Incremental Push launching method, Cantilever method, Maintenance, Maintenance of Bearings, Expansion Joints.

Recommended Book(s):

1. T R Jagadeesh & M A Jayaram (2004), "Design of Bridge structure", PHI Learning Pvt. Ltd.
2. Krishna Raju, (2005), "Design of Bridges", Oxford & Ibh.
3. Ramesh Shah, (2014), "Bridge Engineering", Random Publications.
4. Fundamentals of Seismic Protection for Bridges (2011)

MCT4128	Pavement Design, Construction & Maintenance	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Evaluate the strength of subgrade soil by CBR test.
CLO2: To enhance skills for testing pavement materials.
CLO3: Recognize the knowledge about different physical properties of aggregates by performing different test on road aggregates.
CLO4: Outline the various properties of bitumen material and mixes by performing various tests on it.
CLO5: Students shall connect theory with field observations and ability to identify limitations in theory/models Tests on Pavement Layers.

Course Outlines:

Design of Flexible Pavements: Types of pavements. Flexible and rigid pavements Components of a pavement and their functions. Factors affecting design of pavements. Design of thickness of a flexible pavement by Group Index method, CBR method (including latest IRC guidelines), Tri axial method and Burmister's method. Design of Rigid Pavements: Westergaard's theory, critical locations of loading, load and temperature stresses. Critical combination of stresses. IRC guidelines for determination of thickness of a rigid pavement. Joints: requirements, types, patterns. Spacing of expansion and contraction joints. Functions of dowel and tie bars. Construction of Base, Subbase, Shoulders and Drain Roadway and Drain Excavation, Excavation and Blasting, Embankment Construction, Construction of Gravel Base, Cement Stabilised Sub Bases, WBM Bases, Wet Mix Construction; Crushed Cement Bases, Shoulder Construction; Drainage Surface, Turfing Sand Drains; Sand Wicks; Rope Drains, Geo- Textile Drainage; Preloading Techniques. Bituminous Construction and Maintenance: Preparation and Laying of Tack Coat; Bituminous Macadam, Penetration Macadam, built up Spray Grout, Open Graded Premix, Mix Seal, Semi-Dense Asphalt Concrete-Interface Treatments and Overlay Construction, IRC Specifications. Cement Concrete pavement Construction and Maintenance: Cement Concrete Pavement Analysis – Construction of Cement Roads, Manual and Mechanical Methods, Joints in Concrete and Reinforced Concrete Pavement and Overlay Construction.

Recommended Book(s):

1. L.R. Kadiyali, (2013) 'Traffic Engineering & Transport Planning', Khanna Publishers, India.
2. Khanna & Justo, (1973) 'Highway Engineering', Nemchand & Bros-Roorkee (UA).
3. Chakroborty, P., & Das, A. (2017). Principles of transportation engineering. PHI Learning Pvt. Ltd.
4. Mannering, F., Kilareski, W., & Washburn, S. (2007). Principles of highway engineering and traffic analysis. John Wiley & Sons.

MCT6303	Advance Construction Engineering	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** To analyse various approaches to construction in relation to their historical and cultural context.
- CLO2:** Skill development to work in the field of selection of piles, coffer dams, quality control of ground water in excavations to produce the employability.
- CLO3:** To enhance the skills to analyse and design R.C.C. slab, wall, beam and columns.
- CLO4:** Function effectively as a skilled member of an engineering team and enhance employability development.
- CLO5:** Discuss professional responsibility in light of social context of engineering problems.

Course Outlines:

Pile Foundations: Introduction, uses, selection of pile, types of piles, pile spacing, group of piles, efficiency of group of piles, pile cap and pile shoe, load tests on piles, pile driving, pulling of piles, loads on piles, causes of failures of piles, pile driving formulas. Cofferdams: Definition, uses, selection of coffer dams, types of coffer dams, design D. Lesson planning features of coffer dams; leakage prevention, economic height. Caissons: Definition, uses, construction material, types of caissons, loads on caisson, design features of caissons, floating of caissons, cutting edges, sinking of caisson, tilting of caisson, caisson diseases. Control of Ground Water in Excavations: Methods- pumping, well points, bored wells, electro-osmosis, injections with cement, clays and chemical, freezing process, vibro-flotation. Temporary Works: Form work for R.C.C. wall, slab, beam and column, Centering for arches of large spans and dams, design features for temporary works, and Slip formwork, false work for bridges, Specialty form work. Construction of Earthquake Resistant Buildings: Planning of earthquake resistant building, Construction of walls –provision of corner reinforcement, Construction of beams and columns. Base isolation. Special Structures: Tall structures, spatial structures, pre-stressed structures.

Recommended Book(s):

1. “Advanced Construction Technology” by Mr Roy Chudley (2006)
2. “Advance Construction Technology Civil Engineering Book” by Satya Prakashan (2016)
3. “Advanced Construction Technology” by Atul Prakashan (2013)
4. “Advanced Construction of Buildings” by Stephen Emmitt (2010)

MCT4113	Construction Quality Management	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** To develop the skills for various quality control operations.
- CLO2:** Various methods of conducting performance measurement activities are presented and explained.
- CLO3:** In implementing a quality assurance system, construction organisations can encounter various problematic issues; these are identified and discussed. Suggestions are made as to how to avoid or address problematic issues that might be encountered.
- CLO4:** Total Quality Management (TQM) and the advocated advantages and problematic issues associated with implementing TQM within a modern-day commercial context.
- CLO5:** Key quality theories that inform and underpin the development and implementation of quality management approaches in modern-day organisations.

Course Outlines:

Program Elements: - Policy and Procedures, Goals and Objectives, General Quality Management, Roles and Responsibilities, Approvals and Reviews, Document Control, Process Improvement, Project-Specific Quality Management Plan.

Preconstruction (some activities may not apply): - Review of Plans and Specifications, Quality standards; Review Requirements, Clarify Any Ambiguity, Samples or Mockups, Constructability Reviews, Documenting Existing Conditions, Material Management; Transportation Factors, Receiving at the Jobsite, Storage and Protection, Subcontractor factors; QA/QC Program, Field Procedures, Fabrication Shop Inspections, Testing; Requirements, Procedures, Documentation.

Construction Operations:- Zero Defect Program, Quality Assurance Administration, Roles and Responsibilities, Inspection and Testing Plan, Inspection Checklists, Quality Assurance(QA) Process; Specified Quality Requirements, QA Process, Pre-Installation Meeting and Inspection, First Work-in-Place Meeting and Inspection, Follow-Up or Daily Inspections, Inspections; Inspection schedule, Pre-Cover-Up and Pre-Closure Inspections, Documentation; Written Report, Digital Pictures, Non-conformance Procedures; Report, Tracking, Correction, Material Verification, Water Intrusion Prevention; Preconstruction, Inspections During Construction, Protection of the Work.

Closeout: - Closeout Procedures; As Builts, Punch List Work Management; Systems Turnover Practices; Start-up, Testing of Systems, Training of Personnel, Documentation, O&M Manuals; Final Acceptance.

Post construction: - Warranties, Warranty Management During the Warranty Period, Warranty Call-backs after the Warranty Period, Resulting Damage, Post construction Documentation.

Recommended Book(s):

1. “Quality Management in Construction Projects” by Abdul Razzak (2017)
2. “Field Book For Quality Control In Earthwork Operations” by Alberto Munguia Mireles (2014)
3. “Total Construction Management” by John S. Oakland and Marton Marosszeky (2017)
4. “Construction Quality Management” by Tim Howarth and David Greenwood (2017)

MCT4131	Fire Safety & Hazard Engineering	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Acquire the knowledge to Fire Safety Engineering.
CLO2: Understand the hazard and vulnerability profile of India.
CLO3: Knowledge about existing global frameworks and existing agreements for employability and skill development.
CLO4: Understand the vulnerability of ecosystem and infrastructure due to a disaster.
CLO5: Principles of Fire Suppression and introduction to suppression systems

Course Outlines:

Introduction to Fire Safety Engineering: - Principles of codes and standards, lessons from failures, prescriptive and performance-based design methodologies; some historical context; Overview of relevant codes and standards.

Flammability: - Concept of Flammability and associated principles of storage, hazard classification; standard methods for establishing flammability of different materials; classification and implications related to storage; Combustible/Flammable liquids; Buncefield case study. Fire Detection and Alarm: - Principle of Fire Detection and Alarm; system categories, life and property protection; Alarm and detection zones; Alarm systems and response, Detector technologies. Smoke management: - Principles of ‘Smoke Management’; Fundamental aspects of smoke movement in buildings; Strategies for smoke control; Active and Passive systems; compartmentation requirements and specifications of pressurised. Fire Suppression: - Principles of Fire Suppression; Introduction to suppression systems; design of sprinkler systems; design of gaseous fire suppression systems; Dry chemical fire suppression systems. Fire resistance: - Understand the current methods to establish ‘Fire Resistance’; Fire resistance requirements; Compartmentation; Methods for specifying fire resistance of structural elements; Steel, concrete, timber etc. Codes: BS476-20, BS9999, BS5950-8, BS8110-2, BS5268-4 Egress: - understand the principles of ‘Egress’; prescriptive calculations for egress: travel distances, sizing of corridors and stairways; Human behavior aspects; ASET & RSET; Risk profiles.

Recommended Book(s):

1. Risk Analysis in Building Fire Safety Engineering by A. Hasofer (2006)
2. Safety Professional's Reference and Study Guide by W. David Yates (2017)
3. Safety Management by Ron C. McKinnon (2016)
4. Disaster Medical Systems Guidelines. Emergency Medical Services Authority, State of California, EMSA no.214, (2003)

MCT4132	Foundation Design & Construction	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Identify a suitable foundation system for a structure.
CLO2: Students would be able to identify the objects of site investigation and describe the use of different types of samples and samplers.
CLO3: Calculate the dynamic properties of soil and perform relevant tests in laboratory and on field for the analysis & design of foundations which can tolerate dynamic loads by applying the general principles.
CLO4: Capable of finding out strength properties of in-situ soil.
CLO5: Explain the importance of advanced concepts and theories in soil mechanics.

Course Outlines:

Principles of Foundation Design: Functions of foundations, essential requirements of a good foundation, types of foundations, principal modes of failure, estimation of allowable bearing pressures, calculation of ultimate bearing capacity by theoretical and empirical methods: Terzaghi's Method, Skempton's analysis for clays, Mayerhof's analysis BIS Method (IS:6403), Settlement of foundations. Factors to be considered for foundation design, numerical problem based on BIS method. Shallow Foundations: Introduction, essential requirements, types and depth of footing like Strip footing, Isolated footing, Combined footing, Strap footing, Raft footing, electrically loaded footings; design features and construction details related to size and depth of footing problem of frost heave, its causes and prevention, effect of ground water and environmental considerations; Numerical problems related to size and depth of footings. Pile Foundations: Purpose/uses of pile foundations, Classification of piles based on different criteria, Brief details of timber, concrete, steel piles their advantages and disadvantages, selection of pile type, pile action, behaviour of pile and pile groups under load. Definition of failure load.

Estimation of carrying capacity: Single driven pile in cohesion less soils – methods based on SPT and CPT, ultimate load on driven and cast-in-place piles and bored and cast-in-place piles in cohesionless soils. Factors affecting pile capacity. Numerical problems Ultimate capacity of single pile driven in cohesive soils; modification for driven and cast-in-place piles and bored and cast-in-place piles. Capacity of very long piles – Numerical problems. Carrying capacity of piles on rocks. Piles in fills - negative skin friction. Carrying capacity of pile groups in cohesive soil and cohesion less soils, Efficiency of pile group. Piles subjected to horizontal or inclined loads. Mode of failure of piles Equipment for Installation of Piles by Driving and Boring and cast in place method.

Improvement of Foundation Soils: Purpose: Improvement of granular soils: term used to describe degree of compactness – relative density, density ratio and degree of compaction; Methods - Vibration at ground surface, factors influencing roller compaction; deep dynamic compaction, vibro-compaction impact at depth. Improvement of cohesive soils: preloading, or dewatering, methods of installing sand drains, drain wicks, electrical and thermal methods. Grouting: purpose, functions, types of grouts; soil bentonite - cement mix, cement mix, emulsions, and solutions: grout injection methods. Geo-synthetics: types, functions, manufacturing of geo-textiles, Classification of geotextiles. Specific Applications: Bearing capacity improvement, reinforcement, retaining walls, embankment etc. testing of geo-synthetics, usage in India and a case study. Special Considerations in Foundation Design and Construction: Elementary principles of design and construction of foundations subjected to earthquake or dynamic loads, special measures for foundations constructed under water.

Recommended Book(s):

1. Soil Mechanics and Foundation Engineering, K R Arora, Standard Publishers (2008)
2. Basic and Applied Soil Mechanics, Ranjan, G. and Rao, A.S.R. New Age International Publishers, New Delhi. (2016)
3. Soil mechanics and foundation engineering, Dr B.C Punmia, Ashok kumar (2005)
4. Soil Mechanics, Lambe, T.W. and Whitman, R.V John Wiley and Sons, New York, USA (1979)

MCT4133	Hydraulic Structure, Design & Construction	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** The students will gain an experience in the implementation of Geotechnical Engineering on engineering concepts which are applied in field Geotechnical Engineering.
- CLO2:** The students will get a diverse knowledge of geotechnical engineering practices applied to real life problems of designing of structures.
- CLO3:** The students will learn to understand the theoretical and practical aspects of geotechnical engineering along with the design and management applications.
- CLO4:** Develop Skills to determine aims of the ground Investigation.
- CLO5:** This can explain the methods of soil improvement.

Course Outlines:

Elements of Dam Engineering: Embankment dam types and characteristics, concrete dam types and characteristics spillway types, site selection for dams. Cofferdams: Types of coffer dams, suitability criteria, design considerations, and construction of different types of cofferdams. Concrete Dams: Gravity dams, loading and forces on gravity dams, Considerations and design aspects of basic profile of gravity dam, stability criteria, galleries in dams, instrumentation in dams, temperature control, control of cracking, raising and strengthening of existing dams. Mass Concreting of Dams: Concrete mixes, ad-mixtures, batching, mixing, transportation and placing and compaction and curing of concrete, heights of lifts, Joints and tests on concrete. Earth Dams: Factors influencing design, criteria for safety, design aspects of earth dams, seepage control, methods of construction of earth dams and bonding dam to foundation, building embankment, compaction protection of u/s slope, top and d/s slope, rip rap and concrete lining of slopes. Rockfill Dams: Design consideration and various forces in rock fill dam, rubble backing of impervious face, impervious u/s facing, settlement and sluicing. Lining of Irrigation Channels: Types of lining, design considerations of concrete lining for channels, concrete lining, shotcrete lining, brick lining, tiles, asphaltic lining, stone and concrete block lining, lining of earth materials, comparative water tightness of different types of lining, use of Geo-textiles in canal works. Provision of filters for canals in areas having high sub surface water level. Clearance of Large Irrigation Project from Government of India: concept report (PPR-Preliminary Project Report), Detailed Project Report, Technical clearance from Central Water Commission and Central Electricity Authority, Forest & Environmental clearance, Interstate clearance (if any), Role of planning commission for project provision in Plan Scheme, Funds allocation. Construction planning, schedule of project, Infrastructure Development for project, construction & safety requirements. Introduction to Miscellaneous Structures: River training works, flow measuring structures, river improvement, scale models in hydraulic engineering. Model Investigations, Similitude model laws.

Recommended Book(s):

1. Swami Saran, (2006), “Analysis and Design of Substructures: Limit State Design”.
2. “INTRODUCTION to Geotechnical Engineering” by Braja M Das (2015)
3. “Analysis and design of geotechnical structures” by Manuel Matos Fernandes (2016)
4. “Geotechnical Engineering” Design by Ming Xiao (2015)

MCT6204	Construction Technology	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Able to impart the knowledge about the characteristics, sources and defects in various materials used for construction purposes.
- CLO2:** Able to design and test the materials either in the laboratory or in the field before their actual use at the site.
- CLO3:** Able to attain the knowledge of different building materials, their classification.
- CLO4:** Enhances skills in quality control and thus helps in employability.
- CLO5:** To use the techniques, skills and modern engineering methods involved in the analysis of structures.

Course Outlines:

Underground Construction: Underground and Under water construction – Tunnel shaft sinking, Micro Tunneling, Tunnel driving in hard and soft strata. Underwater Construction: Problems encountered, Underwater drilling, blasting, grouting methods in soft and hard soil including Jet grouting and chemical grouting, dewatering in shallow and deep excavations using different methods, Vacuum Dewatering and Well point system. Construction using concrete Technology: Various methods of shuttering, Ready Mix Concrete, Pumped Concrete, Concrete mix design with various methods of concreting. Pile construction: Piling – Single pile and a group pile (Bored and Driven) during driving, working loads and ultimate loads on driven and cast – in – situ piles, piles in land and marine structures. Construction details of precast piles, pre stressed piles, steel piles and friction piles. Pile capacity – load test on piles initial and routine, failure and causes, Methods of pile driving by vibration and construction of micro piles, Diaphragm piles. Cofferdams: types, design, and construction of single, double wall. Sheet pile cofferdams, movable cofferdams, land cofferdams, Cofferdam wall by ICOS method. Caissons: Types, box, pneumatic and open caissons, Well foundation, details, design, and construction of caissons. Construction Equipment: understanding basics and function of equipment earthmoving machinery, concreting equipment, material handling equipment, and transportation of equipment's.

Recommended Book(s):

1. Bhavikatti, S. S. (2009). 'Design of Steel Structures (By Limit State Method as Per Is: 800 2007)', IK International Pvt Ltd, India.
2. Kuldeep Saluja, (2015), 'Building Construction', Diamond Pocket Books, India.
3. Allen, E., & Iano, J. (2013). 'Fundamentals of building construction: materials and methods', John Wiley & Sons, New Jersey.
4. Varghese, P. C. Edition: Second Edition "Building Construction (2016)

MCT4118	Maintenance of Building Structures	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** Students are introduced to building maintenance job skills and employment opportunities.
- CLO2:** Students also learn how to troubleshoot, repair, and maintain dishwashers, washers, gas/electric dryers, and gas/electric hot water heaters.
- CLO3:** Various maintenance problems falls under remedial maintenance. Remedial maintenance is simply to restore the defected part to its initial condition or removal of defects in the structure.
- CLO4:** The preventive maintenance work has no immediate visible effect. Efforts made on doing preventive maintenance work takes a long duration to give its return and become visible.
- CLO5:** The maintenance is mainly done to upgrade the working of building i.e it is done to increase the serviceability of building and adding new features to the building. This may be done by complete renewal of parts of a building. Special maintenance is done by doing detailed planning.

Course Outline:

Introduction and Safety Procedures in Building Maintenance: Students are introduced to building maintenance job skills and employment opportunities. They learn identification and proper use of hand and power tools. Students are instructed in proper safety precautions in the performance of building maintenance tasks. Emphasis is placed on safety, clothing, and proper use of hand and power tools. Students receive an introduction to Green Technology and Energy Efficiency in the trades. General Mathematics for Building Maintenance: Students review mathematical procedures including computations using fractions, decimals, and percentages. Blueprint Reading: Students are instructed in the use of blueprints showing building stages from excavation to completion. Students learn to read plans, interpret symbols, and identify standard dimensions. Carpentry: Students learn types of construction lumber, installation of studding and joists, and installation and repair of drywall. Practical applications of carpentry taught include identification of moldings; cutting, mitering, and nailing of finished carpentry projects; installation of interior doors, and sub-flooring. Students practice the proper way of sealing around doors and windows as it relates to energy conservation. Screen Repair, And Appliance Repair and Maintenance: Students learn basic screen repair. Students also learn how to troubleshoot, repair, and maintain dishwashers, washers, gas/electric dryers, and gas/electric hot water heaters.

Recommended Book(s):

1. "Maintenance, Repair & Rehabilitation & Minor Works of Buildings" by Varghese (2014)
2. "Concrete Structures Repair Rehabilitation and Retrofitting" by BHATTACHARJEE J (2016)
3. "Building Repair and Maintenance Management" by Gahlot P. S. (2006)
4. "Maintenance & Repair of Civil Structures" by B.L. Gupta (2016)

MCT4122	Green Buildings & Services	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

CLO1: The technique of green building maximizes the use of efficient construction materials and practices.

CLO2: Implementation of the green building concept can lead to a reduction of carbon emission by thirty five percent, water usage by forty percent, solid waste reduction by seventy percent and reduction in energy consumption by fifty percent.

CLO3: To develop the skills on water efficiency, material efficiency and construction site selection strategies.

CLO4: Green Buildings use various methods to reduce water usage, treat and reuse waste water and filter water from sourced from precipitation.

CLO5: To provide employability in future in the field of Design Features for Green Building Construction Site selection strategies, landscaping, building form, orientation, building envelope and fenestration.

Course Outline:

Introduction to Green Buildings Definition of Green Building, Benefits of Green Building, Components/features of Green Building – Site selection, Energy Efficiency, Water Efficiency, Material Efficiency, Indoor Air Quality.

Design Features for Green Building Construction Site selection strategies, landscaping, building form, orientation, building envelope and fenestration – material and construction techniques, roofs, walls, and fenestration and shaded finishes, advanced passive heating and cooling techniques, Waste reduction during construction. Water and Waste Water Management Compliance, fixtures, rainwater harvesting and techniques, water and waste water management, solid waste management. Energy Management Appliances, compliance energy performance, solar water heating system, use of renewable energy options. High performance glass, other energy saving options, provisions of ECBC, insulating materials. Eco-friendly Materials Various types of eco-friendly materials, use of recycled materials like: flyash bricks, recycled ceramic tiles, recycled glass tiles, porcelain tiles, natural terracotta tile, wood, steel, aluminium and renewable materials, agrifibre, linoleum, salvaged material – properties and applications.

Recommended Book(s):

1. “Green Building: Principles and Practices in Residential Construction” by Abe Kruger (2013)
2. “Marketing Green Building Services” by Jerry Yudelson (2008)
3. “The Art of Natural Building: Design, Construction, Technology” by Joseph F. Kennedy (2002)
4. “Green Building Handbook: A Companion Guide to Building Products & Their Impact on the Environment” by Tom Woolley and Sam Kimmins (2017)

MCT4127	Special Construction Methods & Technology	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

CLO1: Understand method of preparation of specifications and their implications.

CLO2: Calculate the analysis of rates for different materials.

CLO3: Understand the method of preparation of estimates for civil engineering works of various Buildings, Masonry tanks and stair case to incorporate mandatory employability skills.

CLO4: Ability to evaluate and analyse present worth, future worth and annual worth analyses on one of more economic alternatives.

CLO5: Introduction to the process of Estimation; Use of relevant Indian Standard Specifications for the same, taking out quantities from the given requirements of the work, comparison of different alternatives.

Course Outline:

Excavation and earth-moving plant. Management theory and tools, Excavation and earth-moving plant. Project delivery methods & Day Labour. Road construction, pipe laying. Construction Tenders and Contracts, Asphalt mix production & placement Cost estimating, Compressors, pumps Construction planning & control Dewatering, coffer dams, cassions financial management. Cranes, Hoists & Piling Explosives, drilling & blasting. Concrete aggregates Concrete properties, Cements Mix design, Water, admixtures, concrete manufacture, Onsite requirements. Concrete testing Concrete formwork.

Recommended Book(s):

1. Mankiw Gregory N. (2002), Principles of Economics, Thompson Asia
2. V. Mote, S. Paul, G. Gupta (2004), Managerial Economics, Tata McGraw Hill
3. Misra, S.K. and Puri (2009), Indian Economy, Himalaya
4. Pareek Saroj (2003), Textbook of Business Economics, Sunrise Publishers

MCT4124	Intelligent Transportation Systems	4-0-0	4 Credits
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Course Learning Outcomes (CLO):

- CLO1:** To enhance skills for Intelligent Transportation Systems.
- CLO2:** Intelligent Transportation Systems (ITS) technologies advance transportation safety and mobility and enhance American productivity by integrating advanced communications technologies into transportation infrastructure and into vehicles.
- CLO3:** Many benefits exist for further deployment and continued development of ITS technologies.
- CLO4:** Students who successfully complete the course will have gained a basic understanding and appreciation of the concepts related to ITS technologies and industry applications of the field.
- CLO5:** The students will conduct a comprehensive independent research project, on topics related to ITS, to enhance their understanding of a specific topic of their interest.

Course Outline:

Introduction to Intelligent Transportation Systems (ITS), Advanced Transportation Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Federal ITS Programs. ITS Highway Safety Perspective, Environmental Aspects of ITS, Connected Vehicle Technology and Applications. ITS Standards and Architecture, ITS Telecommunications, 511 Travel Information Systems, Interactive Voice Recognition (IVR), Mobile Applications, Economics of ITS – Revenue Generation Models, ITS and Security, ITS Policy Issues, International ITS Programs, Case Studies, Careers in the ITS Field.

Recommended Book(s):

1. “Intelligent Transport Systems” by Pradip Kumar Sarkar (2017)
2. “Pavement Analysis and Design” by Huang (2012)
3. “Intelligent Transportation Systems: From Good Practices to Standards” by Paolo Pagano (2016)
4. “Intelligent Transport Systems: Technologies and Applications” by Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva, Ignacio Julio García-Zuazola (2015)